

Assessment of the Effect of Nutrition Education Intervention on Anaemia among In-School Adolescent Girls in Ogun State, Nigeria.

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in Public Health**

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Certification

This is to certify that **Olusola Olamide OYEWOLE** with matriculation number LCU/PG/001558 carried out this research work titled “Assessment of the effect of Nutrition Education Intervention on Anaemia among In-school Girls in Ogun State, Nigeria” in the Department of Public Health, Faculty of Basic Medical and Health Sciences, Lead City University, Ibadan, Oyo state, for the award of Doctor of Philosophy Degree (PhD) in Public Health and that this has not been previously submitted.

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Dedication

This research is dedicated to the Monarch of the Universe, my wisdom, my helper, my strengthener and my unending supply.

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Acknowledgement

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Even though the above-mentioned institutions and people have assisted in the process of this research work, I alone stand responsible for the errors, if any, found in the work.

Abstract

Iron deficiency anaemia (IDA) is the most common nutritional disorder affecting over 2 billion people especially women, children and adolescents. IDA is a condition in which anaemia occurs due to lack of available iron to support normal red cell. Adolescents are a particularly vulnerable group when it comes to IDA because they are going through a period of rapid growth and development, which puts an increased demand on their bodies for iron. Improved nourishment is required for the biological well-being of adolescents. This study assessed the effect of nutrition education intervention on anaemia among in-school girls (10-19years) in public secondary schools in Ogun State, Nigeria. This study was a quasi-experimental approach, with pre-and post-intervention assessments. The study involved an intervention group that receives the 6-weeks nutrition education classes' intervention and a control group that does not. An adapted structured questionnaire from FAO was used to collect data on socio-demographics, knowledge on iron and anaemia, attitude towards IDA, iron intake practice and a 24-hour dietary recall questionnaire. Anthropometry and biochemical assessments of the study participants was also carried out. The data was analysed using statistical package for Social Sciences (SPSS) with statistical difference set at $p < 0.05$. The demographic profile of the participants shows the mean age of 13.64 ± 1.82 . At baseline ($n=277$), 84.48% had some level of anaemia: moderate anaemia (59.6%), mild anaemia (14.1%) & severe anaemia (10.8%). Also, 83% participants generally had poor knowledge of IDA, 56% had negative attitudes towards IDA and 56.3% had inadequate iron intake.

After the six-week intervention, the intervention group showed significant improvement. Knowledge about IDA increased substantially, with 88.1% demonstrating good knowledge. Attitudes shifted positively to 87.4%, dietary practices improved with a decreased in inadequate iron intake and an increase in consumption of iron-rich foods. Haemoglobin levels increased significantly compared to the control group. The control group, on the other hand, experienced a decline in mild haemoglobin levels and an increase in severe anaemia from 8.7% to 14.6% after the intervention period. This emphasizes the positive effect of the intervention on the intervention group's iron status. The control group's mean haemoglobin decreased to 96.1g/L after the intervention, while the intervention group's mean haemoglobin level increased to 103.3g/L, a statistically significant difference (P-value of 0.011). Although both groups showed improvement in knowledge scores after the intervention, the intervention group experienced a significant increase in knowledge, highlighting the effectiveness of the program.

At the end of the study, the intervention group, had a higher knowledge score compared to the control group ($p = 0.000$). The intervention was effective in shifting the attitudes of the participants, where the positive attitudes significantly increased, indicating the success of the nutrition education program in improving their outlook on anaemia. The baseline practices of the participants regarding IDA showed regular fish consumption (44.4%) with limited intake of other iron-rich foods, while the nutrition education intervention led to improved dietary practices, with increased consumption of iron-rich foods and a significant reduction of tea/coffee intake, which inhibits iron absorption.

Keywords: Adolescent girls, anaemia, Nutrition Education, prevalence, dietary intake

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List of Acronyms

BMI	-	Body Mass Index
DDM	-	Dietary Diversifications and Modifications
FBA	-	Food Based approaches
FBS	-	Food Based strategies
FAO	-	Food and Agriculture Organization
HBM	-	Health Belief Model
IDA	-	Iron Deficiency Anaemia
KAP	-	Knowledge, Attitude and Practice
RDA	-	Recommended Dietary Allowance
SBCC	-	Social and Behaviour Change Communication
Unicef	-	United Nations Children's and Education Fund
WHO	-	World Health Organization

Chapter One

Introduction

1.1 Background of the Study

Over 2 billion people globally are affected by anaemia, making anaemia the most common nutritional disorder. Anaemia is a condition in which there is insufficient iron available to maintain healthy red blood cells¹. Although, it is a prevalent public health disorder affecting all group of ages, adolescents are at a higher risk.

A population that is more susceptible to iron deficiency anemia is adolescents. This is because their bodies are becoming more in need of iron because of their rapid growth and development.

Also, adolescents may not always have the healthiest eating behaviours and diets and may often not consume enough iron-rich foods to meet their daily needs. Girls in their adolescent stage are especially vulnerable, due to the loss of iron during menstruation, which can further deplete their iron stores. It is estimated that up to 20% of adolescent girls worldwide are affected by anaemia ².

Approximately, one-fifth of the world population are mainly adolescents, with one-fourth of this residing in low-income countries. In Nigeria, adolescents account for approximately one - quarter of the over 200 million inhabitants³. The adolescent period is a phase of rapid growing and development, and thus they are at a peril of numerous nutritious deficiencies, which includes iron deficiency⁴. Unfortunately, adolescents continue to be an underserved and hard-to-measure demographic with frequently disregarded needs⁵.

Anaemia is a common nutritional problem among girls aged 10-19 years living in low-income countries including Nigeria, with prevalence ranging from 13.4 to 62.9%^{6, 7, 8}. The 2018 Nigeria Demographic Health Survey found that 60.5% of adolescent girls in Nigeria had anaemia. In Ogun State, Nigeria, the prevalence of anaemia in adolescents was 49%, which is still high even if it is lower than the national prevalence. Research shows that the prevalence of anaemia in adolescents tends to rise with age and that the greatest growth acceleration occurs throughout adolescence⁸. Between the ages of 12 and 15, when needs are at their highest, the prevalence is highest. It has been observed that over 50% of females in this age group are anaemic^{10,11,12}.

Factors associated with IDA are decreased mental performance and physical endurance, impaired regulation of body temperature, impaired immune response, poor growth development, and decreased cognitive performance¹³. Additionally, anaemia impairs adolescent girls' ability to focus, lowers their productivity, physical strength, and academic achievement, and raises their risk of infection¹⁴. Furthermore, it decreases the ability of red blood cells to carry oxygen to the body's tissues, resulting in symptoms like weakness, dizziness, shortness of breath, and conjunctival pallor. These symptoms can have a detrimental effect on clinical outcomes and raise morbidity, mortality, and quality of life^{13, 15}.

Anemia has a detrimental effect on adolescents' economic and educational well-being. It has been linked to stunting, wasting, underweight, poor cognitive performance, limited physical activity, and attention deficit hyperactivity disorders^{14,17,18,19}. Anemia is currently recognized as the primary cause of disability adjusted life years in adolescents²⁰. It is recognized that the functional effects happen before the clinical stage of iron insufficiency manifests. Adolescents

with iron deficiency (ID), which has detrimental impacts on their health and physical stamina, are far more common than those who are just anaemic. Adolescent iron deficiency and iron deficiency anemia (IDA) are therefore serious public health issues.

Iron deficiency anaemia can be regarded as a disorder that is caused by many factors and thus, requires a multi-faceted approach for its prevention and treatment ²¹. Interventions for IDA can be implemented during the adolescent years. Since adolescents are open to new concepts, knowledge, and methods as they strive for academic or athletic success, this demand can be readily satisfied by utilizing high group involvement or school attendance to reach a significant number of both boys and girls ²². It has recently been noted that poor nutritional status can be prevented by using nutrition education interventions^{23,24,25,26}.

Nutrition education may be the most cost-effective of all the suggested strategies for reducing the prevalence of anaemia if followed by the adolescents. Adolescents in several nations have demonstrated improved nutrition and healthy eating practices, attitudes, and knowledge because of this intervention ^{27,28,29}. Also, studies showed that adolescents' nutritional status and haemoglobin levels were considerably improved by following the various nutrition education programs^{30, 31}. Adolescents enrolled in school make up most of the participants in this research rather than members of the general community.

Nutrition education interventions have been identified as one of the most effective strategies for preventing and managing IDA, particularly in resource-limited settings like Nigeria ³². However, the impact of such interventions on adolescents' remains poorly understood, and there is a need

for rigorous evaluation to determine their effectiveness. Schools create an exceptional setting to help children and adolescents to cultivate a positive viewpoint on life and help them establish healthy lifestyles since most children and adolescents spend one third of their time in schools. School based health services are the first and the most accessible point of contact with health services for many school age children, with a likelihood to often reach most school-age children with preventive, curative and supportive health interventions. School based health services are a very typical type of provision of health services in most countries. The school system therefore provides an exceptional platform to impact the behavioural choices of adolescents by using different health education programs²².

This study therefore assessed the effect of nutrition education intervention on IDA among in-school adolescent girls aged 10-19years in Ogun State, Nigeria. This study employed a before – after (pre–post) study design for execution. Study related data were collected before and after a nutrition education intervention among the in-school adolescent population. The outcomes from this study will have a major implication for policy and practice, as they will offer scientific evidence recommendations for the design and implementation of nutrition education interventions to address IDA among adolescents in Nigeria and other similar contexts. The study also contributes to the broader literature on nutrition education interventions and their impact on adolescent health and development.

1.2 Statement of the Problem

Globally, iron deficiency is estimated to be accountable for over 50% of anaemia characterized by low levels of haemoglobin in the blood, of which iron is a major component of haemoglobin³³.

Most meals consumed by adolescents in Nigeria are plant-based and limited in bio-available dietary iron; starchy staples form the bulk of adolescents' diets, and there is a meagre consumption of fruits and food groups that provide micronutrients like Vitamin C.

In Nigeria, there is relatively high prevalence of IDA, and it is especially pronounced among children, adolescents, and pregnant women. Although IDA is one of the most prevailing public health challenges with severe consequences for individuals and national growth, its incidence among Nigerian female adolescents is under-reported. The Nigerian National Population Council reported in its 2018 NDHS publication that 58% of women aged 15-49 and 60.5% of girls, 15-19 years are anaemic in Nigeria. In Ogun State, anaemia prevalence among women 15-49 years is reported as 49%⁹. The high incidence of anaemia among adolescents is mostly owing to the low nutritional consumption of foods rich in iron. This might be attributed to either lack or low nutrition knowledge.

The Food and Agriculture Organization (FAO) of the United Nations reported that lack of knowledge on nutrition in Africa rather than food unavailability is responsible for nutrition inadequacy. Previous studies also shared this view, whose findings indicated that adolescents in developing nations possess poor knowledge and practice regarding healthy eating behaviors³⁴. Being a period of rapid growth and development, individuals at the adolescent stage are especially vulnerable to multiple nutritional deficiencies, including iron deficiency, which leads to IDA¹³.

Research findings show that the correlation of serum-ferritin with Haemoglobin and the higher percentage of iron depletion in girls than boys suggests that the risk of developing IDA is higher in girls⁹.

Iron Deficiency Anaemia usually develops gradually without any specific clinical symptoms; this makes its presence unknown until the condition becomes severe⁶. IDA is generally more serious in adolescent females compared to their male counterparts⁹. The health, economic and social burdens associated with IDA in Nigerian adolescent females have made the condition a significant public health challenge that needs urgent attention.

Several studies have investigated interventions by which IDA can be reduced in different populations³⁵. The desire to consume healthy and balanced foods is present among adolescents, but it does not translate fully to behaviour modification. Continuous eating of unhealthy food leads to serious health problems. The effect of nutrition education on the knowledge and practices in addressing iron deficiency anaemia among female adolescents in Nigeria has not been adequately reported. Hence, the need to assess the effect of nutrition education on iron deficiency anaemia among adolescents' girls who attend public secondary schools in Ogun State, Southwest, Nigeria.

1.3 Research Justification

Iron deficiency anaemia is a prevalent nutritional deficiency in developing countries. In Nigeria, IDA is a significant public health concern, affecting about 30% of the populace. Adolescents are a particularly vulnerable group, with up to 50% of adolescent girls in Nigeria being anaemic. Anaemia can have significant consequences on physical and cognitive development, impacting academic performance and future productivity.

One strategy to address this issue is through nutrition education interventions, which aim to improve dietary intake and knowledge of healthy eating practices. Nutrition education interventions have shown promise in improving iron status among teenagers, but there is

inadequate indication on the effectiveness of such interventions in school settings in Nigeria. Therefore, there is a need to carry out research to evaluate the influence of nutrition education intervention on iron deficiency anaemia among in-school adolescents in Nigeria.

1.4 Aim and Objectives of the study

The aim of the PhD thesis is to assess the effect of nutrition education intervention on iron deficiency anaemia amongst in-school adolescent girls in public secondary schools in Ogun state, Nigeria.

The specific objectives of this study were to:

- i. determine the knowledge, attitude and practice of the adolescent girls about iron deficiency anaemia
- ii. determine the prevalence of iron deficiency anaemia among in-school adolescent girls in Ogun State, Nigeria.
- iii. assess the dietary intake of iron and other relevant nutrients among in-school adolescent girls in Ogun State, Nigeria.
- iv. determine the knowledge, attitude and practice of the parents/caregiver of the in-school adolescent girls about iron deficiency anaemia
- v. develop and implement a nutrition education intervention for in-school adolescents in Ogun State, Nigeria.
- vi. evaluate the effect of the nutrition education intervention in improving haemoglobin level among in-school adolescent girls in Ogun state, Nigeria.

1.5 Research Questions

The questions (RQ) that this study seeks to answer are as follows:

1. What is the prevalence of iron deficiency anaemia among in-school adolescent girls in Ogun State, Nigeria?
2. What is the knowledge, attitude, and practice of in-school adolescent girls about iron deficiency anaemia?
3. What is the dietary intake of iron and other relevant nutrients among in-school adolescent girls in Ogun state, Nigeria?
4. What is the knowledge, attitude and practice of the parents/caregiver of the in-school adolescent girls about iron deficiency anaemia?
5. What are the key components of an effective nutrition education intervention for in-school adolescent girls in Ogun State, Nigeria?
6. What is the effectiveness of a nutrition education intervention in improving iron status among in-school adolescent girls in Ogun State, Nigeria?

1.6 Hypotheses of the Study

The hypotheses of this study are as follows:

- H₀₁: The prevalence of iron deficiency anaemia among in-school adolescent girls in Ogun state, Nigeria is low.
- H₀₂: In-school adolescent girls have poor knowledge, poor perception of iron deficiency anaemia and poor iron intake practices
- H₀₃: In-school adolescent girls have inadequate dietary intake of iron and other relevant nutrients

- H₀₄: Parents/Caregivers of adolescent girls have poor knowledge, poor perception of iron deficiency anaemia and poor iron intake practices
- H₀₅: There is no significant difference in the key components of a nutrition education intervention for in-school adolescent girls in Ogun state, Nigeria.
- H₀₆: The nutrition education intervention has no significant effect on improving iron status among in-school adolescent girls in Ogun state, Nigeria.

1.7 Significance of the Study

Anaemia is a significant public health problem, particularly in low- and middle-income countries like Nigeria. Adolescents are particularly vulnerable to iron deficiency anaemia due to the rapid growth and development that occurs during this period of life. Iron deficiency anaemia can have serious consequences for physical and cognitive development, school performance, and overall quality of life. Therefore, it is important to implement interventions that can effectively prevent and treat iron deficiency anaemia among adolescents. The study assessed the effect of a nutrition education intervention on anaemia among in-school adolescent girls in Ogun State, Nigeria.

The significance of this study lies in several key areas:

Iron deficiency anaemia is a significant public health problem in Nigeria, particularly among adolescent girls. By identifying effective interventions that can prevent and treat iron deficiency anaemia, this study has the potential to improve the health and well-being of a large population. The study identifies high-risk groups for iron deficiency anaemia among adolescents in Ogun State. This information can be used to develop targeted interventions that focus on the specific needs of these groups.

The study assessed the knowledge, attitudes, and practices of both adolescent girls and their parents/caregivers regarding iron deficiency anaemia. This information can be used to develop culturally appropriate nutrition education interventions that are more likely to be effective. The study developed and implemented a nutrition education intervention for in-school adolescents. By evaluating the effectiveness of this intervention, the study provides valuable information about the most effective strategies for preventing and treating iron deficiency anaemia among adolescents.

The study contributes to the body of knowledge on iron deficiency anaemia prevention and treatment in low- and middle-income countries. This information can be used to inform future research and interventions aimed at improving the health and well-being of vulnerable populations. The study has significant public health implications and has the potential to contribute to the development of effective interventions for preventing and treating iron deficiency anaemia among adolescents in Ogun State, Nigeria.

The study also provides valuable information about the knowledge, attitudes, and practices of adolescents and their parents/caregivers regarding iron deficiency anaemia, which can be used to inform the development of culturally appropriate interventions. Finally, the study contributes to the body of knowledge on anaemia prevention and treatment in low- and middle-income countries.

1.8 Scope of the Study

The study focused on nutrition education literacy which consist of knowledge, attitude and practice relating to iron deficiency anaemia among in-school adolescents' girls aged 10-19 years

in public secondary schools in Ogun State, Nigeria. The study also involves parents/caregivers of the in-school adolescent girls.

The study is a quasi-experimental design, with pre- and post-intervention assessments. The study will involve an experimental group that receives the nutrition education intervention and a control group that does not receive the intervention. The study was conducted in selected public secondary schools in the three (3) senatorial districts in Ogun State, Nigeria. The schools were selected using a purposive sampling method. The independent variable is the 6-weeks training intervention. The dependent variable is the nutrition education literacy which measures the knowledge, attitude and practice of the in-school adolescent girls and their parents.

The study assessed the prevalence of iron deficiency anaemia among in-school adolescent girls aged 10-19years. It also assessed the knowledge, attitudes, and practices of both the in-school adolescent girls and their parents/caregivers regarding iron deficiency anaemia. The dietary intake of relevant nutrients and anthropometric measurements among in-school adolescents were assessed.

The study also developed and implement a nutrition education intervention for in-school adolescents and evaluate the efficacy of the intervention in improving the haemoglobin level. Nutrition education training curriculum was developed to fit into the contextual setting in South-western, Nigeria.

1.9 Operational Definition of Terms

Nutrition Education Intervention: Structured teaching sessions delivered to in-school adolescent girls, focusing on iron-rich foods, dietary practices to prevent iron deficiency anaemia,

and healthy eating habits. In this study, it refers to the educational program provided to the intervention group during the research period.

Anaemia: A condition characterized by low haemoglobin levels due to inadequate iron in the body. In this study, anaemia is determined using haemoglobin concentration measured by a portable haemoglobinometer, with values below WHO cut-off (<12 g/dL for adolescent girls) classified as anaemic.

In-School Adolescent Girls: Female students aged 10–19 years enrolled in secondary schools within the selected Local Government Areas of Ogun State, who participated in the study.

Knowledge of Iron Nutrition: The level of correct understanding about iron-rich foods, consequences of iron deficiency, and ways to prevent iron deficiency anaemia, as assessed through a structured questionnaire.

Dietary Practices: The habitual food consumption patterns of participants with respect to iron-rich foods and enhancers/inhibitors of iron absorption, assessed using a 24-hour dietary recall.

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Chapter Two

Literature Review

This chapter provides information on the topic of iron deficiency anaemia based on the evidence gathered from previous studies. At the beginning of the chapter, information was provided on the methods and strategies used to gather research articles that were used in this study. The information provided include the databases that were used for journal gathering, the exclusion and the inclusion criteria that were used in the selection process, the strategies for selecting the final articles and the flow chart that visually depicts the selection process.

The remaining part of the chapter explore several sub-topics that are related to the focus of this study, these include: definition of anaemia, types of anaemia, iron deficiency, sources of iron rich food, iron enhancers, iron blockers, iron metabolism, bioavailability of dietary iron, recommended dietary allowance for iron, iron deficiency anaemia among adolescents, risk factors of iron deficiency anaemia, clinical manifestation, diagnosis and outcomes of iron deficiency anaemia, consequences of iron deficiency anaemia, nutritional intervention, and other related subtopics.

The chapter also examines the conceptual model that was adopted and its applications to this study. The chapter ends with a concise summary of the information that was given in the chapter, and it also gives a brief overview of the contents that will be examined in the next chapter.

2.1 Conceptual Review

Literature Search Strategies

Literature review involves the identification, synthesis, and assessment of available evidence to generate robust, empirically derived solutions that answer specific research questions. The approach involves a rigorous and objective review of relevant literature that is aimed at minimizing bias and ensuring reproducibility. The protocols associated with the literature review process allow researchers to gather information about already established evidence, the mechanisms used to produce the evidence, and the variation of the evidence across studies in my interest.

Resources within 5 to 10 years were reviewed using both online and offline resources. The comprehensive electronic discovery service provided by EBSCO and Cochrane libraries were used in searching for relevant literature. EBSCO is made up of key health and social care databases such as Science Direct, Ovid, MEDLINE, Web of Science, and CINHALL (Citation Index for Nursing and Allied Health Literature). The keywords that were used to search for

relevant literature are as follows: anaemia, iron deficiency anaemia, nutritional education, adolescents, knowledge, attitude and practice and developing countries.

The databases mentioned above were searched for relevant studies using the search terms. A total of 1,230 articles were initially gathered. 408 duplicates were removed from the initial articles leaving 822 articles. Further screening of the remaining articles showed that 152 of the articles did not meet the predetermined language criteria. Subsequent processing resulted in the removal of 225 articles that did not meet the title criteria, 215 papers that did not meet the abstract requirements, and 30 papers whose full texts are not available. At the end of the review process, only 200 relevant works of literature were included in this study. The flow chart depicting the selection process is shown in figure 2.1

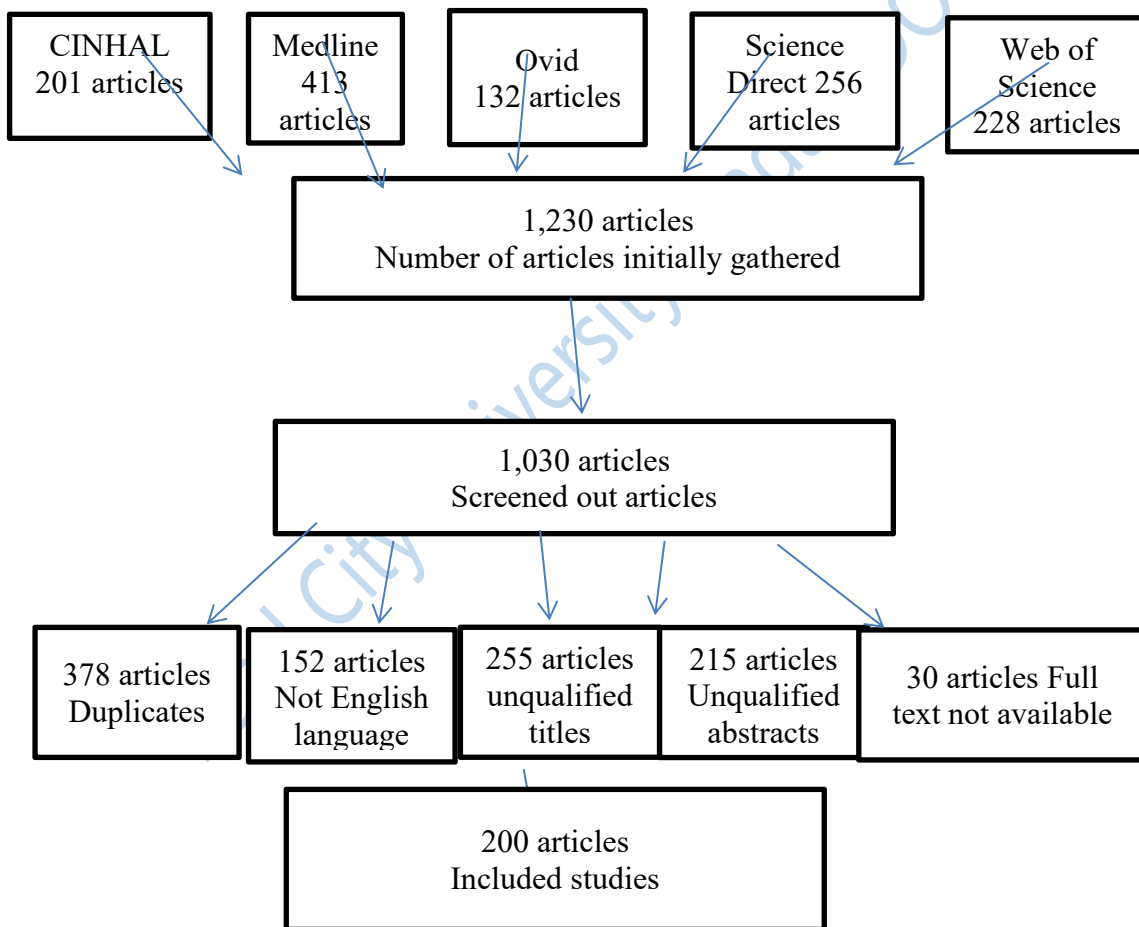


Figure 2.1. Flow Chart Depicting the Literature Search Strategy

Source: Field Survey, 2024

2.1.1 Definition of Anaemia

There is some debate in the literature regarding appropriate values for haemoglobin concentration indicative of anaemia in young children. Haemoglobin concentration changes rapidly in the first year of life, decreasing in the first few months and then increasing again. Anaemia has conventionally been defined by reference limits for haemoglobin < -2 SD of the mean for a specified population group. The WHO value for diagnosing anaemia is Hb < 110 g/L for children aged 6-59 months. However, this value was chosen somewhat 'arbitrarily' and the WHO definitions for anaemia were explicitly not designed to indicate optimal human function¹. In addition, by using haemoglobin concentration as the only biomarker, they could not be used to assess iron deficiency as opposed to other causes of anaemia. Haemoglobin alone is not a specific or sensitive biomarker of iron status. The WHO values used as cutoffs were first established in 1959 by the WHO Study group on Iron Deficiency Anaemia, based on a review of data derived from studies of apparently normal persons throughout the world. The haemoglobin values selected were intended to indicate reference values considered the lower limits of normal for investigators conducting nutritional surveys¹.

These WHO 1959 haemoglobin values were updated in 1968 using more recent data (as g/dl of venous blood at sea level). The cut-offs were: children 6 months to 6 years, 11 g/dl (110 g/l); children aged 6-14 years, 12 g/dl (120 g/l); adult males, 13 g/dl (130 g/l); non pregnant females, 12 g/dl (120 g/l); and pregnant females, 11 g/dl (110 g/l). However, it is noteworthy that the haemoglobin values for children were based on infants who were routinely given iron- fortified cereals from 2-3 months of age¹.

The values indicative of overall anaemia have remained unchanged since 1968, although in a later WHO document as show in Table 2.1. The worldwide prevalence of anaemia among adolescents is 15%, 27% in developing countries and 6% in developed countries². In Nigeria, anaemia prevalence among women of 15 - 49 years is 58%, and 60.5% among women aged 15 - 19 years³.

Table 2.1. Classification of Anaemia

Population	Non-anaemic (g/L)	Mild (g/L)	Moderate (g/L)	Severe (g/L)
6 – 59 months	≥110	100 – 109	70 – 99	<70
5 – 11 years	≥115	110 – 114	80 – 109	<80
12 – 14 years	≥120	110 – 119	80 – 109	<80
>15 (Non-pregnant)	≥120	110 – 119	80 – 109	<80
Pregnant women	≥110	100 – 109	70 – 99	<70
>15 (Men)	≥130	110 - 129	80 - 109	<80

Source⁴: Adapted from Haemoglobin concentrations for the diagnosis of anaemia and assessment of severity, WHO

Other studies have shown that the normal physiological haemoglobin level for infants may be lower than the current WHO cut-off for children 6-59 months. For example, a study proposed -2 SD values for anaemia and iron deficiency based on data from a randomized controlled trial of iron supplementation in infants from Honduras and Sweden. All infants were exclusively or nearly exclusively breastfed until 6 months and partially breastfed until 9 months of age. Iron deficient infants were excluded based on - 2 SD reference limits for MCV, ferritin and TfR, and + 2 SD reference limit for zinc protoporphyrin (ZPP). Hence, they were therefore able to determine reference values based on the expected biological norm of breastfed infants who were born at full term, of normal birth weight⁵.

A study from the UK sought to determine the normal distribution of haemoglobin and ferritin in a representative sample of children in a geographically defined area in the Avon health authority. At 8 months of age, they reported a haemoglobin concentration arithmetic mean of 117 g/L with a fifth centile of 97 g/L, for all children (96 g/L for boys and 99 g/L for girls). Iron deficient children, as defined by plasma ferritin concentration of < 12 µg/L unadjusted for infection, were not excluded from this sample. However, only 1.2% of the population cohort met that definition for iron deficiency. This UK group later followed the same children at aged 12 and 18 months

and set a fifth percentile reference limit of haemoglobin concentration for defining anaemia at aged 12 and 18 months of < 100 g/L. An alternative set of reference values for normal Hb concentrations were derived from a meta-analysis conducted in and ranges for infants therefore appearing more vague than earlier published statistics. The authors stated that the values for infants 1-2 years should only be regarded as rough approximations ⁶.

In addition, some researchers have sought to determine the haemoglobin concentration at which adolescents would be at risk for cognitive or physical impairments. The study of Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) reported that there was slight developing benefit in Hb levels above 95 g/L for babies aged 8 months. A study reported that young children in Costa Rica aged 12-23 months with Hb < 100 g/L had lower mental and motor development scores compared to those with Hb > 100 g/L after putting into consideration factors relating to birth, nutrition, family background, parental IQ, and the home environment. However, children with Hb > 100 g/L to 105 g/L had similar mental and development scores compared to those with Hb > 105 g/L⁷.

It is evident from the discussion above that the most valid haemoglobin interpretive criteria for determining anaemia in infants has not been well established. However, the accumulating evidence suggests that a lower value than the current WHO recommendation, at least for infants 6-12 months, should be used. This would represent the physiological lower limit of the normal range, and importantly with no adverse effects on cognitive or motor development.

Africa's Magnitude

The high incidence of anaemia is a serious public health concern in most African nations. Pregnant WRA is the second most common cause of anaemia in Africa, after children under the age of five⁸. Pregnant women (56%) and non-pregnant WRA (48%) from Central and West Africa have the highest rates of anaemia. In East Africa, the second-highest prevalence of anaemia (40%) was found in non-pregnant women.

The prevalence of anaemia among teenagers from these areas has decreased over time. The prevalence decreased in 2017 from 52% to 48% in Central and West Africa, from 40% to 28% in East Africa, and from 33% to 28% in Southern Africa respectively⁸.

Magnitude in Nigeria

The prevalence of stunting, thinness, vitamin A, and iron deficiencies among teenage students in Nsukka, Nigeria, as well as the factors linked to these nutritional issues, were determined by a recent study. 400 participants in all were chosen at random from 717 students in three randomly chosen secondary schools, ages 12 to 18. Anthropometric measurements, blood analyses, and questionnaires were used to gather data. 31.0% of people were thin, and 33.3% of people were stunted. Obesity and overweight were not noted. 44.0% had vitamin A deficiency (VAD), and 64.0% were anaemic. A total of 40% had anaemia + VAD, 42% had VAD + thinness, and 48.0% had both anaemia and stunting. Vitamin A status was predicted by household income. Compared to children from low-income households, children from medium- and high-income households were more likely to have VAD (AOR=0.14; 95% CI=0.031, 0.607; P=0.009). Height-for-age status was independently determined by household income (AOR=0.12; 95% CI=0.021, 0.671; P=0.016) and age (AOR=0.09; 95% CI=0.014, 0.587; P=0.012)¹⁰.

According to a systematic review, among children ages 0 to 19 from four countries, the WAVG prevalence of anaemia ranged from 25% to 53%, iron deficiency from 12% to 29%, vitamin A deficiency (VAD) from 14% to 42%, zinc deficiency from 32% to 63%, and iodine deficiency from 15% to 86%. In general, compared to children aged 5 to 19, children under the age of five had higher prevalence of anaemia (32%–63%), VAD (15–35%), and zinc deficiency (35%–63%). Inadequate intakes varied from 51% to 99% for zinc, 13% to 100% for iron, and 1% to 100% for vitamin A according to studies with the intake of data ¹¹.

According to a recent study conducted in Nigeria, less than 1% of the population is anaemic, with a prevalence of 21.7% among non-pregnant women of reproductive age. The prevalence of anaemia in pregnant women was 42 percent¹⁰. The prevalence of anaemia among women of reproductive age rose from 45% to 59% between 2003 and 2008, then fell to 42% in 2014. In Nigeria, the prevalence of anaemia decreased between 2014 and 2017. Anaemia has dropped from 41.3% to 21.7% in non-pregnant women and from 44.6% to 42% in pregnant women¹². In Nigeria, anaemia in non-pregnant women is now considered a moderate public health issue rather than a serious one. But even with the decrease, the anaemia rate among pregnant women is still a serious public health issue ¹⁰.

Age, educational attainment, place of residence, and household wealth do not significantly affect the prevalence of anaemia among non-pregnant women in Ghana. However, compared to women in the Southern (23.9%) and Northern (27.6%) belts, the middle belt has the lowest prevalence of anaemia (17.5%)¹¹.

2.1.2 Consequences of Anaemia

It is well known that anaemia negatively affects people's health and well-being, particularly in women and children. Among women of reproductive age, anaemia raises the risk of low birth weight and an early delivery. Performance and work rate are impacted when anaemia is more common in women of reproductive age.

It is also thought to affect the outcomes of pregnancies in women and the unborn child, which has a significant detrimental influence on people's health, economic potential, and community development. It is estimated that iron deficiency-related anaemia alone results in over 90,000 deaths in males and females of all ages. According to estimates for ten developing nations, the combined economic losses from decreased productivity at work and cognitive decline came to nearly \$17 per person ¹³.

Mortality among mothers and children

A higher risk of maternal and infant mortality is associated with anaemia. According to a meta-analysis of roughly 12,000 children in six African nations, a 1g/dL increase in haemoglobin concentration reduces the risk of death by 24%¹¹. Maternal anaemia was found to be a risk factor for low birth weight in a systematic analysis to ascertain the relationship between the two conditions ¹¹. According to a study done in Nigeria, 117 (83.6%) of the 140 severely anaemic children under the age of five who were enrolled in the study recovered, while 19 (13.6%) died¹⁴. Among the children in this study, coma ($P < 0.001$), tachycardia ($P = 0.033$), malnutrition ($P = 0.02$), and not receiving blood transfusions were the factors linked to higher mortality ($P = 0.001$)¹³. In a different study, 305 pregnant women with iron deficiency had a 5.24% mortality rate. Additionally, these women were more likely to experience complications like antepartum haemorrhage (16.06%) and renal failure (15.73%) as a result of the iron deficiency¹⁵.

Reduced Development of Cognition

Research indicates that iron deficiency may put teenagers at higher risk for cognitive changes¹⁶. Women aged 18 to 35 who were categorized as iron sufficient (control group), non-anaemic but with iron deficiency (ID group), or with iron deficiency anaemia (IDA group) participated in a blinded, placebo-controlled study.

At baseline (n=149) and four months into the experiment (n=113), participants' cognitive abilities were evaluated using eight (8) cognitive performance tasks (Detterman's Cognitive Abilities Test). At baseline, the control group outperformed the adolescents with iron-deficient anaemia on cognitive tasks ($p < 0.011$) and completed them more quickly ($P < 0.038$). Following treatments, there was a notable increase in serum ferritin and a five to seven-fold improvement in cognitive function. Additionally, a notable increase in haemoglobin concentration was positively correlated with the speed at which cognitive tasks were completed¹⁶. Similar findings were found in another study involving primary school-aged girls, where the non-anaemic girls performed noticeably better on a number of cognitive function tests, even after adjusting for under nutrition.

Anaemia may have an impact on a child's cognitive development. Iron deficiency anaemia has a detrimental impact on children's behaviour, motor skills, and cognition, with those from low socioeconomic backgrounds being particularly affected, according to a secondary data analysis on the subject that focused mostly on the last 15 years¹⁷. In contrast to the study mentioned above, a study done on 916 pre-schoolers to evaluate the effects of anaemia and body mass index (BMI) on neuromotor development found that mild anaemia positively correlated with a child's neuromotor development, while being overweight or obese negatively correlated with it.

However, the lack of moderate or severe anaemia in the study participants was a significant limitation that could have demonstrated the beneficial effects of anaemia on neuromotor development¹⁵. Another study found that when compared to children who were not anaemic, children who were anaemic between the ages of two and six showed worse language development. 44 children served as controls in this cross-sectional study, meaning they had no anaemia, and 22 children served as cases, meaning they had anaemia. The two groups' language evaluations were found to differ significantly in every section. At $p < 0.001$, the controls' cognitive performance score (77) was higher than the cases' (45).

Additionally, there was a significant difference ($p < 0.02$) in the reception performance score¹⁶ between the anaemic group (75) and the non-anaemic group (100). Iron-rich proteins and enzymes play a major role in the development of the central nervous system (CNS). This suggests that iron deficiency may impact brain development in a number of ways¹⁸.

Low Productivity at Work

Iron deficiency anaemia is known to have a significant impact on people's physical working capacity. The impact of iron deficiency (ID) and anaemia on the physical and cardiorespiratory fitness of Indian women employed in small-scale industries was demonstrated by a study. 600 non-pregnant, non-lactating women (NPNL) between the ages of 18 and 55 participated in the study.

Two hundred women were split up into three groups: control, ID, and anaemic. The Queens College step test (QCT) and the calculation of their maximum oxygen uptake (VO_2 max) were used to determine their physical fitness index (PFI). The average VO_2 max for the participants

with ID was 40.24 ml/kg/min, the average for the women in the anaemic group was 38.65 ml/kg/min, and the highest was 45.53 ml/kg/min for the control group. It was proposed that anaemia and ID both affect how well oxygen reaches the tissues, which lowers VO₂ max and influences physical activity levels¹⁹.

To determine whether iron and energy supplements increase the physical work capacity of female students aged 16 to 20, another study was carried out.¹⁵ Participants in the study were divided into two groups: those who were anaemic but had sufficient energy and those who were anaemic but had insufficient energy. To raise their haemoglobin levels to 12 or higher, both groups received iron supplements for nine months. Based on the energy difference between the two groups, the energy-deficient group was also given energy supplements. Following the administration of iron supplements and both iron-energy supplementation, exercise duration and maximum workload increased significantly ($p < 0.01$) in both groups¹². These findings were consistent with a study that found that teenage girls between the ages of 9 and 14 who were not anaemic were able to walk more and recover more quickly than those who were. The girls were given a set of five steps to climb up and down in three minutes in order to evaluate this. In the three minutes, girls who were moderately anaemic climbed an average of 165 steps, whereas those who were not anaemic climbed an average of 175 steps. The recovery time was significantly longer for anaemic girls (3.69 minutes) than for non-anaemic girls (2.55 minutes on average; $p < 0.001$)¹³.

2.1.3 Causes of Anaemia

Anaemia has a variety of causes, including both non-nutritional and nutritional ones. Nutrient deficiencies brought on by inadequate food intake and eating disorders are the primary nutritional causes of anaemia. Non-nutritional factors are thought to be responsible for at least half of all cases of anaemia worldwide. Blood loss from injury or specific physiological states (e.g., menstruation in women), chronic inflammation, infection, and disease, as well as drug toxicity, are examples of non-nutritional factors that contribute to anaemia¹⁶.

2.1.3.1 Nutritional Causes of Anaemia

Anaemia Due to Iron Deficiency

A form of anaemia known as iron-deficiency anaemia is defined by a lack of iron necessary to make haemoglobin, which carries oxygen throughout the body¹³. Iron deficiency anaemia (IDA) is thought to be the cause of about half of all anaemia cases worldwide. A review claims that this figure is inflated and that the actual level of iron deficiency is lower than anticipated. The percentage of anaemia caused by iron deficiency was approximately 25% among children and 37% among women of reproductive age, according to the findings of 25 nationally representative studies that assessed ID, IDA, and anaemia in children (6–59 months) and women of reproductive age (15–49 years) from all over the world between 2003 and 2014. Countries with a severe burden of anaemia had a significantly lower proportion of anaemia linked to ID for both groups¹⁷. Iron deficiency affected about 14% of women of reproductive age who were not pregnant. Reduced cognitive development and work capacity are two characteristics of iron deficiency anaemia. It has been demonstrated that taking iron supplements helps women's cognitive function and increases their levels of physical activity. Iron deficiency anaemia is accompanied by signs and symptoms like headaches, brittle nails, dizziness, weakness, and an

easy way to get tired¹⁷.

Menstruation, pregnancy, and lactation put women of reproductive age at higher risk for iron deficiency anaemia. Pregnancy-related iron deficiency anaemia is brought on by a higher plasma volume (30–40%) than haemoglobin mass and red blood cell volume (20–25%). As a result, Hb levels fall, which raises the amount of oxygen that is transported to the foetus and the placenta, raising the need for iron¹⁸.

Iron deficiency anaemia can also result from consuming insufficient amounts of iron-containing foods. Iron from animal sources has been shown to be more easily absorbed than iron from non-haem sources, which are usually derived from plants. This indicates that the bioavailability of iron in food varies. In Northwest Vietnam, 354 women of reproductive age participated in a study to determine the extent to which meat consumption affects anaemia status.

Iron deficiency anaemia was prevented by eating meat three or more times a week, according to logistic regression analysis. $p=0.002$, OR 0.46 (0.28, 0.76)¹². Various substances and cooking techniques can either increase or decrease the bioavailability of iron in food. Vegetables' iron bioavailability is increased by boiling. Iron absorption is enhanced by the addition of vitamin C or by cooking with vitamin C-rich vegetables like tomatoes. However, chemicals like phytic acid and polyphenols reduce the bioavailability of iron. The association between green tea, coffee, and the serum ferritin levels of Korean adults was examined using data from the Korean National Health and Nutrition Examination Survey (2007–2012). Data on 24-hour recall and food frequency were utilized to assess their intake.

Coffee consumption was negatively correlated with serum ferritin concentration for both males and females when multivariate linear regression was used to control for age, BMI, educational attainment, smoking status, physical activity, alcohol consumption, hypertension, diabetes mellitus, and daily iron intake. Among those who consume three or more cups of coffee in a day, serum ferritin levels dropped by 8.4% in men and 18.8% in women¹⁷.

Anaemia Due to Folic Acid and Vitamin B12 Deficiency

Anaemia is caused by insufficient folate and vitamin B12 in addition to iron deficiency. These two vitamins are essential for numerous bodily cellular functions. Megaloblastic anaemia is the type of anaemia that results when one or both are insufficient. A folate and vitamin B12 deficiency impairs DNA synthesis, which results in megaloblastic anaemia. Both vitamin B12 and folate deficiencies in humans can be identified by measuring the plasma homocysteine level. Increased serum homocysteine levels are a sign of megaloblastic anaemia's advanced effects, which include memory and vision loss. Pernicious anaemia is the term for megaloblastic anaemia brought on by a vitamin B12 deficiency. It is mostly brought on by a lack of intrinsic factor, which is in charge of absorbing vitamin B12, or by inadequate vitamin B12 intake from the diet¹⁷. 50 patients with megaloblastic anaemia and 50 patients without megaloblastic anaemia (control) had their serum levels of homocysteine, vitamin B12, and folate compared. Of the 50 patients with megaloblastic anaemia, 40 (80%) had extremely low levels of vitamin B12, and 44 (88%) had extremely low levels of folate. Just two (four percent) and twelve (24 percent) of the fifty control patients, respectively, had low levels of vitamin B12 and folate. Eighty percent of

patients with low serum levels of vitamin B12 and folate had high serum homocysteine levels¹⁷. Megaloblastic anaemia is widespread, but not enough is known about how common it is globally. In nations where malnutrition is a serious issue, its burden is high. Pregnant women and the elderly also have higher prevalence's¹⁸. Using data from the 2011 national-level secondary survey, the prevalence of megaloblastic anaemia among Pakistani women of reproductive age (n=22,278) was examined in 2017. Serum levels of vitamin B12 and folate were measured using an electrochemiluminescence immunoassay technique. There were 8,400 (52.4%) and 8,371 (50.8%) women who were deficient in vitamin B12 and folate, respectively. Compared with women who ate eggs monthly, those who ate eggs daily and weekly had lower odds of having folate deficiency (RR 0.89; 95% CI 0.81, 0.98; P=0.02 and RR 0.88; 95% CI 0.78, 0.99; P=0.03, respectively). The risk of folate deficiency anaemia was also found to be reduced by increasing consumption of green leafy vegetables, which are well-known to be good sources of folate¹⁸.

2.1.3.2 Non-Nutritional Causes

Infections and Infestations

Anaemia can be brought on by illnesses or infections in a variety of ways. Infections may affect metabolism and absorption. Anaemia can also be brought on by infections through blood loss, dietary deficiencies, and drug side effects. Anaemia can result from both acute and chronic infections, including cancer, HIV, TB, malaria, and chronic heart failure. Chronic infections typically result in anaemia through a decrease in serum iron, a reduction in total iron-binding capacity, and a decrease in the percentage of transferrin saturation brought on by reticuloendothelial siderosis. Depending on the disease type, multiple mechanisms may be at

work simultaneously, but the primary mechanism is the reticuloendothelial system. The brief rise in hepcidin¹⁸ is the cause of all the processes involved¹⁸.

Infections Caused by Soil-Transmitted Helminths

In areas with inadequate sanitation, soil is contaminated by soil-transmitted helminth infections, which are typically spread by human faecal eggs. Soil-transmitted helminth affects more than 1.5 billion people worldwide. Around 800 to 1 million, 600 to 800 million, and 500 to 700 million people worldwide are infected by roundworms, whipworms, and hookworms, respectively ¹². Hookworm infections are the primary cause of iron deficiency anaemia, blood loss, and iron deficiency. Iron and protein are lost as a result of the worms' eventual consumption of host tissues, including blood. Anaemia may result from hookworms' chronic intestinal blood loss¹³. According to reports, each hookworm (*Ancylostoma duodenale*) can lose 0.25 millilitres of blood in a day. Depending on the host's iron status, a hookworm load of 40–160 worms is linked to iron deficiency anaemia. Due to their low iron stores, young children and women of reproductive age are most at risk of developing hookworm-related iron deficiency anaemia.

To ascertain the prevalence of intestinal helminthic infection and anaemia in Oromia, Ethiopia, a study was carried out among pregnant women receiving prenatal care. By taking a single stool sample and looking at it under a microscope, intestinal helminthic infection was evaluated. Anaemia was present in 17.5% of the patients. Intestinal helminth infections affected nearly 25% of the 372 pregnant women. The most common intestinal helminth infection was hookworm (15.1%), which was followed by roundworm (6.5%). The only factors that were significantly linked to anaemia after controlling for confounders like residence, age, educational attainment,

food diversity, birth interval, and other independent variables were gestational age ($p=0.009$), history of malaria infection within the previous year ($p=0.003$), and irregular iron use ($p=0.022$). Additionally, pregnant women with roundworm infection [AOR, 95% CI: 1.82 (1.1, 3.8), $P=0.022$] and hookworm infection [AOR, 95% CI: 3.53 (1.6, 6.7), $P=0.001$] had a high prevalence of anaemia¹⁹.

This conclusion was supported by the findings of a different study that involved teenage girls attending school in an urban area of Tamil Nadu, India. The odds of anaemia were 2.84 times higher for female students who had intestinal parasite infection [OR, 95% CI: 2.84 (1.19, 6.76), $P=0.014$]²⁰.

Malaria

The WHO estimates that over 219 million cases of malaria were reported worldwide in 2017, resulting in about 400,000 fatalities. Anaemia was the direct or indirect cause of a sizable number. Plasmodium falciparum is the primary cause of malaria in the WHO African Regions, accounting for about 90% of all cases. Worldwide, malaria is recognized as one of the major causes of anaemia. Children and pregnant women are particularly at risk, particularly in regions where malaria is highly prevalent. Reduced red blood cell production and red blood cell destruction are both factors in malaria-related anaemia. Other variables that affect its ability to cause anaemia include the individual's age, pregnancy status, genetic composition, antimalarial immune status, and the malaria endemicity in the area.

Within a year (May 2021 to May 2022), observational studies were conducted on hospitalized children under five years old to estimate the prevalence of anaemia and malaria parasites in

Uganda. Every three months, finger-prick blood samples were used for HIV testing, haemoglobin concentration measurements, and blood smears as part of the study. The rates of anaemia and malaria parasitemia were 56.3% and 54.6%, respectively. Compared to children without parasitemia (10.0 g/dl), patients with parasitemia had an average haemoglobin level that was significantly ($p=0.001$) lower (8.3 g/dl). Once more, 76.8% of all paediatric cases of severe anaemia were linked to malaria parasitemia²¹.

Genetic Illnesses

A number of genetic disorders can also result in anaemia. Alpha and beta thalassemia, sickle cell disease, and haemoglobin E are examples of genetic blood disorders that affect haemoglobin concentrations and are referred to as haemoglobinopathies. A class of hereditary diseases known as haemoglobinopathies is distinguished by aberrant haemoglobin molecule production or structure²². Red blood cells (RBCs) in sickle cell disease have a different shape than healthy normal RBCs, which are typically smooth and resemble donuts. Sickled red blood cells cannot flow through blood vessels. Instead, they create obstructions that prevent oxygen-carrying blood from reaching other tissues and organs. People with ancestry from sub-Saharan Africa, parts of the Western Hemisphere, India, Saudi Arabia, and some other Mediterranean nations are more likely to have sickle cell disease. People in the Mediterranean, Middle East, Africa, and Southern Asia are most likely to have thalassemia. When genes governing the formation of the alpha and beta globin chains are absent or malfunctioning, thalassemia develops, resulting in aberrant haemoglobin with decreased oxygen-carrying capabilities. Alpha and beta thalassemia are the

most common inherited single genes worldwide in regions where malaria is endemic²¹. According to research, thalassemia may cause delayed puberty and the development of secondary sexual traits in females by interfering with the normal function of hormones like progesterone, oestrogen, and luteinizing hormone.

Anaemia caused by genetic haemoglobin disorders was a stronger predictor of anaemia than iron deficiency, according to a specific study conducted in 2012⁷⁹. The study's objective was to look into the variables linked to anaemia in 450 reproductive-age rural Cambodian women. A genetic haemoglobin disorder involving 25 distinct gene variants affected more than half of the study participants (54%) in some way. Thalassemia trait (11.6%) and haemoglobin E trait (14.9%) were the two most prevalent genetic haemoglobin disorders that affected them⁷⁹. Anaemia was most accurately predicted by haemoglobin E homozygous disorder 95% of the time. Pregnancy status 95% CI -11.99 (-15.60, -8.39), $P < 0.0001$, and CI -18.24 (-21.74, -14.73), $P < 0.0001$.

Women with genetic haemoglobin disorders were more likely to have anaemia (~45%) than women without any disorder (~11%). According to a global review, haemoglobin disorders were present as a major health issue in 71% of 229 countries. More than 300,000 babies are born with haemoglobin abnormalities, of which 83% have sickle cell anaemia and 17% have thalassemia. Significant genetic haemoglobin disorders are thought to be carried by more than 7% of expectant mothers⁸⁰.

Inflammatory Anaemia

Anaemia of inflammation, sometimes referred to as anaemia of chronic disease (ACD), is a form of anaemia that typically affects individuals who have inflammatory chronic illnesses, such as cancer, autoimmune diseases, or infections. After iron deficiency anaemia, it is thought to be the second most common cause of anaemia worldwide. Any age group can be affected by anaemia of inflammation, but older people are more vulnerable because they are more likely to develop chronic inflammation-causing diseases. It is possible to have a low iron level on your blood with this type of anaemia even though your body tissues have a normal or even higher amount of iron stored in them¹⁶.

Because of the inflammation, the body may not be able to use the irons that are stored, which can result in anaemia. Chronic disease-related anaemia has no known cause, but it can coexist with other illnesses. It could be brought on by the hormone erythropoietin or by a reduction in the chances of red blood cells surviving¹⁶. The cytokines that cause chronic inflammation disturb iron homeostasis, which lowers erythropoietin's sensitivity to low haemoglobin levels and alters bone marrow's sensitivity to erythropoietin.

Anaemia has been connected to a number of inflammatory diseases, particularly in the elderly. A recent study involved 191 consecutively hospitalized elderly patients with iron deficiency anaemia and chronic disease anaemia (56 IDA and 135 ACD). Of the patients with ACD, 96 (71%) had acute infections, including gastrointestinal, urinary, and respiratory tract infections; 12 (12.3%) had cancer diagnoses, including colon, prostate, and other cancers; and 22 (16%) had autoimmune inflammatory diseases, including rheumatoid arthritis, gout, and others¹⁷.

Cancer patients are more likely to develop anaemia as a result of inflammation. Anaemia was found to be 63.4 percent common in 888 cancer patients in a prospective observational study conducted between 2011 and 2014. The authors found that the type of cancer had a significant impact on the mean haemoglobin concentration. For example, patients with breast cancer had the highest mean haemoglobin concentration (12.1 ± 0.2), while those with ovarian cancer had the lowest (10.9 ± 1.8). Once more, patients with advanced cancer stages (stages 3 to 4) had a higher prevalence of anaemia. This was further highlighted by the fact that patients with advanced cancer had higher levels of inflammatory markers, such as C-reactive protein (CRP), fibrinogen, interleukin 1 beta (IL-1 β), interleukin 6 (IL-6), tumour necrosis factor alpha (TNF α), reactive oxygen species (ROS), and erythropoietin¹⁸.

Table 2.2: Current WHO thresholds for serum ferritin and soluble transferrin receptor concentrations in population surveys (not including pregnant women)

% Serum Ferritin Values	% Soluble Transferrin Receptor Values	Interpretation
Before Threshold	Above Threshold	
<20	<10	Iron deficiency not prevalent
<20	>10	Iron deficiency prevalent Inflammation is prevalent
>20	>10	Iron deficiency prevalent
>20	<10	Iron depletion is prevalent

Source ²³: Adapted from assessing the iron status of populations

Another measure of iron deficiency that has been used is zinc proporphyrin. In iron deficiency, zinc is incorporated into proporphyrin instead of iron, generating ZPP instead of haems. As a result, ZPP levels increase in iron deficiency. Iron deficiency has previously been evaluated using serum iron and total iron binding capacity, which are used to calculate transferrin saturation levels. Serum ferritin and sTfR values can also be used to calculate total body iron, which is based on the ratio of serum transferrin receptor to serum ferritin.

Most recently, assays of serum, plasma or urinary hepcidin concentrations by ELISA or immunoassay for pro-hepcidin are being performed to measure depletion of iron reserves. However, reference limits, assay methods and interpretation of the hepcidin measures are still under development. In populations where a high proportion of subjects have genetic haemoglobin disorders, some of these biomarkers are affected, notably sTfR, which is elevated

in certain genetic Hb disorders. Hence, interpretation of sTfR values in those affected is difficult, and their subsequent use for calculating total body iron, yields estimates that are not valid

2.1.4 Sources of Iron-rich Foods

Animal Sources: These are good sources of dietary iron because they contain heme iron which is more easily absorbed in the intestine. Animal foods that originally contained haemoglobin contain haemoglobin, which is the source of heme iron²⁴. Examples of animal sources are red meat, liver, kidney, chicken, turkey, pork, tuna, sardine, shell fish, etc.

Plant Sources: In plant foods, iron is not attached to the heme protein and is classified as non-heme iron, which is not readily absorbed in the intestine¹⁷. Examples of plant sources are grains, legumes, and leafy green vegetables. Absorption of non-heme iron can be increased by incorporating foods and substances that aid with iron absorption, a good example of this is Vitamin C²⁴.

Iron-Fortified Foods: Production of iron-fortified foods is an economic, sustainable, and long-term strategy to prevent iron deficiency²⁴. A prerequisite for the formulation of iron-fortified foods is that they deliver adequate iron content within the recommended dietary standard. The panacea of iron deficiency through iron-fortified foods is ensuring high bioavailability, avoiding negative effects on physicochemical and sensory properties of food vehicles, and ensuring ready absorption of iron by the human body. From the industrial production perspective, the food matrix used as the vehicle of iron should have three important characteristics:

1. mainstream food product commonly used by consumers;
2. maintains excellent organoleptic properties after iron fortification;

3. affordable ²⁵.

Additionally, the iron-fortified foods should ideally possess the two functional qualities listed below:

- 1) high bioavailability;
- 2) a safe or easily accessible source.

Different nations have different laws governing foods fortified with iron. The highest amounts of ferrous sulphate that can be added to cocoa powder, baby food, and salt in China are 11–12 mg/kg, 300–500 mg/kg, and 3000–6000 mg/kg, respectively. In a similar vein, China allows a maximum of 4800–6000 mg/kg of gluconate in salt. The highest amount of ferrous gluconate that can be added to edible olive oil in Japan is approximately 150 mg/kg²⁶. Therefore, it's critical to adhere to the food standards of the nations where iron-fortified foods are made and sold.

One of the most efficient ways to treat iron deficiency is to consume iron-fortified staple foods. The main barrier to increasing consumption of this type of food is the presence of phytic acid, which inhibits iron absorption²⁷. One of the most accessible staple foods is rice, which is a suitable food vehicle to carry iron and alleviate insufficient iron intake. Ferritin-fortified parboiled rice (I-rice) had a significantly higher iron content and its bioavailability than unparboiled and parboiled rice. Subsequent research showed that continuous intake of I-rice (18 mg ferrous sulphate per 100 g rice) was able to improve haemoglobin and haematocrit content in women with iron deficiency anaemia ²⁷.

The effectiveness of this strategy is anticipated to be significantly impacted by the consumers' age, gender, degree of education, and capacity to purchase I-rice kernels. According to a

Philippine survey, iron-fortified rice and iron rice premixed with regular rice at a 1:250 ratio could supplement iron at a moderate rate of acceptance ²⁹. Noodles, steamed buns, and dumplings, as well as bread and cake, are all made with wheat flour.

A study investigated the impact of fortifying wheat flour with various iron-rich components. These authors included electrolytic iron (60 mg of iron per kilogram), FeSO₄ (30 mg of iron per kilogram), and NaFeEDTA (20 mg of iron per kilogram) into wheat flour. The largest body iron store was attained by NaFeEDTA-fortified flour after six months of feeding, followed by FeSO₄ and electrolytic iron flours³⁰. The inclusion of NaFeEDTA was linked to a decrease in the prevalence of iron insufficiency, according to another study that gave children iron-fortified whole maize flour ³¹. Iron-fortified finger millet demonstrated how EDTA and ferrous fumarate or ferric pyrophosphate might work in concert to significantly increase the bioavailability of zinc and iron. When EDTA was present, the bioavailable iron content in ferrous fumarate supplemented sorghum flour (6 mg iron per 100 g wheat) was significantly higher (iron: EDTA=1:1) ³².

Iron's bioavailability in the ferrous fumarate and EDTA combination was four to five times greater than that of the ferrous fumarate and folic acid groups alone, and six times greater than that of the unfortified control. Nevertheless, it was discovered that this boosting or synergistic impact diminished with storage time ³¹.

Bakery Goods

Around the world, biscuits are widely accepted by the public and have a long shelf life. Two types of iron-fortified biscuits can be distinguished:

1) sandwich biscuits that incorporate iron-boosting substances into the cream, and 2) biscuits made with fortified flour. According to a Brazilian survey, 20–30% of children's RDI iron, 9.5–14% of adults', and 5-7.2% of pregnant women's iron intake came from biscuits made from iron-fortified flour³³.

The prevalence of iron deficiency anaemia in preschool-aged children was also decreased by using biscuits made with bovine liver, which is high in heme iron ³⁴. The amount of phytate in bread made with whole grain rye is comparatively low. Regular use of iron-fortified whole grain rye bread was found to stabilize the iron concentration of women aged 20 to 38³⁴. The iron supplementing effects of various iron-rich (supplementing) substances, including iron sulphate monohydrate, ferrous fumarate, reduced iron, and NaFeEDTA, varied significantly, according to a study done on French bread made with refined wheat flour. The French bread with NaFeEDTA added had the highest iron supplementing efficacy ³⁴. Additionally, bread with NaFeEDTA added has sensory qualities that are comparable to those of bread without it ³³. Using microencapsulated components with iron at the core can further improve the quality of iron-fortified bread. It has been demonstrated that products utilizing microencapsulated iron have increased levels of iron and its bio-accessibility in the gastrointestinal tract ^{33, 34}. The bio-accessibility of iron in fortified bread was enhanced by 80% and 84%, respectively, by using microencapsulated ferrous sulphate and ferrous lactate. A common ingredient in ice cream, biscuits, cakes, sweets, and pastries, margarine has a bright yellow look, a consistent texture, and a delicate, pleasing flavour. In one study, ferric pyrophosphate or NaFeEDTA were added to

margarine to create iron-fortified margarine (14 g iron per 1 kg margarine). According to the authors, margarine supplemented with NaFeEDTA had a body iron reserve rate that was two to three times more than that of margarine treated with ferric pyrophosphate⁸³.

Dairy Goods

The main source of protein, calcium, phosphorus, and vitamins is dairy products; however, their iron level is too low to be supplemented²⁵. It is demonstrated that both goat and cow milk may be fortified with iron using the Caco-2 cell model and in vitro digestion³⁵. A moderate amount of ascorbic acid can be added to dairy products to boost their iron bioavailability³⁶. It was discovered that infants up to 18 months old could benefit from iron supplements from cow milk that has been

enriched with iron (10mg/L). Iron, on the other hand, showed the same supplementing effect as zinc-containing milk (5 mg/L)³⁵. Because of its appealing colour and rich scent, iron-fortified chocolate milk was also discovered to be a useful product for reviving children's iron stores³⁷.

Given that breast milk has a low iron content (0.25-0.35 mg daily), it makes sense to provide infant formula products that are enriched with iron. A healthy balance of proteins, lipids, carbs, minerals, and vitamins can be found in infant milk powders (IMF), which are produced and prepared to meet the developing needs of newborns at various growth stages. The organoleptic properties of a typical unfortified IMF powder should be preserved in an iron-fortified IMF powder³⁸.

The iron fortified IMF should dissolve in water with ease, just as the unfortified IMF. The risk of diarrhoea is the most significant obstacle to be addressed with iron-fortified formula products. Diarrhoea is a constant concern associated with iron-fortified IMF products. In general, the safest

dosage for iron supplementation is the lowest amount (2.5 mg daily). However, it is advised to take 12.5–15 mg daily to restore iron³⁶. Diarrhoea and intestinal inflammation may result from the replenishing iron dose's detrimental effects on gut bacteria and iron absorption. According to research, two-week-old babies showed good tolerance to the iron-fortified formula containing 0.6g/L of bovine lactoferrin³⁶.

Yogurt and other fermented dairy products can help prevent the growth and spread of bacteria that cause spoiling in the digestive system. According to a study conducted on school-age children in Bangladesh, iron-fortified yogurt can provide three-tenths of the daily dose of iron that is recommended³⁷. Because it aids digestion and encourages gastrointestinal peristalsis, yogurt is also an excellent way for lactose intolerant patients to augment their iron intake.

One drawback of iron-fortified yogurt is the potential for certain yogurt ingredients to react with iron-carrying (fortifying) ingredients³⁷. The development of encapsulation and nanomaterial technologies offers a solution to this issue. It was demonstrated that the yogurt enhanced with iron oxide nanoparticles (encapsulated in inulin) had superior acidity, density, and colour when compared to conventional iron-fortified yoghurt. In a similar vein, a novel kind of yogurt with iron contained in niosomes demonstrated favourable iron augmenting effectiveness.

Beverages

A specially designed micronutrient-fortified beverage reduced the prevalence of iron deficiency anaemia in Tanzanians by 56%. Vitamin A (1050 µg, retinol equivalents), iron (10.8 mg), iodine (90 µg), zinc (10.5 mg), ascorbic acid (144 mg), riboflavin (1.2 mg), folic acid (280 µg), VB12 (6 µg), VB6 (1.4 mg), niacin (10 mg, niacin equivalents), and VE (21 mg, alpha-tocopherol

equivalents) 38 were the micronutrients included in this fortified beverage. Additionally, school-age youngsters really liked the iron-fortified beverage.

School-age children (grades 1-6) with iron and iodine deficiencies benefited from a fortified fruit powder beverage (4.8 mg iron and 48 µg iodine per 25 g beverage powder), according to a research conducted in the Philippines. The patients' iron storage, iodine status, cognitive function, and physical fitness all improved after consuming 200 cc of this beverage twice daily⁸². Similarly, coffee, which was first introduced in America in 1977, and iron-fortified orange juice were also effective ways to restore iron in pre-schoolers in Brazil⁸³.

Condiments

It is easy to fortify table salt with iodine and iron. Iodine deficiency may now be controlled and eradicated at a minimal cost thanks to salt iodization initiatives. It is simple to create iron-iodine double-fortified salts. It is now possible to supply iron in isolated and impoverished places by using salt as the carrier ⁵⁸.

Adding iodine and ferrous fumarate microencapsulated into regular salt is a very tenable strategy. By using this method, the interaction between iodine and iron is avoided. Additionally, it lengthens the storage duration and enhances bioavailability.

Iron fortification, which allows for high bioavailability of iron, can also be accomplished with soy sauce. It has been demonstrated that soy sauce supplemented with NaFeEDTA may shield consumers from iron deficiency anaemia. Consumption of iron-fortified soy sauce and related goods is also influenced by customers' educational attainment, with nutritionally conscious consumers more likely to purchase iron-fortified items, such as soy sauce³⁹.

A new seasoning product called monosodium glutamate (MSG) improves the inherent flavour of food, particularly meat and vegetables. Adults' haemoglobin levels were shown to rise when monosodium glutamate was consumed. As a result, adding iron to MSG may increase its effectiveness in a synergistic way.

Snacks

Sugar was utilized to make iron-fortified foods as early as the 1970s. The study mixed 1 kilogram of sugar with 10 g of ascorbic acid and 1 g of ferrous sulphate. When compared to maize porridge cooked with unfortified sugar, the authors found that the fortified sugar could quadruple the absorption of iron. Additionally, adding ascorbic acid to the formulation enhanced the rate of iron absorption by at least three times³⁹. The effectiveness of double-blind sugar was examined, using 130 mg of iron (1 g NaFeEDTA per 1 kg sugar) and 15 mg of vitamin A (15 mg retinol per 1 kg sugar) as iron enhancers.

Even though the sugar supplemented with NaFeEDTA had a yellow colour, customers still found it acceptable, and it was successful in lowering the incidence and prevalence of anaemia. Candy is one of the most popular treats among kids because of its sweet flavour, appealing shapes, and reasonable price. According to a study, the prevalence of anaemia decreased by around 82%⁴⁰ in children aged 4-6 who received ten candies (3 mg iron each candy) per person every week for about three months.

Jellies have a pleasing look, vibrant colour, and a smooth, gentle flavour. It is especially popular among kids and teens as a semi-solid dessert. A 2.5-month trial was carried out in Indonesia to find out how well jelly delivered iron to teenage girls with moderate anaemia. Agar flour and iron-fortified snake fruit seed flour were used to make the jelly. It was discovered that this

fortified jelly was effective in providing iron along with other micronutrients like zinc, ascorbic acid, and iron ⁴⁰.

Additional Iron Fortification Vehicles

There are numerous other food items that can be used for iron fortification in addition to the ones mentioned above; however, they might require additional functionalization. For example, combining iron with probiotic bacteria (*Lactobacillus casei*) can enhance the bio-accessibility of iron and the sensory qualities of the iron-fortified pumpkin by around three to four times. For iron fortification, egg white and egg yolk can be a suitable option. Fortifying the hen's feed could improve the nutritional value of eggs by raising the iron content of the yolk and egg white⁴¹. Iron supplements (iron soy protein chelates) were shown to significantly increase the hatchability and iron content of egg yolks when added to hen feed⁴¹.

Iron fortification can also be applied to meat products. Although the amount of heme iron in meat products varies by species, cooking techniques seldom ever have an impact on it. An investigation into the absorption of iron in beef pâté cans (15 mg iron from enhancer) that contain ferrous sulphate and liposome-encapsulated ferric pyrophosphate. Like a hamburger, meat pâté was sandwiched between two pieces of bread. According to the scientists, iron was effectively delivered by the pork pâté enriched with ferric pyrophosphate encapsulated in liposomes.⁴² Likewise, sausages, particularly those that are doubly fortified with calcium and iron, can serve as effective delivery systems for iron ⁴².

2.1.5 Recommended Dietary Allowance for Iron

Iron is needed by newborns, children, adolescents, and adults to meet their growth and development demands. Age and gender-specific iron requirements exist, and they outline the absolute daily needs of these populations²⁴. Table 3 displays the recommended dietary intake for iron.

Table 2. 3: Recommended Dietary Allowance for Iron

Age (both sex)	RDA (mg/day)	Females (Age)	RDA (mg/day)	Male (Age)	RDA (mg/day)
<1 year	6 – 10	6 – 11years	10	6 – 11years	10
1 – 2years	10	12 19years	– 15	12–19years	12

3 – 5years	10	20	–	20	–
		29years	15	29years	10
		30	–	30	–
		39years	15	39years	10
		40	–	40	–
		49years	15	49years	10
		50	–	50	–
		59years	10	59years	10
		60	–	> 60years	10
		69years	10		
		>70years	10		

Source³²: **Recommended Dietary Allowance for Iron**

2.1.6 Strategies to address iron deficiency

A variety of policies, programs, and interventions must be implemented throughout the life course and in a wide range of sectors, including food systems, trade and investment, social protection, food safety and antibiotic resistance, water, sanitation, and hygiene, to improve the nutrition of women, children, and adolescents¹². Strong and robust health systems and policies that support universal health coverage are also necessary for non-nutrition interventions in the health sector. Nutrition may also be significantly impacted by non-health-related interventions

outside of the health sector, however the evidence supporting these measures is conflicting and needs more clarification ¹².

Iron supplementation, fortification of processed or staple foods with iron, point-of-use fortification with multiple micronutrients including iron, nutrition counselling that encourages dietary modification or diversification to improve iron intake and absorption, and treatment of preventable causes of iron losses from parasitic infestations like hookworm and other infections are the main public health strategies and interventions that can be used alone or in combination to improve iron status in populations and correct iron deficiency and other micronutrient deficiencies during pregnancy²⁵. Bio-fortification through genetic engineering or plant breeding is a novel strategy²⁶. Important aspects also include preventing low birth weight and prematurity, improving access to healthcare, improving baby feeding, improving food security, improving socioeconomic status, and optimizing maternal nutrition before and during pregnancy ²⁷.

Therefore, to prevent iron insufficiency, pregnant women must consume more iron to ensure they have adequate iron storage¹². Therefore, encouraging high intakes to start pregnancy with sufficient iron stores is the greatest way to combat iron shortage during pregnancy. One study suggests that women should have at least 500 mg of iron stored before becoming pregnant, while another study suggests that women should have at least 300 mg of iron stored before becoming pregnant ^{28, 29}. However, iron stores this big are rare among women today ²⁷.

According to estimates, a sizable percentage of expectant mothers in the underdeveloped world will have exhausted iron stores by the conclusion of their pregnancy. Less than half of pregnant women are thought to have insufficient iron stores, and more than 20% of pregnant women in affluent nations have extremely low iron stores at the start of their pregnancies ^{28, 29}.

Iron-Folic Acid Supplementation

Periodically administering pharmaceutical preparations of nutrients via injection, tablet, or capsule is referred to as supplementation²⁷. The foundation of many low-income nations' nutritional strategies to increase iron reserves and treat iron deficiency and iron-deficiency anaemia, especially in pregnant women, has been iron-folic acid (IFA) supplementation^{30, 31}. Iron supplementation may need to be started before conception in order to assure an effective intervention for the prevention of maternal iron insufficiency, as many pregnant women have inadequate iron stores^{12, 28}.

It was suggested that all women take a folic acid supplement from the time they start trying to conceive until 12 weeks of gestation¹². As part of normal ANC, daily oral iron-folic acid should be started as soon as possible and continued for the duration of pregnancy. When considering additional iron-containing therapies, such as fortified meals, multiple micronutrient powders, or lipid-based nutritional supplements, daily iron supplementation should be taken into account¹². Given the challenges of accurately assessing iron levels during pregnancy using standard laboratory techniques, it is best administered in conjunction with folic acid¹². For at least six months during pregnancy and three months after giving birth, the federal ministry of health stresses the importance of taking iron supplements every day²⁹.

The revised recommended plan for daily iron-folic acid supplementation in pregnant women is to give 400µg (0.4 mg) of folic acid once daily throughout pregnancy in all settings, along with 30–60 mg of elemental iron (30 mg of elemental iron equals 150 mg of ferrous sulphate

heptahydrate, 90 mg of ferrous fumarate, or 250 mg of ferrous gluconate)¹². Supplementing with iron and folic acid should start as soon as feasible. A daily dose of 60 mg of elemental iron is suggested above a smaller amount in situations where pregnant women's anaemia is a serious public health concern (40 percent or more). A woman should get daily iron (120 mg of elemental iron) and folic acid (400 µg or 0.4 mg) if she is diagnosed with anaemia at any point throughout her pregnancy until her haemoglobin concentration rises to normal. To avoid recurrent anaemia, she can then transition to the usual prenatal dosage¹². Adults with iron-deficiency anaemia are typically treated with a 300 mg ferrous sulphate (60 mg iron) tablet three or four times a day³². Due to their low cost and good absorption in multiple micronutrient preparations, ferrous iron salts (ferrous sulphate and ferrous gluconate) or iron-folic acid are recommended for oral iron, which is widely accessible as a single micronutrient supplement in liquid and tablet formats³².

Iron supplementation decreased maternal anaemia at term by 70% and iron deficiency at term by 57%, according to a review of randomised or quasi-randomised trials assessing the effects of oral preventive supplementation with daily iron and iron-folic acid. The study concluded that while supplementation lowers the risk of maternal anaemia and iron deficiency during pregnancy, the positive effects on other maternal and infant outcomes are less pronounced^{23, 31}.

According to a study, women who use iron supplements have lower haemoglobin levels and less severe anaemia, which developed gradually during pregnancy, than women who do not take iron supplements³³. Although modest iron supplementation (up to 60 gm/dl) did not prevent iron-shortage anaemia, a review also found that women who had an iron deficiency early in

pregnancy and did not take iron supplements had a considerably greater prevalence of iron deficiency after delivery³⁴.

Anaemia was 1.90 times more likely to occur in pregnant women who were not taking iron-folic acid, according to a study conducted in Ethiopia³⁵. The study also found that following the first month of supplementation, the concentration of haemoglobin increased linearly. A substantial 0.23gm/dl increase in haemoglobin was linked to each month of supplementation, even after controlling for the gestational trimester in a linear regression model. In East Ethiopia, pregnant women who did not take iron supplements during their pregnancy were 1.30 times more likely to develop anaemia. Furthermore, the advantages of iron-folic acid go beyond boosting iron storage; they also reduce the risk of iron deficiency and iron-deficiency anaemia, which can lead to better birth outcomes and a decrease in the incidence of low birth weight^{12, 34, 35}. It is advised to take folic acid supplements both before and during the first trimester of pregnancy in order to prevent neural tube abnormalities. Vitamin A increases the body's ability to consume iron by assisting in its release from its reserves. Therefore, iron deficits may be a symptom of vitamin A deficiency. Iron deficiency may be addressed by vitamin A and iron supplements than by iron alone.

However, it is suggested that for low birth weight, preterm birth, maternal anaemia, and iron deficiency at term, the overall quality of the evidence supporting iron supplementation versus no iron was moderate. For maternal mortality, severe anaemia in the mother, congenital abnormalities, birth weight, and infections during pregnancy, the quality of the evidence is poor¹².

Fortification of Food

The addition of nutrients at quantities greater than those present in the original diet is known as food fortification²⁸. The practice of increasing the nutritional value of staple crops using both

conventional breeding methods and contemporary technologies is known as biofortification³⁴. Through the use of contemporary biotechnology methods, bio-fortification raises the nutritional content of foods²⁸. In addition to delivering naturally fortified foods to those with limited access to commercially marketed fortified foods, it offers a practical way to reach hungry populations in very remote rural locations²⁸.

The population's nutritional needs and deficiencies, the typical consumption profile of fortifiable staple foods, the population's use of vitamin and mineral supplements, the sensory and physical effects of the fortifying nutrients, and costs should all be taken into consideration when deciding which nutrients to add and in what amounts to fortify flour³⁴. Therefore, choosing foods for fortification requires careful evaluation of the population's eating habits¹².

Finding the iron compound that has the highest absorbability while avoiding unacceptably altering the food vehicle's sensory qualities is the main goal when choosing one to use as a food fortifier. Of all the iron fortifiers, water-soluble iron compounds have the highest relative bioavailability due to their high solubility in stomach fluids; hence, they are typically the recommended option^{12, 28}.

Iron fortifiers come in a variety of forms. The highest bioavailability and comparable iron concentration are found in ferrous sulphate and fumarate. The most affordable and popular fortifier for flour is ferrous sulphate. Ferric pyrophosphate and orthophosphate, two insoluble substances, are less reactive with food but have lower bioavailability. Although they have been employed, elemental iron complexes have a low bioavailability and alter flavour at practical doses³⁶.

Food- Based Strategies

In light of the high prevalence and impact of iron deficiency and iron-deficiency anaemia on a national and worldwide scale, as well as the fact that prevention efforts are primarily supported by iron-folic acid supplementation programs that continue to face numerous obstacles, the following issues and questions will be brought up for scientific consideration: how can a pregnant woman in such disadvantaged circumstances manage to obtain the necessary amount of iron knowing that standard dietary practices are likely to be insufficient for a good portion of her pregnancy and birth outcome?

Therefore, now is the right moment for a seamless paradigm shift away from the conventional excessive emphasis on ineffective supplementation and fortification programs that focus on a single nutrient and toward comprehensive strategies and packages of intervention that acknowledge the multifaceted whole foods and entire dietary diversification approaches for a sustainable prevention and control of micronutrient deficiencies³⁶.

Food-Based Strategies (FBS), also known as Dietary Diversification and Modifications (DDM), are characterized by modifications to traditional family methods for processing and preparing indigenous foods, as well as changes in patterns of food production and selection. Enhancing the availability, accessibility, and use of foods with high micronutrient content and bioavailability is the overarching objective of the initiatives for the year²⁸.

The initial focus for addressing micronutrient shortages has been suggested to be food-based methods ²⁸. When a participatory research process is employed, which focuses on establishing

relationships with the community to involve them in the design and implementation, food-based strategies have the potential to prevent coexisting micronutrient deficiencies simultaneously without running the risk of antagonistic interactions. They are also culturally acceptable, economically feasible, and sustainable, even in settings with limited resources. Furthermore, dietary changes and diversity can improve the micronutrient adequacy of diets for all members of the family and for generations to come. The community-based aspect of dietary diversity and adjustments may also yield a number of other non-nutritional benefits. These could include revenue generating and women's empowerment in the neighbourhood. Another benefit of dietary diversification and change is that it is more in line with the culture and psychology of the population³⁷.

Therefore, food-based approaches (FBA) are the best way to address several nutrient deficiencies in a sustainable manner. Targeting the known determinants is a drawback of strategies other than dietary diversification. One benefit of a strategy for diet diversity is that it addresses the "uncertainty of unknown" ³⁷. Meat and other foods high in bioavailable iron are costly, and it is typically challenging to alter dietary habits and preferences. Additionally, the solutions face a number of challenges, including a lack of proof, sluggish returns, a lack of quantifiable endpoints, pricing concerns, and the difficulty of breaking the inertia of dietary habituation. The strategy's weaknesses are sometimes concealed by the absence of such reliable evidence bases.

2.2 Theoretical Framework

Theories of Nutrition Education (NE) Interventions

Models of behaviours serve as the theoretical foundation for developing interventions meant to modify health-related behaviours³⁹. The phases of change/translocation theory, social learning

theory, health belief model, and social action theory are a few of the theoretical philosophies that are commonly applied in nutrition education approaches.

Social Learning Theory: Cognitive processes, such as thinking, seeing, and believing, lead to changes in behaviours. When a behaviour is performed or watched, attitudes and beliefs about it are most readily altered. It entails the interplay and effect of social environment elements that reflect and alter behaviours. The environment, providing incentives and disincentives, circumstances that have consequences, and self-efficacy are all elements of influence³⁹.

Phases of Transition or Relocation Theory: This theory focuses on crafting distinct messages for individuals at varying levels of preparation to modify specific behaviours. Pre-contemplation, contemplation, and final action are the stages of behaviours. The idea places a strong emphasis on target audience attitudes and attitudinal assessment⁴⁰. **The Model of Health Belief:** According to this hypothesis, people who think they are healthy will engage in behaviours that either prevent or identify disease. The will to stay healthy or prevent illness is crucial⁴¹. Perceived severity, perceived risk, perceived benefits, and perceived barriers are some of the elements that make up the Health Belief Model. People can use the Health Belief Model to modify their eating habits, and counsellors can use it as a guide to help their client⁴².

Social Action Theory: The information processing theory assumes that people would choose options that will result in the greatest number of "good" outcomes and the fewest "undesirable" ones. The theory looks at people's intentions to act in a particular way and determines the likelihood of specific acts based on those intentions and the impact of others⁴³.

The Expert Consultation of the Food and Agriculture Organization (FAO) has agreed that it is challenging to put these theories into practice because there isn't a single behaviour modification approach that works in every circumstance⁴⁴. Two professional groups were surveyed for the study, NE and consumer behavior⁴⁵. Both were interested in influencing food choices by offering information. They were asked to share their thoughts on which models and ideas were most familiar and useful. Although respondents felt that theories were not very significant because there are frequently gaps between research and practice, the professionals in both professions selected a few well-known and up-to-date theories. Even if theories try to pinpoint every element that could influence a behaviours' outcome, they could not accurately represent reality. Additionally, one theory could work better in a certain circumstance than another. This makes it difficult to apply a single theory to the entire intervention procedure. However, the use of theoretical models and theory-based NE activities are beneficial because they allow educators to consider the impact of barriers, motivators, and other significant elements when planning and carrying out NE projects. Perhaps using eclectic would be more accurate³⁹.

2.3 Review of Empirical Studies

2.3.1 Nutrition Education Approaches

According to one study, NE and nutrition communication are essential parts of other nutrition intervention strategies, such as promotion of breastfeeding, food production, food assistance, food fortification, supplemental feeding, and nutrition-related health services. To alter target

groups' dietary beliefs, attitudes, and behaviours, NE and communication programs have evolved beyond a traditional one-way flow of communication, or the simple delivery of information⁴². This traditional approach mostly includes of health discussions at health centres, according to an analysis of NE programs in developing nations. The approach was found to be mainly ineffectual and to have produced minimal improvements in nutritional status or behaviour linked to nutrition. The program's failure can be largely ascribed to the employment of poor communication techniques in conjunction with inappropriate content of the message.

It is preferable to have a two-way sharing approach that allows for the unrestricted sharing of nutrition-related knowledge, values, and practices⁴³. The benefit of this nutrition intervention strategy is that it offers a forum for communication and guarantees the active involvement of those who must make decisions. The present strategy also results in long-lasting effects or modifications and the adoption of better practices. Over the years, several NE tactics have been created and successfully implemented, such as development-support communication, social marketing, and social mobilization⁴⁴.

2.3.2 Effect of Nutrition Education

The impact of nutrition education on dietary modification, nutrient intake, and iron status has been recognized by numerous experimental research. It has been demonstrated that dietary counselling and education increase mothers' awareness of and consumption of foods high in iron,

like as fish. Both urban and rural teenagers require culturally tailored nutrition education programs, according to a collaborative study⁴⁵.

An investigation of the effects of nutrition education alone, daily iron, folate, and vitamin C supplements, or both, on the knowledge, attitudes, and haemoglobin status of teenage pupils was carried out in Tanah Merah, a rural district of Kelantan, Malaysia. One of four treatment groups was assigned to each of the 288 fourth-year secondary pupils by the school. After three months of each intervention, there was a three-month break from therapy. Before and after the intervention, haemoglobin levels were assessed, and a validated self-reported knowledge and attitude questionnaire was given out. There was no discernible variation in haemoglobin levels across the four groups at baseline ($p=0.06$). At three months, the supplementation, nutrition education, combination, and control groups experienced changes in haemoglobin levels of 11, 4.6, 3.9, and -3.7%, respectively. At six months, the corresponding changes were 1.0, 6.8, 3.7, and -14.8%. Both the combined and nutritional education groups showed notable gains in attitude and knowledge⁴⁵.

Three months of nutrition education for pregnant women in Nigeria revealed that the intervention had a major impact on the women's understanding of the value of eating fruits and vegetables. The results also showed that the intervention had a good impact on increased intake, as the pregnant women seemed to eat more fruits and vegetables than they had previously⁴⁶.

In Tanah Merah, a rural district in Kelantan, Malaysia, a study was conducted to examine the impact of nutrition education and non-nutrition education interventions on school-age adolescents' awareness of iron deficiency. Haemoglobin levels ($Hb = 7-11.9$ g/dL for girls; $Hb =$

7–12.9 g/dL for boys) served as the basis for the selection criteria. Two groups were formed out of them. While one group was eligible to get a non-nutrition education intervention (Non-Nutrition Education, NNE) (supplement only), the first group received a nutrition education package (Nutrition education, NE). The duration of both therapies was three months. Multiple-choice questions were used to assess the awareness shifts among respondents in both groups. After the intervention, the nutrition education recipient group (NE) showed an increase in awareness. The comparable group (NNE) showed no discernible improvement⁴⁷.

Using a 30-minute lecture accompanied by a visual display of foods such as rich sources, enhancers, and inhibitors of iron absorption, another study evaluated the effects of nutrition education interventions among post-adolescent girls in India. Thus, prior to the intervention, 30 percent of the individuals had low nutrition knowledge (<17), 42.3% had medium nutrition knowledge (17–23), and 27.5% had high nutrition knowledge (>23). The same questionnaire was used to reassess the knowledge level one month later, and the results showed that 4.4% scored medium and 95.5% scored high. Prior to the intervention, roughly 52%, 39%, and 54% of respondents correctly identified dietary enhancers, inhibitors, and processing; one month later, those percentages rose to 82%, 84%, and 70%, respectively. One month after the education intervention that could help battle micronutrient deficiencies, the overall knowledge scores of each investigated group at the pre and post education program increased significantly at the 1% level, indicating that knowledge retention is highly satisfactory⁴⁸.

An intervention study evaluating the efficacy of nutrition education among teenagers with anaemia in Malaysia discovered that after receiving nutrition education for one hour a week for three months, the mean knowledge score had changed by 18.3. Additionally, a study conducted in Kenya found that nutrition education greatly increased the understanding of nutrition among

elementary school students and that there was a statistically significant beneficial correlation between nutrition knowledge, nutrient intake, and haemoglobin levels⁵².

A study examined the effects of nutritional education on the knowledge, attitudes, and haemoglobin status of teenagers with anaemia in Malaysia, both with and without iron supplementation. For three months, there were four lectures on nutrition, and the supplements included a capsule containing 250 mg of ferrous gluconate, 1 mg of folic acid, and 50 mg of vitamin C. The findings demonstrated that the nutrition education groups significantly improved the respondents' knowledge and attitudes scores by 15.22 and 3.34, respectively. All groups except the nutrition education groups saw a significant rise in mean haemoglobin levels, which went from 10.78 mg/dl to 11.28 mg/dl. The supplements group had an 89.3% compliance rate. Another combined intervention of iron-folate (60 mg of elemental iron plus 0.5 mg of folic acid) and calcium tablets supplemented on alternate days for three months, accompanied by nutrition and healthy eating lectures, also reported similar results, saying that the experimental anaemic Indian adolescent girls' haemoglobin increased by 19.55 mg/dl and their food intake increased during the study period^{53,54}.

Participants in a comparative study that examined and contrasted the knowledge, attitudes, and behaviours of anaemic and non-anaemic pregnant women in Sierra Leone performed poorly (64% accurate) on a 10-item test anaemia knowledge questionnaire. Only a small percentage of the women were able to pinpoint aspects of poor nutrition as causes of anaemia, and approximately 45% of them gave inaccurate information regarding the condition. About 53% of respondents were able to accurately identify preventive and treatment alternatives for anaemia, such as taking iron supplements and eating nutritionally sufficient meals that contained green leafy vegetables and foods high in protein, even if 40% of respondents gave false information

about increasing iron status. The women's views toward perceived anaemia dangers were not significantly influenced by their anaemia status, and less than half of them were engaging in behaviours that lower their risk of becoming anaemic⁵⁵.

Nutrition knowledge scores and mean intakes of nutrients, such as dietary iron, absorbable iron, and vitamin C, were significantly higher in the intervention group than in the control group, according to a quasi-experimental design conducted among adolescent girls in Southern Benin that involved four weeks of nutrition education followed by a 22-week increase in the content and bioavailability of dietary iron. Additionally, the intervention group's mean haemoglobin and serum ferritin levels were considerably greater than those of the control group (122 versus 11.2 mg/dl and 32 against 19 µg/L, respectively). However, compared to the control group, the intervention group had a significantly reduced prevalence of anaemia (32% versus 85%) and iron-deficiency anaemia (26% against 56%). The mean scores of dietary habits and nutrition knowledge increased by 12.3% (from 46.7% to 58.8%) in the intervention group, according to another study that evaluated the effectiveness of nutrition education tools among teenage Indian girls. After three months of the intervention, there was no change in the mean scores, indicating that the knowledge acquired had been retained⁵⁷.

Iron nutrition education is not yet well integrated into programmatic agendas, and there are few examples of documented significant impact from an isolated approach alone, even though nutrition education as a public health intervention is obviously valuable and valued among populations at nutritional risk⁵⁸. In Nigeria, 58.3% of pregnant women who attended ANC reported not receiving nutrition-related health education⁵⁴. Another study found that 42.2% of pregnant women in south-southern Nigeria did not receive any nutritional information during

their pregnancy, while another study found that approximately 43% of Nigerian mothers in the study did not receive counselling, specifically regarding dietary practices and feeding options, while attending ANC ^{57,59}.

2.3.3 Nutritional Intervention

The adolescent stage is a great time for intervention in terms of enhancing nutritional status and starting healthy eating and health practices, as prior research shows that nutritional status throughout adolescence plays significant roles in the human life cycle ⁴². The causes of iron deficiency anaemia can be addressed by cost-effective anaemia preventive and management measures, according to research.

Adolescent health can be improved through school-based interventions, therefore it's critical to understand the severity and causes of anaemia during this time. For adolescent females whose nutritional health is already marginal, early intervention is especially important to improve their nutritional status. Given the advantages of better nutrition for adolescent girls in terms of reproduction, this is even more important ⁶⁰.

Nutritional Education

One kind of intervention that attempts to combat malnutrition by bringing about behavioural change is nutrition education. Nutrition education is the most common way to acquire nutritional knowledge. Understanding nutrition is a key component of good eating practices. Positive attitudes on eating healthier meals are more prevalent among those with greater nutrition knowledge. Knowledge, attitude, and practice (KAP) are the three elements that show the behaviour⁶². These community-based determinants end up being the primary causes of nutrition

and health issues. Teenage girls are regarded as a key target group to be trained to reduce or prevent iron deficiency anaemia because of the high prevalence of iron deficiency anaemia in adolescent girls and the serious symptoms that follow⁶³. Controlling health issues is especially important, as is raising awareness and knowledge as a strategy to prevent IDA. The most assessed youth engagement tactics in the health sector are those that involve advocacy and youth engagement in health peer education, or the encouragement of healthy behavior for youth by youth. The young people running the programming, or the peer educators themselves, have benefited from such interventions⁶³.

Peer promoters themselves are more self-assured, have better interpersonal, leadership, and communication skills, have higher aspirations, and engage in fewer health-risky behaviours. Their usefulness in altering health outcomes for the larger group of young people they are intended to target has not been thoroughly tested, despite being better evaluated than most. This illustrates a specific difficulty in environments with limited resources, as well as a conflict between the need to implement rigorous, smaller-scale treatments and the desire to scale up beneficial ideas.

Over the past 20 years, the UN and other international organizations have promoted a global expansion in the involvement of adolescents and young people in health-related campaigning. Similar procedures have been carried out by organizations that aid youth at the national and local levels⁶⁴.

As we move closer to the Sustainable Development Goals (SDGs), it is critical to first determine the extent of iron deficiency anaemia by evaluating knowledge, attitudes, and practices (i.e.,

symptoms, sources, advantages, absorption enhancers, and barriers) of this crucial micronutrient, namely iron, and then promoting its significance in the establishment of sufficient iron stores.

The frequency of anaemia in less developed cities may be reduced by teaching girls in schools and colleges the value of eating regular, healthful meals and the need of maintaining good health. Since many teenagers attend school, there is a great chance to reach a wide range of people outside of only the students themselves, including families, community members, and school staff ⁶⁵. In addition to helping to accomplish the SDGs, schools provide a special platform for achieving several advantages for children and their communities.

Additionally, schools have the power to impact people outside of the student body by acting as a catalyst for the participation of educators, parents, and other community members. Community development can be accelerated, social protection and economic empowerment can be brought about, agricultural production systems can be influenced to produce a variety of nutrient-dense foods, lifelong healthy eating habits can be encouraged, and basic health, sanitation, and hygiene issues that impact wellbeing can be addressed ⁶⁶.

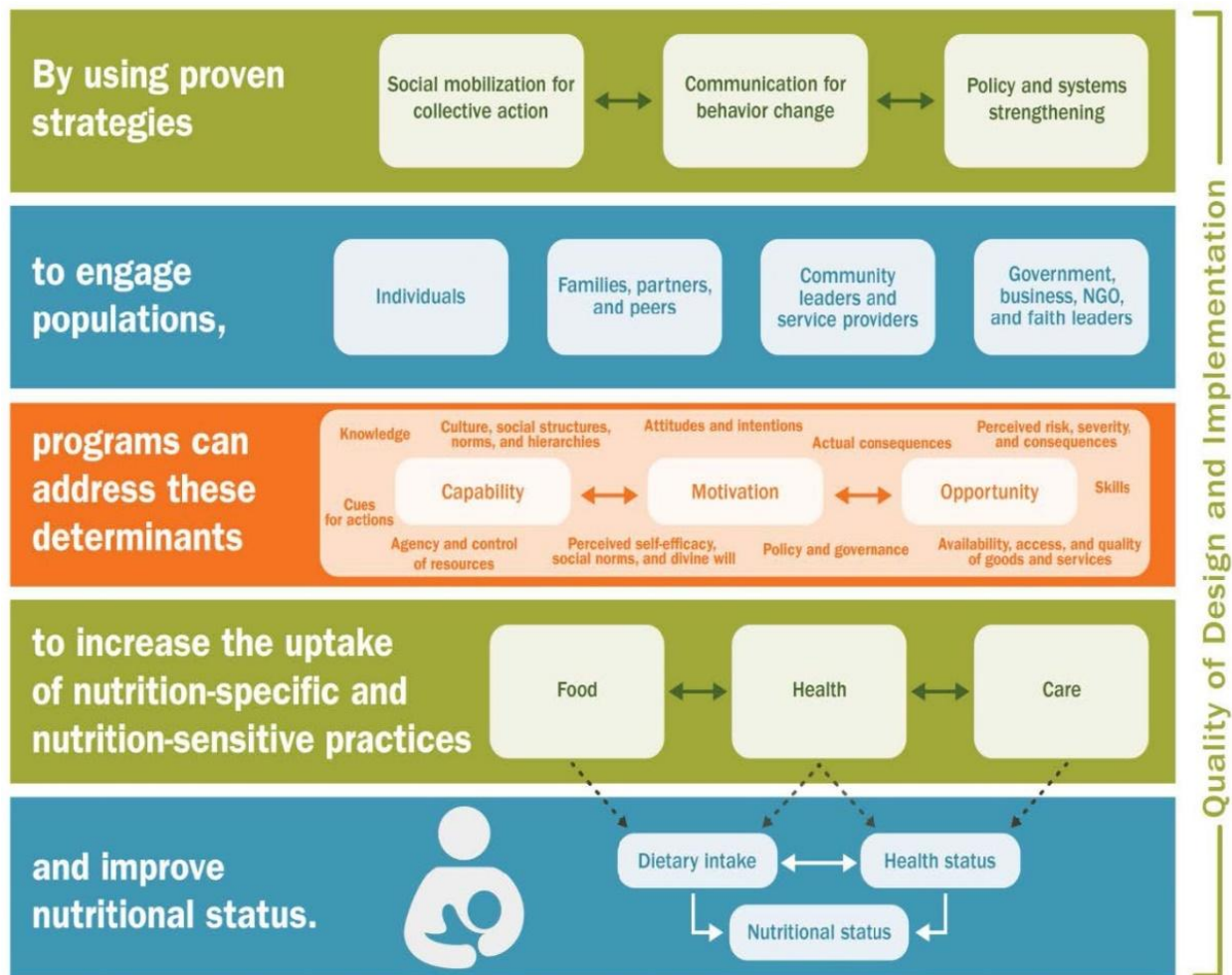
2.3.4 Knowledge, Attitude and Practice

Knowledge, attitude, and practice are the three elements that make up behaviour (KAP). Assessments of knowledge, attitude, and practice can be used to gauge how well intervention programs are working. Additionally, before creating and carrying out the intervention research, it can evaluate a target group's present knowledge, attitude, and practice on a certain topic to

identify their needs, issues, and potential barriers⁶¹. Evaluation of knowledge, attitude, and practice has been widely used in contemporary nutritional studies.

Therefore, understanding nutrition is a must for adopting healthy eating practices. People who were more knowledgeable about nutrition were more inclined to eat healthier foods. On the other hand, one of the risk factors for malnutrition is inadequate information⁶⁷. Nutrition knowledge can be increased by utilizing SPRING's Social Behaviour Change Framework, which incorporates aspects of the UNICEF Conceptual Framework on Nutrition⁶⁸.

Figure 2.2: Social Behaviour Change Framework



Source⁶⁸: Adapted from UNICEF Conceptual Framework on Nutrition

The framework outlines how to use interventions that communicate with various audiences, channels, and techniques to enhance food consumption as well as the health and nutritional

condition of communities. According to the concept, using tried-and-true delivery methods to reach communities can boost the adoption of nutrition-specific and nutrition-sensitive activities to improve nutritional status by strengthening enablers and lowering behavioural barriers. Research demonstrates that individuals may modify their behaviour to enhance nutrition outcomes, particularly when their living and working environments encourage such adjustments.

In this study, Knowledge, Attitude and Practice (KAP) survey was used to accomplish the following:

- i. Determine the baseline knowledge, attitude and practice of adolescent girls about iron deficiency anaemia.
- ii. Determine the baseline knowledge, attitude and practice of parents/caregivers about iron deficiency anaemia
- iii. Develop and implement a nutrition education intervention for in-school adolescents in Ogun State, Nigeria
- iv. Evaluate the effectiveness of nutrition education in improving iron status among in-school adolescent girls in Ogun State, Nigeria.

Dietary Diversity and Iron deficiency anaemia

The quantity of foods ingested within and between food groups during a reference period is known as dietary diversity. It is a commonly used indicator of diet quality. Consuming and expanding a variety of foods and food types in the diet is a concept that supports optimal health and enough intake of vital nutrients⁶⁹.

According to research conducted in underdeveloped nations, switching from a diet that consists of the same foods to one that includes a wider variety of meals increases the consumption of energy and micronutrients⁷⁰. Increasing the availability and accessibility of foods high in iron and micronutrients is still the fundamental strategy for improving dietary diversity, and the agricultural and education sectors play a big part in this. Micronutrient content should be taken into account in all facets of food production, preservation, processing, marketing, and preparation.

Furthermore, changing diets requires improved knowledge and practice through behaviour change communication and counselling. It has been suggested that eating a wide range of foods will help you get enough nutrients, and many countries' dietary recommendations support this idea. Nutrient adequacy, or whether a person or group satisfies their needs for energy and all important nutrients, has been successfully predicted using dietary diversity.

Furthermore, it has been observed that dietary diversity metrics reliably correlate with micronutrient density, nutrient sufficiency, and favourable health outcomes across various age groups and nations⁷¹. Numerous studies from both industrialized and developing nations demonstrate that dietary diversity is a crucial component of diet quality since it is in fact closely linked to nutrient adequacy.⁷²

2.4 Conceptual Model

Conceptual Model of the Study

A conceptual model is a mental representation of an item, system, or procedure that explains the general functional relationships between its constituent parts. It is a purposefully reduced depiction of a piece's graphic form that aims to highlight the key components of any process structure and their interrelationships. One of the main factors influencing people's health is their behaviour. In order to establish communication tactics that encourage positive behaviours, this study will employ the notion of Social and Behaviour Change Communication (SBCC)⁷³.

Communication for Social and Behaviour Change in addition to encouraging safe and healthy behaviours among groups of individuals, SBCC is a strategy that supports and enables changes in knowledge, attitudes, norms, and beliefs. The intended audiences of a strategy are the target demographics. Theories of behaviour change help us understand why people behave in certain ways and why behaviours change. When choosing which audiences and behavioural determinants to concentrate on, SBCC theories can be a useful guide⁷³.

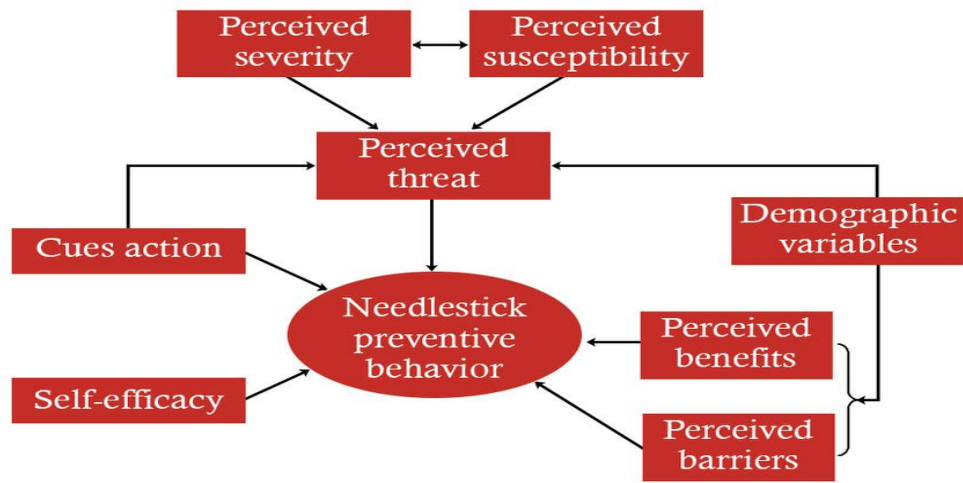
Behaviour theories and behaviour change models have garnered more attention in recent years. These ideas explain how behaviours evolve and change over time, which helps to support public health initiatives. Because of this, behavioural models are made to help us better understand human behaviour and the fundamental causes of it. Although there are other theories of behaviour modification, the Health Belief Model (HBM) will be employed in this investigation.

The two pillars of health-related behaviour, according to psychological and behavioural theory, are 1) the desire to prevent illness or, if already ill, to recover from it, and 2) the conviction that a

particular health action will prevent or cure illness⁷⁴. In the end, a person's decision frequently hinges on how they view the advantages and disadvantages of engaging in healthy behaviour.

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Figure 2. 3: Diagrammatic representation of Health Belief Model



Source⁷³: Theory of Behaviour Change Modification

The Health Belief Model has six (6) constructs⁷⁵. They are as follows:

- i. Perceived susceptibility: This is a person's subjective assessment of their chance of contracting a disease or sickness. People's perceptions of their own susceptibility to a disease or illness vary greatly.
- ii. Perceived severity: This describes how someone feels about the gravity of getting a sickness or illness (or not getting treatment for one). People's perceptions of severity vary greatly, and when assessing the severity, they frequently take into account the social and medical repercussions (such as family life and social ties) as well as the medical ones (such as death and disability).
- iii. Perceived Benefits: This is a person's assessment of the efficacy of certain measures that can be taken to lessen the risk of illness or disease (or to treat illness or disease). A person's approach to preventing (or curing) illness or disease depends on taking into account and assessing both perceived benefit and perceived vulnerability. If the suggested health measure was seen as advantageous, the individual would follow it.
- iv. Perceived barriers: This describes how someone feels about the challenges they face when carrying out a suggested health action. People's perceptions of barriers, or impediments that result in a cost/benefit analysis vary greatly. The individual compares the perceived cost, risk (e.g., adverse consequences), unpleasantness (e.g., discomfort), time commitment, or inconvenience to the success of the acts.
- v. The stimulation required to start the decision-making process to accept a suggested health activity is known as the "cue to action." These cues may be external (such as newspaper stories, family members' illnesses, or advice from others) or internal (such as chest aches, wheezing, etc.).

vi. Self-efficacy: This is the degree to which an individual believes that they can carry out a behaviour successfully. In the middle of 1980, this build was incorporated into the model. Many behavioural theories use the concept of self-efficacy since it has a direct bearing on whether or not an individual engages in the desired behaviour.

Assessment with Health Belief Model: The Health Belief Model will be used to generate data in the following manner:

Assessment of Perceived Susceptibility and Severity

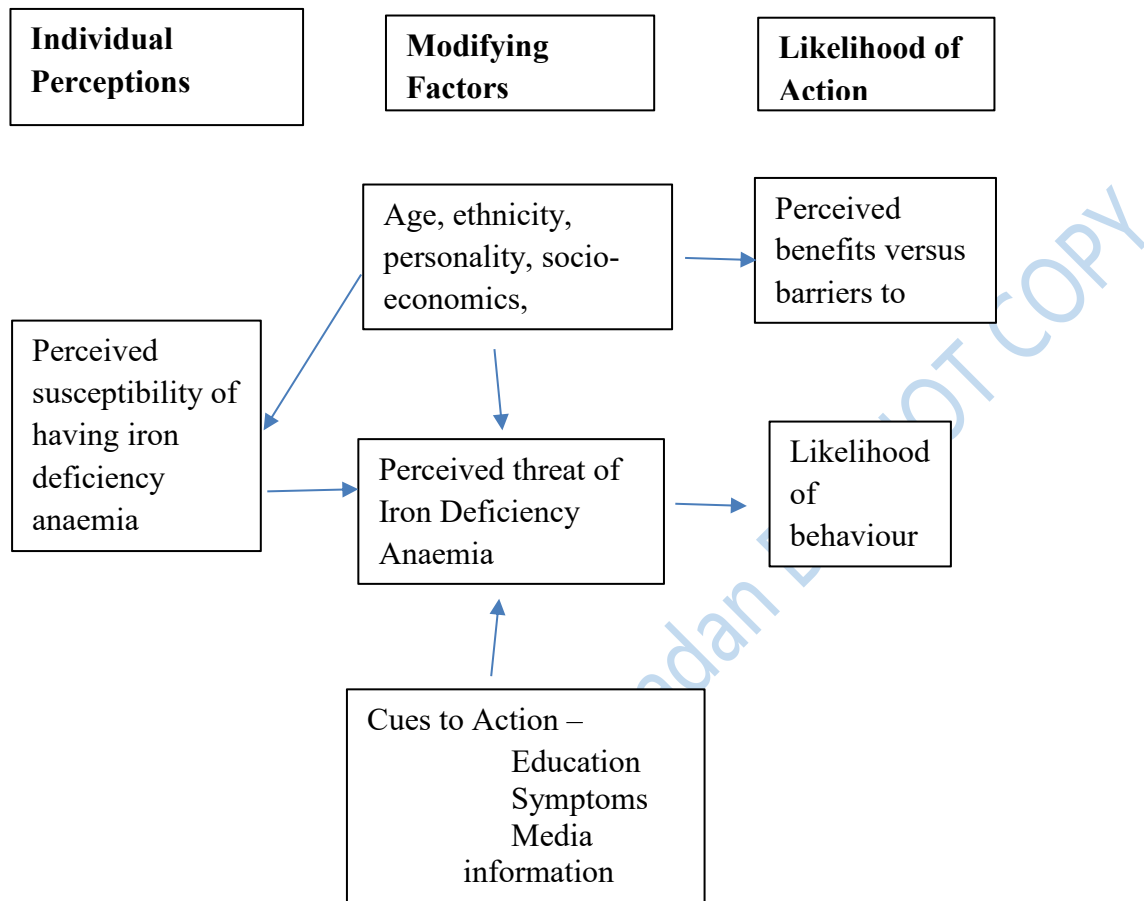
The following questions will be used to explore the perceived susceptibility and severity of the participants:

- i. How do you think iron deficiency is affecting your health? (*Current susceptibility*).
- ii. How might it affect your health in 10 years' time or when you are married? (*Future susceptibility*).
- iii. What would it be like if it happened that you have iron deficiency anaemia? (*Severity*).

Assessment of Perceived Benefits and Barriers

- i. What are the advantages of eating junks, skipping meals and not eating well? (*Current benefits*).
- ii. What are the benefits of eating balanced diets, taking iron supplements and iron fortified meals? (*Future benefits*).
- iii. Is there anything stopping you from eating balanced diets, taking iron supplements and iron fortified meals? (*Current barriers*).

Figure 2. 4. Conceptual Model



Source⁷³: Theory of Behaviour Change Modification

2.5 Summary of Gaps in Literature Reviewed

This chapter reviewed the previous studies that have been conducted on the topic of iron deficiency anaemia and the feasibility of preventing and controlling it among female adolescents by means of nutritional education intervention program. The studies reviewed suggested that female adolescents are highly prone to iron deficiency anaemia compared to their male counterparts. The consequences of IDA are grave both for the affected adolescents and the future children that they will give birth to.

As a result of this, many studies have been conducted to find efficient means of mitigating the effects of IDA. Research findings indicate that nutritional education has been effectively used previously to control IDA among adolescent girls in different developing nations of the world. In view of this, this study is focused on tackling IDA among in-school adolescents girls by means of nutritional education based on the evidence gathered from previous research.

Many studies have examined the impacts of iron deficiency anaemia on adolescent girls in different settings and many control and prevention approaches have been explored for effective elimination of the condition.⁷⁶ Despite this, there is a scarcity of studies that examine the impacts of IDA on adolescent girls and how its effects can be mitigated via nutritional education intervention in southwest Nigeria. Therefore, this study is focused on utilization of nutritional education to mitigate the effects of Iron Deficiency anaemia on adolescent girls attending secondary schools in Ogun State, Nigeria.

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Chapter Three

Methodology

This chapter outlines the design that was used to conduct the research, including the study population, study design, research area description, sample size and sampling technique, data collection materials, validity and reliability, data collection procedures, data analysis, and ethical considerations related to the study.

3.1 Study Design

The study used a quasi-experimental design, with pre-and post-intervention assessments. The study involved an intervention group that receives the nutrition education intervention and a control group that does not receive the nutrition education intervention. Ogun State's three senatorial districts served as the study's locations. The multi-stage sampling technique was used in this study. Each senatorial district has one (1) Local Government Area (LGA) chosen using a simple random sample approach (ballot system).

Two (2) public secondary schools in the randomly selected LGA per senatorial district was purposively selected to ensure distance between the study participants and to avoid contamination of information. The two (2) schools purposively selected in each LGA per senatorial district was randomly assigned by the ballot system as Intervention and Control group.

The study participants, adolescent girls were selected purposively from each class arm, those that met the criteria, willing to participate, obtained informed consent from their parents. The study consisted of one (1) intervention group per school and one (1) control group per school in each senatorial district. The intervention groups participated in a one-hour interactive nutrition education classes for a period of 6 weeks. Using lectures, power points, brochures, and other materials, the students learned about iron and anaemia, its causes, effects, prevention, and various foods high in iron. They also learned about the prevalence of anaemia and its risk factors, as well as nutrition education on dietary sources of iron, iron inhibitors, and iron enhancers. Various educational resources, including posters, brochures, and diet charts, were used in the classroom.

Throughout the four months of the trial, the groups that did not get the intervention did not receive any instruction on nutrition education. However, they received the nutrition education intervention and materials right after the end-line evaluation.

Baseline assessment, intervention (structured nutrition education), and end-line evaluation comprised the three main phases of the quasi-experimental study. Using a modified standard questionnaire from the Food and Agriculture Organization, the participants' nutrition education literacy, attitude, food-intake practices, and 24-hour dietary recall were evaluated at baseline and end-line for both the experimental and control groups¹. Biomarker measurement of haemoglobin level was conducted at baseline and end-line for both intervention and control groups.

Table 3.1: Summary of the quasi-experimental component of the research design

Group	Measurement		
	Pre- Intervention	Intervention	End-line evaluation(At the end of 6-weeks follow up period)
1(Experimental)	√	A 6-weeks nutrition education classes training	√
2(Control)	√	X	√

Source¹: Adapted from Quasi Experimental Research design

3.2 Study Population

The study focused on in-school adolescent girls aged 10-19 years attending public secondary schools in the three (3) senatorial districts of Ogun State, Nigeria. The study also involved parents/caregivers of the adolescent girls.

3.3 Study Area

The study was conducted based on the geographical divisions: the three (3) senatorial districts of Ogun State which represents the broader population of the State due to their similar demographic, cultural and socio-economic characteristics. Due to the study design: pre- and post-test assessment, two (2) schools were selected in each geographical division to obtain the true representation of each population by geographical division.

The study was conducted in six (6) selected public secondary schools across the three (3) senatorial districts in Ogun State, Nigeria. Two public secondary schools were purposively selected in each of the three senatorial districts in Ogun State, Nigeria.

Description of Study Area

This study was conducted in Ogun State, Nigeria. One of the six states in Nigeria's southwest is Ogun State, which is also one of the States with the quickest rates of development. Its entire land

area is 16,980.55 square kilometers. About 100 kilometers north of Lagos, the commercial center of Nigeria, is Abeokuta, the state capital. Because of its position, other economically developed regions of Nigeria may readily reach it.

3,751,140 people live in the state, with 1,864,907 men and 1,886,233 women, according to the 2006 national census. With a projected 3.3% annual growth rate, the current population forecast for 2022 is 6,267,473.

The State has twenty (20) Local Government Areas with two hundred and thirty-six (236) wards for local administration. These are separated into three geopolitical zones, which include senatorial districts in Ogun Central, Ogun West, and Ogun East. Abeokuta South, Abeokuta North, Ewekoro, Ifo, Obafemi Owode, and Odeda are the six LGAs that comprise Ogun Central. The senatorial district of Ogun East is composed of nine LGAs. Ogun Waterside, Odogbolu, Ikenne, Remo North, Sagamu, Ijebu Ode, Ijebu North, Ijebu Northeast, and Ijebu East are the LGAs. There are five LGAs in the Ogun West Senatorial District: Ipokia, Ado Odo Ota, Yewa North, Yewa South, and Imeko Afon.

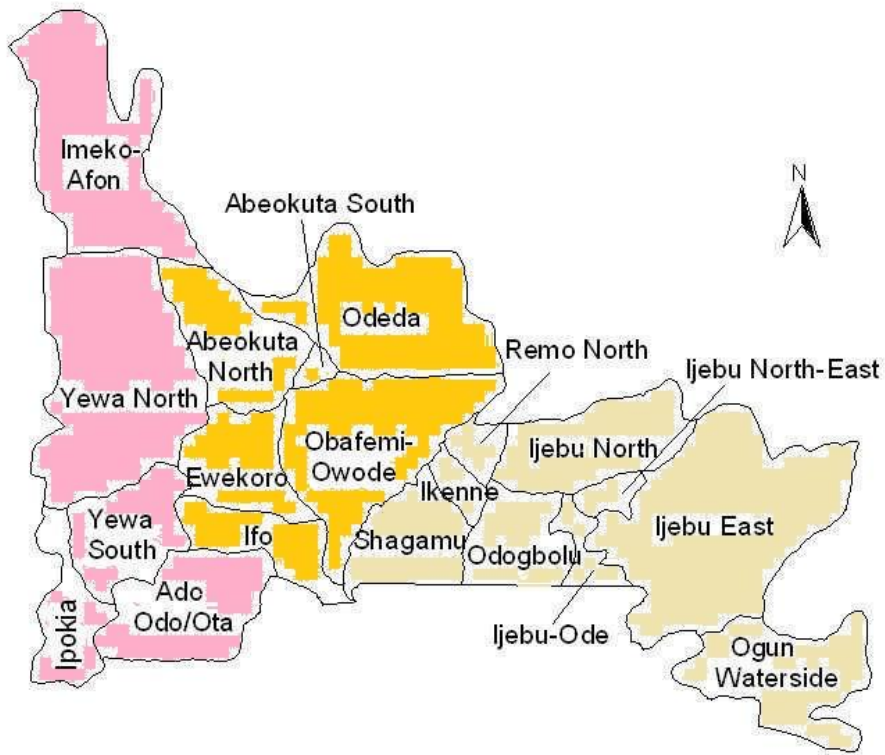


Figure 3.1: Map of Ogun State, Nigeria

Source ²: Ogun State

Lead City University Iba

COPY

3.4 Sample and Sampling technique

Sample size

The sample size formula for mean comparison was used to get the study's sample size². The formula estimates the minimum sample size required to detect changes between the means of desired outcome continuous variable before and after an intervention. The formula uses four inputs in its calculation which are the significance level, power, the estimated effect size and the standard deviation. The estimated sample size 'n' using the formula is the minimum required per study arm for an intervention study. Findings from different research, revealed effect size of $\delta = 1\text{g/dl}$ with a standard deviation, $\sigma^2 = 1.4$ to detect a statistical significant ($p < 0.05$) difference of haemoglobin (Hb) levels between the experimental groups and control groups^{3,4,5,6}. The study's sample size is based on an 80% power assumption and a 95% degree of confidence^{7,8,9}.

$$n = \frac{2SD^2 \left(\frac{Z_{\alpha}}{2} + Z_{\beta} \right)^2}{d^2}$$

In this case, $Z_{\alpha/2}$: with a 95% confidence level of $\alpha = 0.05$, the critical value of the normal distribution at $\alpha/2$ is 1.96. Z_{β} : The normal distribution's critical value at 80% power, β is 0.2 and the critical value = 0.84

SD = standard deviation; estimated to be 1.4. ^{3,6}

d is the effect size, or the size of the change that is intended to be detected. According to estimates, this is 1g/dl. ^{4,5}

$$n = \frac{2(1.4)^2 (1.96 + 0.84)^2}{(1)^2}$$

$$n = \frac{2(1.96) (7.84)}{1} = \frac{30.73}{1}$$

$$n = 30.73$$

Attrition risk of 50% loss to follow up was considered, $n = 30.73 + 15.35 = 46.08$ per group

For the 6 schools,

Estimated sample size; $n = 46 * 6 = 276$

A total of 46 adolescent girls was required for each study group in the quasi-experimental component. This makes a total of 276 participants for the 6 study groups.

Inclusion Criteria

The criteria for inclusion of participants into the study was as follows:

- a. Nigerian nationals
- b. Female
- c. Adolescents within the age range 10 – 19 years.
- d. Presently attending public secondary school in Ogun State, Nigeria
- e. Speak and understand English language
- f. Not managing any ill health condition.
- g. Whose parents/guardians acknowledged consent form for participation.

Exclusion Criteria

Students in these categories were disqualified from the research:

- a. Secondary students that are yet to reach adolescent stage and those who have by-pass the stage.
- b. Students in certificate classes that is JSS3 and SSS3 because they might not be available during the follow-up period.
- c. Qualified students, who are not willing to partake in the study.

- d. Qualified students, whose parents are not willing to sign the research study consent form.
- e. Qualified students, who do not submit their parental consent form within the stipulated time.
- f. Qualified Students, who are living with sickle cell disease, pregnant, lactating or managing ill-health conditions.

Recruitment of study participants

In each of the selected schools, names of the students that indicated readiness to partake in the study were collected. The eligibility criteria were used in recruiting in-school adolescent girls (10-19 years) that participated in the study. A total of 277 eligible in-school adolescent girls were recruited for the study at 46 per each intervention arm (school). The study's goals, roles, duties, information privacy, length, and willingness to participate were all explained to the participants. Every consenting study participant at each of the six study locations provided their informed consent.

The study was carried out in March – July 2025 in the selected six secondary schools in the three senatorial districts of Ogun State.

Study Variables

The study assessed the prevalence of iron deficiency anaemia among in-school girls aged 10-19 years. It also evaluated the knowledge, attitudes, and practices of both adolescent girls and their parents/caregivers regarding iron deficiency anaemia. The dietary intake of relevant nutrients among in-school adolescents was assessed. The study also develops and implements a

nutrition education intervention for in-school adolescent girls and evaluate the effectiveness of the intervention in improving iron status.

Sampling Technique

The multi-stage sampling strategy was used in this investigation. The study participants would be chosen using a two-stage random sampling procedure as follows:

Stage 1: Selection of participating LGAs in the Senatorial districts: Simple ballot system was utilized to select participating LGAs per Senatorial districts. Abeokuta South LGA was selected for Ogun Central Senatorial district, Sagamu LGA for Ogun East Senatorial district and Ado Odo/Ota LGA for Ogun West Senatorial district.

Stage 2: Selection of Participating Public Secondary Schools: Purposive method was used in selection of the two (2) participating schools in the randomly selected LGA per senatorial district to ensure distance between the study participants and to avoid contamination/diffusion of information.

Stage 3: Allocation of Schools to the treatment arm: The two (2) schools purposively selected in each LGA per Senatorial district were randomly assigned by the ballot system as Experimental and Control group.

Stage 4: Selection of study participants: The recruitment criteria and the first 11 students to submit their informed consent from their parents within the time frame per class arm was used to purposively select adolescent girls aged 10-19 years for the study. 277 eligible in-school girls aged 10-19years, 46 each per intervention arm, was recruited for the study.

Table 3.2: Description of study participants according to Intervention arms

Intervention Arm	Geographical Division	Selected LGA	Selected Secondary Schools	Public	Number of selected In-school Female Adolescents
Experimental Group 1	Ogun Central	Odeda	Nawarudeen GrammarSchool, Obantoko		46
Experimental Group 2	Ogun East	Sagamu	Methodist School, Sagamu	High	46
Experimental Group 3	Ogun West	Ado/Odo/Ota	Sango School, Sango	High	46
Control Group 1	Ogun Central	Odeda	Salawu Secondary School, Osiele	Abiola	46
Control Group 2	Ogun East	Sagamu	Sagamu School, Sagamu	High	47
Control Group 3	Ogun West	Ado Odo/Ota	Iganmode School	High	46
Grand Total					277

3.5 Description of Research Instruments

A structured questionnaire was used as the technique for gathering quantitative data. The quantitative tool consists of a 24-hour dietary recall questionnaire and a Knowledge, Attitude, and Practice (KAP) questionnaire on iron deficiency anaemia. These were modified from the Food and Agriculture Organization of the United Nations' Guidelines for Assessing Nutrition-related Knowledge, Attitudes, and Practice Manual¹ (Appendix B), while the Dietary Diversity questionnaire was modified from the Food and Agriculture Organization's Guidelines for Measuring Household and Individual Diversity (Appendix C). Based on reviews of the literature, the biochemical evaluation, anthropometry measurements, and demographic traits were created. Experts in public health and nutrition, particularly specialists in health promotion, also reviewed the tools.

Questionnaire

Section A: Socio-demographic Information: This consisted of 12 items. The age of the participants were assessed as an open-ended question; while other socio-demographic variables were coded as close ended questions.

Section B: Anthropometric Indicators: This consisted of 3 items to determine the nutritional status of the participants. This was handled by the research assistants.

Section C: Biochemical Assessment: This consisted of an item and was filled by the laboratory scientist for each participant.

Section D: This section consisted of 15 semi-structured questions about IDA knowledge. Awareness, recognition, causes and prevention, consequences, iron-rich foods, and foods that increase or decrease iron absorption were all measured in this area.

Section E: Eight Likert-based attitude statements are included. The study participants' opinions regarding the probability of developing IDA, the severity of the illness, their level of confidence in cooking meals high in iron, and the flavour of such meals were all assessed in the attitude section.

Section F: This is a 7-item food intake practice statements. This section assessed the consumption of the different iron-rich foods and the meal pattern.

3.6 Validity of Research Instruments

The following procedure was used to verify the validity of the quasi-experimental study's instruments:

Face validity: In order to make sure that the items in the modified questionnaire accurately measure the study's components, the validity of its contents was assessed by consulting pertinent literature and earlier studies. To make sure the items accurately measure the study's constructs, the KAP questionnaire was also sent to public health and nutrition experts for review, including the State Nutrition Officer, the Senior Dietician at the Federal Medical Center in Abeokuta, and the SBC Specialist at UNICEF and Breakthrough Action-Nigeria. Following expert evaluation of the content validity, thirty (30) adolescent girls enrolled in school participated in a pre-test.

Content validity: To ensure the instrument's clarity and comprehension, thirty (30) draft questions were pre-tested among in-school adolescent girls (10–19 years old) in the state's three

senatorial districts who shared similar socio-demographic traits with the study participants. Separate from the study districts, the LGAs were chosen at random from the three (3) senatorial districts. Before the study began, the instrument (KAP questionnaire) was updated to include the comments from the pilot trial. The tool provided clearer explanations for questions and items that needed clarification. The goals of the study served as the framework for the creation of the questionnaire items.

Construct validity: The goals of the study served as the framework for the creation of the questionnaire items.

3.7 Reliability of Research Instruments

The reliability of the questionnaire was tested using the Cronbach's Alpha model technique. In one (1) LGA per senatorial district that is distinct from the study locations, 30 in-school adolescent females (10 per senatorial district) who are comparable to the study participants were given the questionnaire once. The IBM SPSS program version 21 was used to calculate the coefficient reliability. With a range of 0.77 to 0.83, the average Cronbach's α score was 0.80. Questions that the respondents did not sufficiently or appropriately answer were corrected and modified based on the pre-test results.

3.8 Administration of the Research Instrument

The data collected include socio-demographics, anthropometry (weight, height and BMI), a 24-hour dietary recall questionnaire for the assessment of dietary intake, and biochemical data for the assessment of haemoglobin level. The data was collected from participants by trained

research assistants, nutritionist, dietician and phlebotomist. Both at baseline and six weeks following the intervention, data were gathered.

Trained research assistants (RAs) gathered the data. Twelve (12) RAs in all received training in data gathering. Each senatorial district in the research was given a team of four RAs. The RAs received a one-day training to acquaint them with the study's background and objectives, data collection ethics, data instrument administration, data quality, confidentiality, participant rights, informed written consent, data entry, monitoring, and intervention supervision. Both at baseline and after the study's intervention, quantitative data were gathered at two distinct stages.

Criteria for selecting Research Assistants include:

- Public health/Social Sciences graduates/Students
- Experience in surveys/research
- Residents in the State and LGA of study
- Fluent in local language (written and oral)

Baseline Data Collection

Quantitative data were collected at the baseline of the study using the validated instrument (Appendix B). The questionnaire for quantitative data were administered to all the selected study participants in both the intervention and control groups. The findings from the baseline data served as a reference for the effectiveness of interventions in the 3 experimental groups on the outcome variables.

Socio-demographic characteristics

Research assistants gathered sociodemographic information about participants (age, sex, education) and guardians (age, occupation, income, and educational attainment).

Assessment of Nutritional Status

Anthropometric Indicators

To reduce measurement mistakes, all the research assistants received extensive training on how to take the anthropometric indices. All study participants' anthropometry measurements (weight and height) were obtained to use the Body Mass Index (BMI) to evaluate their nutritional condition.

Study participant's height was measured twice according to standard procedures using a stadiometer or height board with the average height calculated. Height was measured in meters (m) to the closest 0.1 m without wearing shoes and with their heels touching the wall. The average height was calculated and used for statistical analysis.

Weight of the participants was measured twice using a digital weighing scale. Weight was measured in kilograms (kg) with minimum clothing, to the nearest 0.1 kilogram. The average weight was calculated and used for further analysis.

Body Mass Index (BMI)

The individuals' weight (kg) divided by height (m²) was used to get their body mass index (BMI). According to the standard formula, a person's weight in kilograms is equal to their height in meters squared (kg/m²). Using WHO Anthro Plus version 10.4, the anthropometric index data for height and weight were transformed into a BMI-for-age-Z (BAZ) score, and participants were

categorized as healthy, underweight, overweight, and obese: BAZ < -2SD indicates underweight as BAZ < -2SD, normal weight as $(-2 \text{ SD} \leq \text{BAZ} \leq 1)$, overweight as $1 \text{ SD} < \text{BAZ} \leq 2 \text{ SD}$ and obesity as $\text{BAZ} > 2 \text{ SD}$ ¹⁰.

Dietary Diversity Assessment

Dietary diversity was measured using the WHO and FAO 24-hours dietary recall diversity questionnaire. This was used to determine the dietary iron intake, vitamin C, Zinc and other micro nutrients. Study participants were asked to recall all foods eaten, beverages taken and in-between snacks taken in the last 24hours both in and outside the home. Food models were shown to participants to estimate the quantity of food eaten. Adequate dietary iron and vitamin C were defined as 8 mg/day and 45 mg/day respectively, adapted from the Dietary Reference Intake series¹¹. Inadequate micronutrients intake such as iron, Vitamin C, Zinc and others was described as estimated dietary intake less than the recommended dietary reference intake series.

Biochemical Assessment

Blood sample Collection and Analysis

Infection and prevention control were ensured when collecting the blood samples of the study participant by wearing of appropriate protective equipment such as gloves, use of needles/lancets once, with proper disposal in a safety box. Study participants were asked to relax and sit comfortably at the phlebotomy site. The phlebotomist introduce himself/herself to the study participant, discuss the test to be performed, reassure the participant about the procedure.

The selected study participants were identified using their name and age. The finger (collection site) was disinfected using an alcohol swab. The used alcohol swab was discarded appropriately

and collection site allowed to dry. The lancet was gently used to prick the finger, and the blood placed on the haemoglobin strip in an hemocue analyser and allowed to read. Dry cotton swab was given to the study participant to apply gentle pressure over the collection site. The lancet was immediately discarded into the safety box. Readings on the hemocue analyser was read immediately after 15seconds and recorded on the participants' form.

Haemoglobin level testing

A portable Haemoglobin Testing Meter (Hemo system DG-300HB) was used to determine the haemoglobin levels of all the study participants in the schools. A drop of the capillary blood was obtained from the thumb after a prick and was placed on the haemoglobin meter strip. The haemoglobin value of the participant sample was displayed within 10-15 seconds. The haemoglobin value was recorded. Based on WHO classification, Haemoglobin (Hb) levels lower than 8g/dl were described as severe anaemia, 8g/dl -10.9g/dl as moderate anaemia, 11.0 -11.9g/dl as mild anaemia and haemoglobin levels greater than 12g/dl were described as normal (non-anaemia)¹².

Study Intervention

Nutrition Education

Participants in the intervention groups of the study were given a nutrition education program. Participants in the study's intervention groups received interactive nutrition education training from certified dieticians and nutritionists for six weeks, lasting one hour every session. The intervention's goal was to educate study participants about the connection between iron deficiency and iron deficiency anaemia and the need of proper diet. The importance of iron for

adolescent health, sources of iron-rich foods, identifying locally accessible iron-rich foods, iron-enhancing foods, and how to properly combine them to promote iron absorption were the main topics of the nutrition education intervention.

A 50% attrition risk (loss to follow-up) was taken into consideration as a measure to handle potential dropouts or non-adherence to the study. The training curriculum consists of six modules, each of which was taken once a week as detailed in Table 3.3. The training was delivered through leaflets, lectures, videos, pamphlets, posters, charts, and interactive sessions. The effectiveness of the intervention was evaluated based on the study participants' dietary iron intake, haemoglobin level, knowledge of IDA, and BMI-for-age across the intervention and control groups. Participants were followed up with for six weeks to monitor progress and ensure adherence to the intervention program.

Table 3.3: Modules for the Nutrition Education Training

Week	Topic	Method
1	- Knowing how iron and red blood cells function in the body; -the signs of iron deficiency anaemia and how common it is in teenage girls; and the causes of girls' iron requirements.	Audio-visuals / Food pyramid model/Teaching
2	-The frequency of teenage iron deficient anaemia -The causes of iron deficiency and its riskfactors of Lack of iron Anaemia	Teaching
3	-Food Groups/ Adequate diet -Dietary sources of iron	Interactive session /Poster
4	Iron absorption enhancer/inhibitors	Lecture /song
5	Risk factors and prevention of iron deficiency anaemia	Audio-visuals/Teaching
6	-Different types of iron in food	

Source: Field Survey, 2024

Follow-Up

The study groups were followed up for the period of 6-weeks. The researcher conducted a bi-weekly supportive supervisory visits to the participants in the experimental groups. This is to review and encourage proper dietary habits and discourage poor dietary habits among the study participants. Furthermore, weekly text messages were sent to parents of study participants in the experimental group to reinforce key learnings and actions points as agreed during the training with the study participants.

End-line Evaluation

This was collected after 6 weeks after the intervention. The same questionnaire (validated instrument) used at baseline intervention was also administered at the end-line evaluation to both the experimental and control groups. Quantitative data, nutritional status and biochemical assessment were collected at end-line for both experimental and control groups.

3.9 Method of Data Analysis

Data analysis was conducted using IBM's Statistical Package for Social Science (SPSS) version 25. WHO Anthro Plus version 10.4 was used to convert the weight and height anthropometric index data to the BMI-for-age-Z (BAZ) score. Participants' socio-demographic traits, anthropometry measurements, biochemical evaluations, knowledge and attitudes regarding anaemia, and eating habits were all measured using descriptive statistics such as mean, mean difference, standard deviation, and percentages. Categorical variables including the prevalence of

anaemia, underweight, and inadequate iron intake among the groups were estimated using chi-square analysis. The significance level was tested using Fisher's Exact test.

Mean differences between and among study groups at baseline and end-line were compared using the t-test. T-test was used to compare the means of the nutritional factors (knowledge, attitude, and practice). The effect of the intervention, the observed changes between the baseline and end-line data within the control and intervention groups, and the paired sample T-test were all assessed. The risk variables for anaemia were predicted using regression analysis. A P value of less than 0.05 was considered statistically significant.

Food processor software was used to analyse the participants' 24-hours dietary food recall to evaluate their nutritional content, to get a breakdown of their nutritional content, such as calories, protein, fat, carbohydrates, fibre, vitamins, minerals etc.

Methods of Data Presentation

The data obtained during the data collection process are presented in descriptive forms. Methods of presentation include tables, diagrams, charts, and appendices. The presentation methods was used with the aim of enhancing clarity and understanding where appropriate. Induction and inferences were made based on the results obtained from the analysed data.

3.10 Ethical Approval

Ethical approval for this study were obtained from the Lead City University Health Research and Ethics Committee (LCU-HREC) and the Ogun State Ministry of Health Ethics Review Committee (OGHREC) prior to commencement of study. Permissions were also obtained from

the State Ministry of Education, Science and Technology and appropriate schools' authorities. A duration of six (6) weeks was used in the processing of the Ethical approvals.

Informed Consent

The research process, purpose of the study, procedures, benefits, confidentiality, voluntariness, withdrawal options and duration were explained to the study participants before the commencement of the study by the researcher.

The Informed Consent form (Appendix A) which describe the research process, purpose and duration were duly provided to each participant. A study participant only participated in the study after given assent, the guardian agrees to participate in the study and also gives consent either by signing or thumb printing on the informed consent form.

Hence all participants were duly informed of all the processes in the research before commencement. Involvement in the study was voluntary by both the in-school adolescent girls and parents/guardians. No study participant was coerced to be involved in the study.

Beneficence: The study has no financial incentive for participants but participants received nutrition education on combating iron deficiency anaemia.

Non-maleficence: The Research assistants were of good conduct and did not act in any unethical manner towards the research participants. The study posed no form of harm to the respondents.

Voluntariness: participation in the research was absolutely voluntary, no one was compelled to participate.

Confidentiality: Confidentiality of the participants was given a priority. All information given by the participants were kept undisclosed and were never used for non-research purpose. The research did not in any way inflict harm on the participants and every participant was treated

equally as much as possible. Participants who reported any need for health services were linked with appropriate service provision points.

The control group were equally trained on nutrition education with regards to iron deficiency and iron deficiency anaemia after the study was completed.

Adverse Events

Standard operating procedures and the assistance of a phlebotomist helped to decrease discomfort throughout the finger-based blood collection technique. All trial participants received the contact information for the lead investigator and phlebotomists, and they were advised to get in touch with them in the event of any unfavourable outcomes.

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Endnotes

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Chapter Four

Results and Discussion of Findings

4.1 Demographic Data Analysis

This chapter presents the findings of the study and the discussion. The results are presented in the order, in which the objectives were stated in Chapter one of the study.

A total of 277 adolescent's girls participated in the quasi-experimental study. Table 4.1 below shows the demographic profile of the participants, with the mean age of 13.64 ± 1.82 . The larger respondents were in class JSS1 with percentage of 37.5%. Christianity was the major religion with the highest respondent of 62.1%. The level of education of the Father and Mother with the highest frequency is tertiary (48.7%), (49.1%) respectively. Majority of the study participants stay with their parents (89.5%). Most of the study participants comes from a nuclear family (72.9%). The occupation that is common among the fathers and mothers of the participant is Trading/Business 35.4%, 53.1% respectively.

Table 4.1A: Baseline Socio-demographic Characteristics of Respondents

Variable	Intervention (n=139)	Control (n=138)	Total (n=277)
Age			
Mean \pm S.D	13.5 \pm 1.795	13.91 \pm 1.824	13.64 \pm 1.822
Early Adolescents (10-13)	68(48.9)	58(42)	126(45.5)
Mid Adolescent (14-15)	64(46)	71(51.4)	135(48.7)
Late Adolescents (16-18)	7(5)	9(6.5)	16(5.8)
Class			
Jss1	57(41)	47(34.1)	104(37.5)
Jss2	18(12.9)	33(23.9)	51(18.4)
SS1	43(30.9)	29(21)	72(26)
SS2	21(15.1)	29(21)	50(18.1)
Religion			
Christianity	74(53.2)	98(71)	172(62.1)
Islam	63(45.3)	37(26.8)	100(36.1)
Traditional	1(0.7)	1(0.7)	2(0.7)
None	1(0.7)	2(1.4)	3(1.1)
Place of Residence			
Rural	47(33.8)	23(16.7)	77(27.8)
Urban	92(66.2)	115(83.3)	200(72.2)
Highest Education Level (Mother)			
None	6(4.3)	7(5.1)	13(4.7)
Primary	11(7.9)	16(11.6)	27(9.7)
Secondary	49(35.3)	52(37.7)	101(36.5)
Tertiary	73(52.5)	63(45.7)	136(49.1)
Highest Education Level (Father)			
None	13(9.4)	6(4.3)	19(6.9)
Primary	10(7.2)	10(7.2)	20(7.2)
Secondary	49(35.3)	54(39.1)	103(37.2)
Tertiary	67(48.2)	68(49.3)	135(48.7)
Who Do You Stay With			
Parents	126(90.6)	122(88.4)	248(89.5)
Guardian	7(5)	10(7.2)	17(6.1)
Grandparents	5(3.6)	6(4.3)	11(4)

Others	1(0.7)	0(0)	1(0.4)
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Table 4.1B: Baseline Socio-demographic Characteristics of Respondents

Variable	Intervention(n=139)	Control (n=138)	Total (n=277)
Fathers Occupation			
Artisan	28(20.1)	41(29.7)	69(24.9)
Trading/ business	50(36)	48(34.8)	98(35.4)
Farming	24(17.3)	12(8.7)	36(13)
Civil servant	25(18)	18(13)	43(15.5)
Others	7(5)	8(5.8)	15(5.4)
N/A	5(3.6)	11(8)	
Mothers Occupation			
Artisan	24(17.3)	22(15.9)	46(16.6)
Trading/ business	71(51.1)	76(55.1)	147(53.1)
Farming	14(10.1)	10(7.2)	24(8.7)
Civil servant	19(13.7)	11(8)	30(10.8)
Others	6(4.3)	7(5.1)	13(4.7)
N/A	5(3.6)	12(8.7)	

Anthropometric Status

Majority of the study participants are under-weight (42.2%) while only 0.7% found to be obese (see Table 4.1.1)

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Table 4.1.1: Anthropometric Status

Variable	Intervention(n=139)	Control (n=138)	Total (n=277)
Body Mass Index (BMI)			
Healthy ($-2 \text{ SD} \leq \text{BAZ} \leq 1$)	63(45.3)	54(39.1)	117(42.2)
Obese ($\text{BAZ} > 2 \text{ SD}$)	1(0.7)	1(0.7)	2(0.7)
Overweight ($1 \text{ SD} < \text{BAZ} \leq 2 \text{ SD}$)	10(7.2)	14(10.1)	24(8.7)
Underweight ($\text{BAZ} < -2\text{SD}$)	65(46.8)	69(50)	134(48.4)

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4.2 Presentation of Results

Prevalence of Anaemia of the Intervention and Control at Baseline

Research Question One: The prevalence of anaemia among in-school adolescent girls in Ogun State, Nigeria.

At baseline, majority of the entire study population; 234 adolescent girls, which accounts for about 84.48% of the participants, are experiencing some level of anaemia, whether mild, moderate, or severe. Only, a total of 43 (15.5%) of the study participants are non-anaemic.

The distributions of anaemia severity among the participants are as follows: a total of 165 (59.6%) are experiencing moderate anaemia, 39 (14.1%) experiencing mild anaemia, and 30 (10.8%) experiencing severe anaemia (Refer table 4.2).

Table 4.2: The Prevalence of Anaemia among In-School Adolescent Girls in Ogun State, Nigeria

Baseline

Haemoglobin Level	Intervention (n=139)	Control (n=138)	Total (n=277)
Mild (110-119 g/L)	17(12.2)	22(15.9)	39(14.1)
Moderate(80-109 g)/L	80(57.6)	85(61.6)	165(59.6)
Non-anaemic(>120 g/L)	24(17.3)	19(13.8)	43(15.5)
Severe(<80 g/L)	18(12.9)	12(8.7)	30(10.8)

Research Question Two: The knowledge, attitude and practice of the adolescent girls about iron deficiency anaemia

A. Baseline Knowledge of the Adolescent Girls about Anaemia

The result at baseline showed that majority of the study participants across the study groups have poor knowledge on iron deficiency anaemia. Only 92 adolescent girls (33.2%) across the study groups (control and experimental), have heard about iron deficiency anaemia, while majority 175 (63.2%) have not, and 10 adolescent girls (3.6%) are not sure. When asked if they could identify the symptoms of anaemia, 73 adolescent girls (27.1%) responded affirmatively, 189 adolescent girls (68.2%) said no, and 15 adolescent girls (4.7%) were not sure. Among the 73 adolescent girls who knew the symptoms, the most recognized symptom was weakness (68%), followed by unusual rapid heartbeat (12%), shortness of breath (5.3%), difficulty in concentration (5.3%), headache (5.3%) and pallor (1.3%) (Refer table 4.3).

Regarding the causes of anaemia, 80 girls (28.9%) knew the causes, while 186 girls (67.1%) did not, and 11 girls (4%) were not sure. For those who knew the causes, the most identified cause was lack of iron in the diet (66.3%), followed by sickness/infection (22.5%), heavy menstrual bleeding (5%), eating too little (3.8%), and other causes (2.5%).

When asked about the prevention of anaemia, only 55 adolescent girls (20.6%) knew how to prevent it, 211 adolescent girls (76.2%) did not, and 11 adolescent girls (3.2%) were not sure.

Among those who knew how to prevent anaemia, the most common preventive measure was eating iron-rich foods (56.1%), followed by treating other causes of anaemia (14%), taking iron supplements (10.5%), and eating vitamin-rich foods during or after meals (3.5%).

The knowledge about the consequences of having iron deficiency anaemia was limited, with only 29 adolescent girls (10.5%) aware of them, while 222 adolescent girls (80.1%) were not, and 26 adolescent girls (3.4%) were not sure. Among the 29 girls who knew the consequences, the most recognized consequence was physical development delay (26.3%), followed by poor reproductive health in women (14%), learning difficulties (8.8%), and delayed brain development (1.8%).

Regarding knowledge of iron-rich foods, 57 adolescent girls (10.8%) could mention them, while 220 adolescent girls (79.8%) could not. Among the 57 whom could, the following were mentioned as iron rich foods: eggs (77.2%), followed by vegetables (5.3%), fruit (3.5%), milk (3.5%), cereals (3.5%), meat (3.5%), and tea (3.5%).

Only 9 adolescent girls (3.2%) knew about foods that help iron absorption, while 243 adolescent girls (87.7%) did not, and 25 adolescent girls (9%) were not sure. Among the 9 adolescent girls, the most mentioned foods were eggs (44.4%), followed by vegetables (22.2%), fish (11.1%), orange/juice (11.1%), and beans (11.1%).

Lastly, when asked about beverages that decrease iron absorption when taken with meals, 24 adolescent girls (8.7%) knew about them, 248 adolescent girls (89.5%) did not, and 5 adolescent girls (1.8%) were not sure. Among those who knew, the most mentioned beverages were alcohol (33.3%), followed by Bournvita/Milo (25%), coffee (20.8%), tea (10%), milk (4.2%), and Zobo (4.2%) (Refer table 4.3).

Table 4.3A: Baseline Knowledge of the Adolescent Girls about Anaemia

Knowledge Questions	Intervention (n=139)	Control (n=138)	Total (n=277)
Have You Heard About Iron Deficiency Anaemia			
Yes	47(33.8)	45(32.6)	92(33.2)
No	92(66.2)	93(67.4)	175(63.2)
Do You Know/ Identify Symptoms of Anaemia			
Yes	35(25.2)	40(29)	75(27.1)
No	104(74.8)	98(71)	202(72.9)
If Yes, What Are the Symptoms			
Weakness	26(74.3)	25(60.9)	51(68)
Pallor	1(2.9)	1(2.3)	1(1.3)
Unusual Rapid Heartbeat	2(5.7)	7(16.67)	9(12.0)
Shortness of Breathe	1(2.9)	3(7.1)	4(5.3)
Difficult in Concentration	2(5.7)	2(4.7)	4(5.3)
Headache	1(2.9)	3(7.1)	4(5.3)
Do You Know the Causes of Anaemia			
Yes	45(33.3)	35(25.4)	80(28.9)
No	83(61.5)	103(74.6)	186(67.1)
Not sure	1(8.1)	0(0)	11(4.0)
If Yes, What Causes Anaemia			
Lack of Iron in the Diet	28(63.6)	25(71.4)	53(66.3)
Eat too Little	1(2.3)	1(2.7)	3(3.8)
Sickness/Infection	11(25)	7(18.9)	18(22.5)
Heavy Menstrual Bleeding	2(4.6)	2(5.4)	4(5.0)
Others	0(0)	2(5.4)	2(2.5)
Do You Know How To Prevent Anaemia			
Yes	29(20.9)	28(20.3)	57(20.6)
No	110(79.1)	110(79.7)	220(79.4)
If Yes How Do You Prevent Anaemia			
Eat Iron Rich Foods	16(55.2)	16(57.1)	32(56.1)
Eat Vitamins	0(0)	2(7.1)	2(3.5)
Rich Foods During or After Meal	2(13.8)	4(14.3)	6(10.5)
Take Iron Supplement	4(13.8)	4(14.3)	8(14.0)
Treat Other Causes of Anaemia	4(13.8)	3(10.7)	7(12.3)
Do You Know the Consequences of Having Iron Deficiency Anaemia			
Yes	22(15.8)	24(82.6)	46(16.9)

No	117(84.2)	114(82.6)	231(83.1)
If Yes, What Are the Consequences of Anaemia			
Physical Development Delay	4(36.4)	11(45.8)	15(26.3)
Learning Difficulties	1(9.1)	4(16.7)	5(8.8)
Poor Reproductive Health in Women	1(9.1)	7(29.2)	8(14.0)
Delayed Brain Development	1(9.1)	2(8.3)	1(1.8)

Table 4.3A: Baseline Knowledge of the Adolescent Girls about Anaemia

Do You Know/Can Mention Iron Rich Foods			
Yes	18(12.9)	12(8.7)	57(10.8)
No	121(87.1)	126(91.3)	220(79.8)
If Yes Mention Anyone You Know			
Egg	43(97.7)	1(2.3)	44(77.2)
Tea	1(2.3)	1(2.3)	2(3.5)
Fruit	1(2.3)	1(2.3)	2(3.5)
Milk	1(2.3)	1(2.3)	2(3.5)
Cereals	1(2.3)	1(2.3)	2(3.5)
Meat	0(0)	2(4.5)	2(3.5)
vegetables	1(2.3)	2(4.5)	3(5.3)
Do You Know About Foods That Helps Iron Absorption?			
Yes	5(3.7)	4(2.9)	9(3.2)
No	109(80.7)	134(97.1)	243(87.7)
Not sure	25(18.5)	0(0)	25(9.0)
If Yes Mention Anyone Know			
Beans	1(20)	0(0)	1(11.1)
Egg	3(60)	1(25)	4(44.4)
Fish	0(0)	1(25)	1(11.1)
Orange/ Juice	1(20)	0(0)	1(11.1)
Vegetable	0(0)	2(50)	2(22.2)
Do You Know Beverages That Decrease Iron Absorption When Taken With Meals?			
Yes	13(9.3)	11(8)	24(8.7)
No	121(87.1)	127(92)	248(89.5)
Not sure	5(3.6)	0(0)	5(1.8)
If Yes Mention Anyone You Know (n=24)			
Alcohol	7(29.2)	1(4.2)	8(33.3)
Bournvita/Milo	5(20.8)	1(4.2)	6(25)
Coffee	0(0)	5(20.8)	5(20.8)
Tea	2(8.3)	1(4.2)	3(10)
Milk	0(0)	1(4.2)	1(4.2)
Zobo	1(4.2)	0(0)	1(4.2)

Level of Knowledge of Adolescent Girls about Anaemia

The level of knowledge about anaemia among adolescent girls in Ogun State is predominantly poor, with 83% of the respondents demonstrating insufficient knowledge.

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Table 4.3 B: Level of Baseline Knowledge of adolescent girls about anaemia

Level of Knowledge	Intervention (n=139)	Control (n=138)	Total (n=277)	P value
Poor	113(81.3)	117(84.8)	230(83)	0.441
Good	26(18.7)	21(15.2)	47(17)	

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B. Baseline Attitude of the Adolescent Girls about Anaemia

The result was measured based on an 8-point perception likert scale. Regarding their perceived likelihood of being anaemic, about two-third of the participants (65.3%) are uncertain, 17.7% think it is not likely, and 17% think it is likely that they are anaemic. Among those who believe they are not likely to be anaemic, the main reasons include being active, eating good food, and never having been diagnosed with anaemia.

When asked about the seriousness of anaemia, 59.2% consider it serious, 21.7% are uncertain, and 19.1% think it is not serious. Opinions on whether anaemia can be prevented with iron supplements alone are divided: 45.1% agree, 38.3% disagree, 10.1% strongly agree, and 6.5% strongly disagree.

A significant majority (84.5%) think it is good to prepare meals rich in iron, with 52% agreeing and 32.5% strongly agreeing. Confidence in preparing iron-rich meals is high, with 46.9% agreeing and 26% strongly agreeing, although 22.7% disagree and 4.3% strongly disagree. Lastly, 74.8% like the taste of iron-rich foods, with 46.6% agreeing and 28.2% strongly agreeing. However, 19.1% disagree and 6.1% strongly disagree. (Refer table 4.4)

Table 4.4A: Baseline Attitude of the Adolescent Girls about Anaemia

Variable	Intervention(n=139)	Control(n=138)	Total(n=277)
How Likely Do You Think/ You Are Anaemia/ Iron-Deficient			
Not likely	27(19.4)	22(15.9)	49(17.7)
Uncertainty	87(62.6)	94(68.1)	181(65.3)
Likely	25(18)	22(15.9)	47(17.0)
If You Chose Not Likely Why?			
I Am Very Active In Everything I Do	5(18.5)	3(13.6)	8(16.3)
I Have Not Started Menstruation	2(7.4)	1(4.5)	3(6.1)
I Do Go To Hospital	0(0)	1(4.5)	1(2.0)
I Don't Have Low Blood	0(0)	2(9)	2(4.1)
I Drink Enough Water	0(0)	1(4.5)	1(2.0)
I Eat Good Food	10(37)	6(27.3)	16(32.7)
I Eat Iron Rich Food Very Much	3(11.1)	2(9)	5(10.3)
I Have Never Been Diagnosed For It	2(7.4)	1(4.5)	3(6.1)
I Know Am Not Anaemic	4(14.8)	3(13.6)	7(14.3)
I Take Blood Tonic	0(0)	1(4.5)	1(2.0)
My Eye Will Be White If I Am Anaemic	1(3.7)	1(4.5)	2(4.1)
How Serious an Issues Do You Think Anaemia			
Not serious	27(19.4)	26(18.8)	53(19.1)
Serious	84(60.4)	80(58)	164(59.2)
uncertain	28(20.1)	32(23.2)	60(21.7)
Do You Think Anaemia Can Be Prevented with Use of Iron Supplement Alone			
Strongly agree	15(19.8)	13(9.4)	28(10.1)
Agree	65(46.8)	60(43.5)	125(45.1)
Disagree	53(38.1)	53(38.4)	106(38.3)
Strongly disagree	6(4.3)	12(8.7)	18(6.5)
Do You It's Good to Prepare			

Meals That Are Rich in Irons

Strongly agree	48(34.5)	42(30.4)	90(32.5)
Agree	75(54)	69(50)	144(52.0)
Disagree	10(7.2)	20(14.5)	30(10.8)
Strongly disagree	6(4.3)	7(5.1)	13(4.7)

Table 4.4B: Baseline Attitude of the Adolescent Girls about Anaemia**Are You Confident When Preparing Meals That Are Rich In Iron**

Strongly agree	39(26.1)	33(23.9)	72(26.0)
Agree	63(45.3)	67(48.6)	130(46.9)
Disagree	31(22.3)	32(23.2)	63(22.7)
Strongly disagree	6(4.3)	6(4.3)	12(4.3)

Do You Like The Taste Of Iron Rich Food Items?

Strongly agree	43(30.9)	35(24.4)	78(28.2)
Agree	63(45.3)	66(47.8)	129(46.6)
Disagree	26(18.7)	27(19.6)	53(19.1)
Strongly Disagree	7(5)	10(7.2)	17(6.1)

Level of Attitude of Adolescent Girls about Anaemia

Table 4.4 C indicates that the level of attitude towards anaemia among adolescent girls is generally more negative than positive. Out of the total respondents, 155 girls (56%) have a negative attitude, while 122 girls (44%) have a positive attitude towards anaemia.

Table 4.4 C: Level of Baseline Attitude of adolescent girls about anaemia

Level of Attitude	Intervention(n=139)	Control (n=138)	Total (n=277)	P value
Positive	52(37.4)	70(50.7)	122(44)	0.026
Negative	87(62.6)	68(49.3)	155(56)	

C. Baseline Practices of the Adolescent Girls about Anaemia

The iron dietary practices of adolescent girls are very poor which is shown in their intake of iron-rich foods and consumption of Vitamin C fruits which aids in iron absorption. A small percentage of the girls reported consuming liver (5.1%) and kidney (0.9%), while beef is more commonly eaten by 14.5%. Chicken and goat meat are consumed by 11.1% and 6.0%, respectively, with fish being the most consumed iron-rich food at 52.6%. Seafood such as prawns and crayfish are eaten by 5.1% of the girls, while other iron-rich foods like sweet potato (6.8%), soybeans (4.7%), fortified breakfast cereals (0.4%), and whole wheat flour (3.8%) have lower consumption rates. Additionally, 75.8% of the girls usually eat fresh citrus fruits, which aid in iron absorption, but only 37.6% of those who eat citrus fruits do so daily, with most girls (66.7%) consuming them at any time during the day.

Regarding their coffee and tea drinking habits, a significant majority (81.9%) of the girls usually drink coffee or tea. Among these, only 19.4% drink it daily. While 48 (23.1%) drinks it during mealtime. The practice of drinking beverages during mealtime is also a poor practice among the participants which decreases their iron absorption when consumed with iron-rich diet. (Refer table 4.5)

Table 4.5: Baseline Practices of the Adolescent Girls about Anaemia

Food - Intake Practice	Intervention(n=139)	Control (n=138)	Total (n=277)	P value
Yesterday During the Day Or The Night Did You Eat Any Of The Following				0.01
Animal Protein	117(84.2)	98(71)	215(77.6)	
Legumes	5(3.6)	6(4.3)	11(3.9)	
Carbohydrates	12(8.7)	13(9.4)	25(9)	
Fortified Foods	0(0)	1(0.7)	1(0.3)	
Others	5(3.6)	12(8.7)	17(6.1)	
Do You Usually Eat Fresh Vitamins C: Orange Lemon Pineapple Watermelon Mango Or Juice Made From Them				0.76
Yes	99(71.2)	111(80.4)	210(75.8)	
No	36(25.9)	26(18.8)	62(22.4)	
Others	4(2.9)	1(0.7)	5(1.8)	
If Yes Do You Eat Them (Fresh Citrus Fruits) Everyday				0.31
Yes	39(41.1)	40(36)	79(37.6)	
No	58(58.6)	67(60.4)	125(59.5)	
Not sure	2(0.3)	4(3.6)	6(2.9)	
When Do Usually Eat Fresh Citrus Fruits				0.07
Before meals	16(16.2)	15(13.5)	31(14.8)	
During meals	6(6.1)	9(8.1)	15(7.1)	
After meals	15(15.1)	9(8.1)	24(11.4)	
Anytime	62(62.6)	78(70.3)	140(66.7)	
Do You Usually Drink Coffee Or Tea				0.45
Yes	121(87.1)	106(76.8)	227(81.9)	
No	14(10.1)	31(22.5)	45(16.2)	
Others	4(2.9)	1(0.7)	5(1.8)	
If Yes Do You Drink Coffee/Tea Everyday				0.02

Yes	21(17.4)	23(21.7)	44(19.4)	
No	98(81)	77(72)	175(77.1)	
Not sure	2(1.6)	6(5.7)	8(3.5)	
When Do You Usually Drink Coffee/Tea				0.44
Two hours before meal	10(8.3)	14(13.2)	24(8.7)	
During meals	23(19)	25(23.6)	48(23.1)	
Two hours or more after meal	27(22.3)	16(15.1)	41(16.6)	
Right before meal	12(9.9)	11(10.4)	23(9.0)	
Right after meal	24(19.8)	15(14.2)	29(15.2)	
Never	12(9.9)	14(13.2)	26(18.1)	
Others	13(10.7)	11(10.4)	24(9.4)	

Research Question Three: What is the dietary intake of iron and other relevant nutrients among in-school adolescent girls in Ogun state, Nigeria?

The result from the dietary intake data for in-school adolescent girls in Ogun State, Nigeria, highlights significant nutritional imbalances. A considerable proportion of the girls (56.3%) have inadequate iron intake, which is a major concern about the essential role of iron in preventing iron deficiency anaemia. Additionally, 96% of the girls have insufficient total fibre intake, and about 50.5% fall short in their zinc intake. These inadequacies are critical as they can impact the girls' overall health, immune function, and cognitive development.

On the other hand, some nutrients are consumed in adequate or even excess amounts by most of the girls. For instance, 84% have adequate protein intake, and 55% meet or exceed the recommended intake for carbohydrates. Calcium and vitamin D intake were adequate for 47.7% and 56.3% of the girls respectively. However, the high prevalence of inadequate intake for key nutrients like iron, fibre, and zinc indicates a need for improved dietary practices. (see Table 4.6)

Table 4.6A: Dietary Intake of Iron and Other Relevant Nutrients among In-School Adolescent Girls in Ogun State, Nigeria

Nutrient	Number of girls with Inadequate (<60%) nutrients intake	Number of girls with Adequate (60-80%) nutrients intake	Number of girls with Excess (>80%) nutrient
Iron (mg)			
Intervention(n=139)	75(54)	47(33.8)	17(12.2)
Control(n=138)	81(58.7)	41(29.7)	16(11.6)
Calories (kcal)			
Intervention(n=139)	43(30.9)	42(30.2)	64(38.8)
Control(n=138)	54(39.1)	38(27.5)	46(33.3)
Protein (g)			
Intervention(n=139)	10(7.2)	122(87.8)	7(5)
Control(n=138)	15(10.9)	111(80.4)	12(8.7)
Carbohydrate (g)			
Intervention(n=139)	25(18)	34(24.5)	80(57.5)
Control(n=138)	36(26.1)	30(21.7)	72(52.2)

Total Fibre (g)			
Intervention(n=139)	135(97.1)	2(1.4)	3(2.2)
Control(n=138)	131(94.9)	4(2.9)	3(2.2)
Vitamin C (mg)			
Intervention(n=139)	30(21.6)	76(54.7)	33(23.7)
Control(n=138)	28(20.3)	79(57.2)	31(22.5)

Table 4.6B: Dietary Intake of Iron and Other Relevant Nutrients among In-School Adolescent Girls in Ogun State, Nigeria

Nutrient	Inadequate (<60%)	Adequate (60-80%)	Excess (>80%)
Calcium (mg)			
Intervention(n=139)	55(39.6)	67(48.2)	17(12.2)
Control(n=138)	48(34.8)	65(47.1)	25(18.1)
Vitamin D (mg)			
Intervention(n=139)	31(22.3)	81(58.3)	27(19.4)
Control(n=138)	36(26.1)	75(54.3)	27(19.6)
Vitamin B12(mcg)			
Intervention(n=139)	37(26.6)	74(53.2)	28(20.1)
Control(n=138)	41(29.7)	64(46.4)	33(23.9)
Potassium (mg)			
Intervention(n=139)	49(35.3)	58(41.7)	32(23)
Control(n=138)	40(29)	54(39.1)	44(31.9)
Magnesium (mg)			

Intervention(n=139)	44(31.7)	67(48.2)	28(20.1)
Control(n=138)	34(24.6)	71(51.4)	33(23.9)
Zinc (mg)			
Intervention(n=139)	71(51.1)	41(29.5)	27(19.4)
Control(n=138)	69(50)	47(34.1)	22(15.9)

Research Objective Four: Knowledge of the Caregivers about Anaemia

Out of the respondents, only 37.1% had heard about anaemia, while the majority (62.9%) had not. Similarly, 37.1% reported that they could identify symptoms of anaemia, and 62.9% could not. Among those who knew the symptoms, 35.4% mentioned weakness, 29.2% identified unusual rapid heartbeat, 20% mentioned pallor, 12.3% noted shortness of breath, and 3.1% mentioned difficulty in concentration.

When asked about the causes of anaemia, only 30.3% said they knew, while 69.7% did not. Among those who claimed to know the causes, 37.7% mentioned lack of iron in the diet, 28.3% mentioned sickness or infection, and both eating too little and heavy menstrual bleeding were mentioned by 17% each.

Similarly, 30.3% of respondents said they knew how to prevent anaemia, while 69.7% did not. Among those who knew how, 35.8% each suggested eating iron-rich foods and eating rich foods during or after meals, 22.6% mentioned taking iron supplements, and 5.7% mentioned treating other causes of anaemia.

When asked about the consequences of iron deficiency anaemia, again only 30.3% said they were aware, while 69.7% were not. Among those who knew, 41.5% mentioned physical development delay, 30.2% cited poor reproductive health in women, 15.1% noted learning

difficulties, 9.4% mentioned delayed brain development, and 3.8% mentioned other consequences.

Regarding knowledge of iron-rich foods, 30.3% said they knew at least one, while 69.7% did not. Among those who mentioned any, 32.1% said meat, 17% mentioned milk, 13.2% mentioned vegetables, 11.3% mentioned beans, while smaller proportions mentioned fruit (9.4%), eggs (7.5%), tea (7.5%), and cereals (1.9%).

About 30.3% of respondents said they knew foods that help iron absorption, while 69.7% did not. Among those who could name such foods, 24.5% mentioned fish, 20.8% each mentioned meat and vegetables, 15.1% mentioned beans, 11.3% mentioned orange or juice, and 7.5% mentioned eggs.

Similarly, 30.3% said they knew beverages that decrease iron absorption when taken with meals, while 69.7% did not. Among those who responded, 45.3% mentioned milk, 30.2% mentioned coffee, 20.8% mentioned Bournvita/Milo, and very small proportions mentioned alcohol (1.9%) and tea (1.9%).

Table 4.7: Knowledge of the Caregivers about Anaemia

Knowledge Questions	Frequency	Percent
Have You Heard About Anaemia		
Yes	65	37.1
No	110	62.9
Do You Know/ Identify Symptoms of Anaemia		
Yes	65	37.1
No	110	62.9
If Yes, What Are the Symptoms		
Weakness	23	35.4
Pallor	13	20
Unusual Rapid Heartbeat	19	29.2
Shortness of Breathe	8	12.3
Difficult in Concentration	2	3.1
Do You Know the Causes of Anaemia		
Yes	53	30.3
No	122	69.7
If Yes, What Causes Anaemia		
Lack of Iron in the Diet	20	37.7
Eat too Little	9	17
Sickness/Infection	15	28.3
Heavy Menstrual Bleeding	9	17
Do You Know How to Prevent Anaemia		
Yes	53	30.3
No	122	69.7
If Yes, How Do You Prevent Anaemia		
Eat Iron Rich Foods	19	35.8
Rich Foods During or After Meal	19	35.8
Take Iron Supplement	12	22.6
Treat Other Causes of Anaemia	3	5.7
Do You Know the Consequences of Having Anaemia		
Yes		

No	53	30.3
	122	69.7
If Yes, What Are the Consequences of Anaemia		
Physical Development Delay	22	41.5
Learning Difficulties	8	15.1
Poor Reproductive Health in Women	16	30.2
Delayed Brain Development	5	9.4
Others	2	3.8
Do You Know/Can Mention Iron Rich Foods		
Yes	53	30.3
No	122	69.7
If Yes Mention Anyone You Know		
Egg	4	7.5
Tea	4	7.5
Fruit	5	9.4
Milk	9	17
Cereals	1	1.9
Meat	17	32.1
Vegetables	7	13.2
Beans	6	11.3
Do You Know About Foods That Helps Iron Absorption?		
Yes	53	30.3
No	122	69.7
If Yes Mention Anyone Know		
Beans	8	15.1
Egg	4	7.5
Fish	13	24.5
Orange/ Juice	6	11.3
Vegetable	11	20.8
Meat	11	20.8
Do You Know Beverages That Decrease Iron Absorption When Taken With Meals?		
Yes	53	30.3
No	122	69.7
If Yes Mention Anyone You Know (n=24)		
Alcohol	1	1.9
Bournvita/Milo	11	20.8
Coffee	16	30.2
Tea	1	1.9
Milk	24	45.3

Level of Knowledge

The level of knowledge of caregivers about anaemia was generally low. About 67.4% of the respondents had a poor level of knowledge, while only 32.6% demonstrated a good level of knowledge about the condition.

Table 4.7 A: Level of Knowledge of Caregivers About Anaemia

Level of Knowledge	Frequency	Percent
Poor	118	67.4
Good	57	32.6

Attitude of the Caregivers about Anaemia

When asked how likely they thought they were to have anaemia or be iron-deficient, just under a quarter (24%) of the caregivers believed it was likely, while 22.9% felt it was not likely, and the majority (53.1%) were uncertain. Among those who thought it was not likely, 27.5% attributed this to eating good food, 25% said it was because blood comes out quickly when injured, 17.5% felt they were healthy, 15% said they did not look pale, 12.5% claimed they “just knew,” and 2.5% chose not to disclose a reason.

On the seriousness of anaemia, 60% of respondents regarded it as a serious issue, 24% felt it was not serious, and 16% were uncertain. Regarding whether anaemia can be prevented with iron supplements alone, 60.6% agreed, 13.7% strongly agreed, while 16.6% disagreed and 9.1% strongly disagreed.

Most caregivers (60.6%) agreed that it is good to prepare meals that are rich in iron, while 26.3% strongly agreed, 9.7% disagreed, and 3.4% strongly disagreed. When asked about their confidence in preparing iron-rich meals, over half (52.6%) agreed they felt confident, 20% strongly agreed, 19.4% disagreed, and 8% strongly disagreed.

Finally, regarding whether they liked the taste of iron-rich foods, 57.7% agreed, 12.6% strongly agreed, while 14.9% each disagreed or strongly disagreed.

Table 4.8: Attitude of the Caregivers about Anaemia

Variable	Frequency	Percent
How Likely Do You Think/ You Are Anaemia/ Iron-Deficient		
Not likely	40	22.9
Uncertainty	93	53.1
Likely	42	24
If You Chose Not Likely Why?		
Blood comes out fast when injured	10	25
I am healthy	7	17.5
I just know	5	12.5
I do not look pale	6	15
I eat good food	11	27.5
No disclosure	1	2.5
How Serious an Issues Do You Think Anaemia		
Not serious	42	24
Serious	105	60
uncertain	28	16
Do You Think Anaemia Can Be Prevented with Use of Iron Supplement Alone		
Strongly agree	24	13.7
Agree	106	60.6
Disagree	29	16.6
Strongly disagree	16	9.1
Do You It's Good to Prepare Meals That Are Rich in Irons		
Strongly agree	46	26.3
Agree	106	60.6
Disagree	29	9.7

Strongly disagree	16	3.4
Are You Confident When Preparing Meals That Are Rich in Iron		
Strongly agree	35	20
Agree	92	52.6
Disagree	34	19.4
Strongly disagree	14	8
Do You Like the Taste of Iron Rich Food Items?		
Strongly agree	22	12.6
Agree	101	57.7
Disagree	26	14.9
Strongly Disagree	26	14.9

Level of Attitude of Caregivers about Anaemia

Table 4.8A: Level of Attitude of Caregivers about Anaemia

Level of Attitude	Frequency	Percent
Positive	67	51.5
Negative	63	48.5

Practices of the Caregivers about Anaemia

When asked about their food intake the previous day, more than half of the caregivers reported eating beef (52%) and fish (60%), while 56.6% consumed seafood such as prawns or crayfish. Liver and kidney were less commonly eaten, reported by 27.4% and 21.7% respectively. About one-third ate chicken (33.7%), goat meat (32.6%), sweet potato (30.3%), soybeans (31.4%), whole wheat flour (32%), or other foods (48%). Fortified breakfast cereals were consumed by over half of the respondents (54%).

Regarding vitamin C intake, 64.6% of respondents reported that they usually eat fresh fruits rich in vitamin C, such as oranges, lemons, pineapples, watermelon, mango, or juices made from them, and all of them (100%) said they consume these fruits daily. When asked when they typically eat fresh citrus fruits, 24.6% reported eating them after meals, 20.6% before meals, 17.7% at any time, and 1.7% during meals, while 35.4% did not disclose a specific pattern.

On coffee and tea consumption, 53.1% said they usually drink coffee or tea, while 46.9% said they do not. Among those who drink coffee or tea, 46.9% indicated they consume it every day, while 53.1% said they do not or were unsure. When asked about the timing of coffee or tea intake, 30.3% reported drinking it two hours before a meal, 13.3% during meals, 14.9% two

hours or more after meals, 6.9% right before meals, and 8% right after meals. A few respondents (1.1%) said they never drink coffee or tea, and 25.7% mentioned other unspecified times.

Table 4.9: Practices of the Caregivers about Anaemia

Food - Intake Practice	Frequency	Percent
Yesterday During the Day Or the Night Did		
You Eat Any of The Following		
Liver	48	27.4
Kidney	38	21.7
Beef	91	52
Chicken	59	33.7
Goat meat	57	32.6
Fish	105	60
Sea food prawns cray fish	90	56.6
Sweet potato	53	30.3
Soyabeans	55	31.4
Fortified breakfast cereals	96	54.9
Whole wheat flour	56	32
Others	84	48
Do You Usually Eat Fresh Vitamins C:		
Orange Lemon Pineapple Watermelon		
Mango Or Juice Made From Them	113	64.6
Yes	62	35.4
No		

If Yes Do You Eat Them (Fresh Citrus Fruits) Everyday

Yes	113	100
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When Do Usually Eat Fresh Citrus Fruits

Before meals	36	20.6
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During meals	3	1.7
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After meals	43	24.6
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Anytime	31	17.7
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No Disclosure	62	35.4
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Do You Usually Drink Coffee Or Tea

Yes	61	53.1
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No	69	46.9
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If Yes Do You Drink Coffee/Tea Everyday

Yes	61	46.9
-----	----	------

No	69	53.1
----	----	------

Not sure

When Do You Usually Drink Coffee/Tea

Two hours before meal	53	30.3
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During meals	23	13.3
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Two hours or more after meal	26	14.9
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Right before meal	12	6.9
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Right after meal	14	8.0
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Never	2	1.1
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Others	45	25.7
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Post Study Assessment Findings

Prevalence of Anaemia Post-Intervention

The prevalence of anaemia among the participants at the end of the study period was 86.8%. The prevalence of anaemia in the intervention group was 85.2%, which was lower than 88.3% observed in the control group. The difference was statistically significant at $P = 0.001$.

The most significant difference between the groups was observed in the mild anaemia category (110-119g/L), where nearly half of the participants in the intervention group (49.6%) were mildly anaemic compared to 15.3% in the control group. In the moderate anaemia category (80-109g/L), the control group showed a higher prevalence (58.4%) compared to the intervention group (31.9%). Despite this, moderate anaemia remained the most common condition post-intervention, with 45.2% of the total study participants falling into this category.

For severe anaemia (<80g/L), the intervention group had a much lower prevalence (3.7%) compared to the control group (14.6%), suggesting that the intervention was effective in

reducing the number of participants with dangerously low haemoglobin levels. Across both groups, only 9.2% of participants were severely anaemic post-intervention.

The non-anaemic group (haemoglobin >120g/L) showed a slight improvement, with 14.8% of participants in the intervention group being non-anaemic compared to 11.7% in the control group.

Table 4.10: Prevalence of anaemia among In-School Adolescent Girls in Ogun State, Nigeria after Intervention

Haemoglobin Level	Intervention	Control	Total	P value
Mild (110-119g/L)	67(49.6)	21(15.3)	88(32.4)	0.001*
Moderate (80-109g/L)	43(31.9)	80(58.4)	123(45.2)	
Non-anaemic (>120 g/L)	20(14.8)	16(11.7)	36(13.2)	
Severe (<80 g/L)	5(3.7)	20(14.6)	25(9.2)	

Post Study Knowledge of Anaemia Among the Participants

The post-intervention data on the knowledge of adolescent girls regarding IDA is shown in table 4.10. At the end of the study period, 97.8% of participants in the intervention group had heard about iron deficiency anaemia, compared to 78.8% in the control group. The difference was statistically significant at $P = 0.001$.

Regarding knowledge of anaemia symptoms, 83.7% of participants in the intervention group could identify symptoms, compared to 35% in the control group ($P = 0.000$). Among those who could identify symptoms, the most recognized were shortness of breath (100%), headache (100%), and difficulty in concentration (90.2%) in the intervention group. In contrast, the control group had lower awareness, with 26.7% recognizing shortness of breath and 0% recognizing difficulty in concentration.

Awareness of anaemia causes was also higher in the intervention group (91.1%) compared to the control group (70.1%), though this difference was not statistically significant ($P = 0.668$). Among those aware, 100% of intervention participants correctly identified lack of iron in the diet,

eating too little, sickness/infection, and heavy menstrual bleeding as causes, compared to 67.7%, 12.5%, and 53.1% in the control group ($P < 0.000$ for most responses).

Knowledge of anaemia prevention was significantly higher in the intervention group (88.1%) compared to the control (46.7%) ($P = 0.987$). Among those aware, 100% of intervention participants correctly identified eating iron-rich foods, taking iron supplements, and treating underlying causes as preventive measures, compared to 67.6%, 15.6%, and 12.5% in the control group ($P < 0.000$ for most responses).

Similarly, knowledge of the consequences of anaemia was higher in the intervention group (83.9%) compared to the control (28.5%) ($P = 0.000$). In the intervention group, 97.5% recognized poor reproductive health in women as a consequence, while only 35.9% in the control group did.

Knowledge of iron-rich foods was significantly higher in the intervention group (94.1%) compared to the control (28.5%) ($P = 0.003$). Among those who identified iron-rich foods, 39.4% in the intervention group recognized vegetables, compared to 20.5% in the control. Meat was identified by 20.6% of the intervention group compared to 7.6% in the control ($P < 0.05$ for several responses).

When asked about foods that help iron absorption, 92.5% of the intervention group had knowledge compared to 2.2% in the control ($P = 0.001$). Among those who responded, 99.2% in the intervention group identified vegetables as aiding iron absorption, while none in the control group did.

Conversely, when asked about beverages that decrease iron absorption, 53.3% of the intervention group were aware compared to 10.2% in the control ($P = 0.000$). Among those who could

identify specific beverages, 60.4% in the intervention group recognized tea, compared to 28.6% in the control (P = 0.012).

Table 4.11: Post study Knowledge of the Adolescent Girls about Anaemia

Knowledge Questions	Intervention	Control	Total	P value
Have You Heard About Iron Deficiency Anaemia				0.001
Yes	132(97.8)	108(78.8)	240(88.2)	
No	3(2.2)	17(12.4)	20(7.4)	
Not sure		12(8.8)	12(4.4)	
Do You Know/ Identify Symptoms of Anaemia				0.000
Yes	113(83.7)	48(35)	161(59.2)	
No	19(14.1)	65(47.4)	84(30.9)	
Not sure	0(0)	24(17.5)	24(8.8)	
If Yes, What Are The Symptoms				0.000
Weakness	97(71.9)	32(77.8)	129(80.1)	0.000
Pallor	99(87.6)	22(48.8)	121(75.2)	0.000
Unusual rapid heartbeat	97(71.9)	4(8.3)	101(62.7)	0.000
Shortness of breathe	113(100)	12(26.7)	125(77.6)	0.000
Difficult in concentration	102(90.2)	0(0)	102(63.4)	0.000
Headache	113(100)	47(97.9)	160(99.4)	0.000
Do You Know The Causes of Anaemia				0.668
Yes	123(91.1)	96(70.1)	219(80.5)	
No	12(8.9)	36(26.3)	48(17.6)	
Not sure	0(0)	5(3.6)	5(1.8)	
If Yes, What Causes Anaemia				

Lack of iron in the diet	123(100)	96(100)	219(100)	0.013
Eat too little	119(99.2)	65(67.7)	184(84)	0.000
Sickness/infection	123(100)	12(12.5)	135(61.6)	0.000
Heavy menstrual bleeding	123(100)	51(53.1)	174(79.5)	0.000
Others	1(0.7)	0(0)	1(0.5)	0.000
Do You Know How To Prevent Anaemia				0.987
Yes	119(88.1)	64(46.7)	183(67.4)	
No	16(11.9)	57(41.6)	73(26.8)	
Not sure	0(0)	16(11.7)	16(5.8)	
If Yes How Do You Prevent Anaemia				
Eat Iron rich foods	119(100)	46(67.6)	165(90.2)	0.000
Eat Vitamin	119(100)	23(35.9)	142(77.6)	0.000
Rich Foods During or After Meal	119(100)	10(15.6)	129(70.5)	0.000
Take Iron Supplement	119(100)	8(12.5)	127(69.4)	0.000
Treat other Causes of Anaemia	117(98.3)	21(32.8)	138(75.4)	0.000
Table 4.11B: Post study Knowledge of the Adolescent Girls about Anaemia				
Knowledge Questions	Interventi on	Control	Total	P value
Do You Know The Consequences of Having Iron Deficiency Anaemia				0.000
Yes	120(83.9)	39(28.5)	159(58.5)	
No	15(11.1)	84(61.3)	99(36.4)	
Not sure	0(0)	14(10.2)	14(5.1)	
If Yes, What Are The Consequences of Anaemia				0.000
Physical Development Delay	109(90.8)	20(51.3)	129(81.1)	0.000
Learning Difficulties	111(92.5)	16(41)	127(79.9)	0.000
Poor Reproductive Health in women	117(97.5)	14(35.9)	131(82.4)	0.000
Delayed brain development	105(87.5)	19(48.7)	124(77.9)	0.000
Do You Know/Can Mention Iron Rich Foods				0.003
Yes	127(94.1)	39(28.5)	166(61)	
No	8(5.9)	81(59.1)	89(32.7)	
Not sure	0(0)	17(12.4)	17(6.3)	
If Yes Mention Anyone You Know				0.019
Egg	20(21.7)	3(7.6)	23(13.6)	0.278
Tea	1(1.08)	0(0)	1(0.4)	0.684
Fruit	10(10.8)	5(12.8)	15(11.8)	0.000
Milk	14(15.2)	0(0)	14(5.1)	0.888
Cereals	9(9.7)	4(10.3)	13(9.9)	0.032
	19(20.6)	3(7.6)	22(13.2)	

Meat	50(39.4)	8(20.5)	58(21.3)	0.017
Vegetables	4(4.3)	8(20.5)	12(12.3)	0.003
Fish	0(0)	8(20.5)	8(7.4)	0.000
Plantain/banana				
Do You Know About Foods That Helps Iron Absorption?				0.001
Yes	125(92.5)	3(2.2)	128(47.1)	
No	10(7.5)	114(83.2)	124(45.6)	
Not sure	0(0)	20(14.6)	20(7.3)	
If Yes Mention Anyone Know				
Blood Tonic	120(96)	0(0)	120(44.1)	0.000
Egg	117(93.6)	3(100)	120(44.1)	0.325
Fish	4(3.2)	0(0)	4(1.5)	0.446
Orange/ Juice	14(11.7)	0(0)	14(5.1)	0.034
Vegetable	124(99.2)	0(0)	124(45.6)	0.000
Beverages	14(11.2)	0(0)	14(5.1)	0.034

Table 4.11C: Post study Knowledge of the Adolescent Girls about Anaemia

Knowledge Questions	Intervention	Control	Total	P value
Do You Know Beverages That Decrease Iron Absorption When Taken With Meals?				0.000
Yes	72(53.3)	14(10.2)	86(31.6)	
No	61(45.2)	114(83.2)	175(64.3)	
Not sure	2(1.5)	9(6.6)	11(4)	
If Yes Mention Anyone You Know				
Bournvita/Milo	5(10.4)	0(0)	5(8)	0.126
Coffee	3(6.3)	6(42.9)	9(14.5)	0.002
Tea	29(60.4)	4(28.6)	33(53.2)	0.012
Milk	11(22.9)	4(28.6)	15(24.2)	0.681

Post Study Level of Knowledge among the participants

The post study information on the level of knowledge about Iron Deficiency Anaemia among adolescent girls revealed that majority had good knowledge (69.9%), with the intervention groups showing significant higher levels (88.1%) compared to the control groups (51.8%). Poor knowledge was more prevalent in the control groups (48.2%) compared to the experimental groups (11.9%).

Table 4.11D: Level of Knowledge after Intervention

Knowledge	Intervention	Control	Total	P Value
Poor	16(11.9)	66(48.2)	82(30.1)	0.000*
Good	119(88.1)	71(51.8)	190(69.9)	

Table 4.11E: Comparison of measures of knowledge about Anaemia among adolescent girls for the study groups at various timepoint

Timepoint	Intervention	Control	P Value
	Mean ± S.D	Mean ± S.D	
Baseline	1.55 ± 1.83	1.44 ± 1.79	0.658
After Intervention	6.48 ± 1.87	4.67 ± 3.05	0.000*

**Significant at P<0.05*

Post study Attitude of the Adolescent Girls about Anaemia

The post-study assessment of adolescent girls' attitudes toward anaemia revealed a more positive outlook among the intervention group compared to the control group. When asked about their likelihood of being anaemic, 59.3% of the intervention group believed they were not likely to be anaemic, whereas a larger proportion (85.4%) of the control group expressed uncertainty. Among those who considered themselves "not likely" to be anaemic, 72.5% of the intervention group attributed this to their consumption of an iron-rich diet, while only 55.6% of the control group linked it to eating good food.

Perception of the seriousness of anaemia was also higher in the intervention group, with 95.5% recognizing it as serious, compared to 64.2% in the control group. Attitudes toward anaemia prevention through iron supplements alone differed significantly, as only 43% of the intervention group agreed with this approach, while a higher proportion (62.8%) of the control group believed supplements alone were sufficient.

Both groups mostly agreed on the importance of preparing iron-rich meals, with 96% of the intervention group strongly agreeing, compared to slightly over 90% in the control group. Confidence in preparing such meals was also higher in the intervention group, with 87.4% expressing confidence compared to 82.5% in the control group.

The intervention group also showed a greater preference for the taste of iron-rich foods, with 89.3% stating they liked the taste, compared to 74.5% in the control group.

Overall, the intervention group demonstrated more favourable attitudes toward preventing anaemia, preparing iron-rich meals, and appreciating the taste of iron-rich foods compared to the control group.

Table 4.12A: Attitude of the Adolescent Girls about Anaemia after Intervention

Attitudinal Questions	Intervention	Control	Total
How Likely Do You Think/ You Are Anaemia/ Iron-Deficient			
Not likely	80(59.3)	9(6.6)	89(32.7)
Uncertainty	20(14.8)	117(85.4)	137(50.4)
Likely	35(25.9)	11(8)	46(16.9)
If You Chose Not Likely Why?			
I Don't Have Low Blood	5(6.25)	4(44.4)	9(10.1)
I Eat Good Food	57(72.5)	0(0)	57(64.4)
I Eat Iron Rich Food Very Much	11(13.8)	5(55.6)	16(17.9)
I Know Am Not Anaemic	1(1.2)	0(0)	1(1.1)
I Take Blood Tonic	5(6.3)	0(0)	5(5.6)
My Eye Will Be White If I Am Anaemic	1(1.2)	0(0)	1(1.1)
How Serious an Issues Do You Think Anaemia			
Not serious	1(0.8)	22(16.1)	23(8.5)
Serious	129(95.5)	88(64.2)	217(79.8)
uncertain	5(3.7)	27(19.7)	32(11.7)
Do You Think Anaemia Can Be Prevented With Use Of Iron Supplement Alone			
Strongly agree	25(18.5)	21(15.3)	46(17.1)
Agree	58(43)	86(62.8)	144(53.3)

Disagree	37(27.4)	30(21.9)	67(24.8)
Strongly disagree	15(11.1)	0(0)	15(5.6)
Do You It's Good To Prepare Meals That Are Rich In Irons			
Strongly agree	59(43.7)	61(44.5)	120(44.1)
Agree	67(49.6)	71(51.8)	138(50.7)
Disagree	9(6.7)	5(3.6)	14(5.2)
Strongly disagree			
Do You Think It's Good To Prepare Meals That Are Rich In Irons			
Strongly agree	64(47.4)	57(41.6)	118(44.5)
Agree	71(52.6)	75(54.7)	146(53.7)
Disagree	0(0)	5(3.6)	5(1.8)
Strongly disagree	0(0)	0(0)	0(0)

Table 4.12B: Attitude of the Adolescent Girls about Anaemia after Intervention

Attitudinal Questions	Intervention	Control	Total
Are You Confident When Preparing Meals That Are Rich In Iron			
Strongly agree	54(40)	34(24.8)	88(32.6)
Agree	64(47.4)	79(57.7)	143(53)
Disagree	15(11.1)	24(17.5)	39(14.4)
Strongly disagree	2(1.5)	0(0)	2(0.7)
Do You Like The Taste Of Iron Rich Food Items?			
Strongly agree	53(39.3)	33(24.1)	81(31.2)
Agree	82(60.7)	69(50.4)	151(55.9)
Disagree	0(0)	35(25.5)	35(12.9)
Strongly disagree	0(0)	0(0)	0(0)

Level of Attitude towards Anaemia at Endline assessment

The result after post-intervention shows that a higher percentage (87.4%) of the experimental groups displayed positive attitude towards iron deficiency anaemia with an overall positive attitude of 78.3% by both the control and experimental groups.

Conversely, 21.7% had a negative attitude, with the control group showing a higher proportion (30.7%) compared to the intervention group (12.6%).

The difference in attitude levels between the two groups was statistically significant ($P = 0.002$), indicating that the intervention played a crucial role in improving awareness and positive perceptions of anaemia.

Table 4.12 C: Level of Attitude towards Anaemia after Intervention

Attitude	Intervention	Control	Total	P value
Negative	17(12.6)	42(30.7)	59(21.7)	0.002
Positive	118(87.4)	95(69.3)	213(78.3)	

Table 4.12 D: Comparison of measures of Attitude towards Anaemia among adolescent girls for the study groups at various timepoint

Time point	Intervention (Mean \pm SD)	Control (Mean \pm SD)	P value
Baseline	13.25 \pm 2.44	12.99 \pm 2.28	0.360
After Intervention	14.57 \pm 2.94	13.97 \pm 2.81	0.087

Post study Practice of the Adolescent Girls about Anaemia

After the intervention, there were noticeable differences in the dietary practices of adolescent girls in the intervention and control groups.

In terms of iron-rich food consumption, 81.3% of the intervention group and 87.7% of the control group reported consuming animal protein, with a total of 84.5% across both groups ($p = 0.152$). This indicates no statistically significant difference in animal protein consumption between the two groups.

When asked about the consumption of fresh vitamin C-rich fruits such as oranges, lemons, pineapples, watermelons, or mangoes, 86.7% of the intervention group and 92.0% of the control group reported consumption, with a total of 89.3% ($p = 0.265$). This suggests no significant difference between the groups in fresh citrus fruit consumption. Among those who consumed these fruits, 41.0% in the intervention group reported daily consumption, compared to 74.0% in

the control group, with a total of 52.6% ($p = 0.006$). This indicates a statistically significant difference, with the control group consuming fresh citrus fruits daily more frequently than the intervention group.

Regarding the timing of fresh citrus fruit consumption, 22.2% of the intervention group consumed them before meals, 3.0% during meals, 13.3% after meals, and 61.5% at any time. In the control group, 35.8% consumed them before meals, 3.6% during meals, 2.2% after meals, and 58.4% at any time. The overall distribution was 29.0% before meals, 3.3% during meals, 7.7% after meals, and 60.0% at any time ($p = 0.001$). This suggests a significant difference in the timing of citrus fruit consumption between the groups, with more participants in the control group consuming them before meals.

For coffee or tea consumption, 7.4% of the intervention group and 81.8% of the control group reported drinking coffee or tea, with a total of 41.2% ($p = 0.002$). This indicates a statistically significant difference, with the control group consuming coffee or tea more frequently. Among those who consumed coffee or tea, none (0.0%) of the intervention group reported drinking it daily, compared to 91.2% in the control group, making up 84.4% overall ($p = 0.007$). This shows a significant difference, with daily coffee or tea consumption being much higher in the control group.

Regarding the timing of coffee or tea consumption, 20.0% of the intervention group and 15.3% of the control group consumed it two hours before meals, totalling 15.6%. None (0.0%) of the intervention group consumed it during meals, while 17.5% of the control group did, making up 16.3% overall. Consumption two hours or more after meals was reported by 60.0% of the intervention group and 17.5% of the control group, totalling 20.4%. None (0.0%) of the intervention group drank it right before meals, compared to 6.6% of the control group, totalling

6.1%. Right after meals, 0.0% of the intervention group and 12.4% of the control group reported consumption, with a total of 11.5%. Coffee or tea was never consumed by 20.0% of the intervention group and 14.6% of the control group, making up 14.9% overall. Lastly, 0.0% of the intervention group and 16.1% of the control group reported consuming coffee or tea at other times, totalling 14.7% ($p = 0.031$). This indicates a statistically significant difference in the timing of coffee or tea consumption between the groups.

Overall, the intervention group demonstrated more favourable dietary practices, particularly in reducing coffee and tea intake, which can inhibit iron absorption, and increasing the consumption of fortified cereals.

Table 4.13: Post Practice of the Adolescent Girls about Anaemia

Food - Intake Practice	Intervention	Control	Total	P Value
Yesterday During The Day Or The Night Did You Eat Any Of The Following				0.152
Animal Protein	113(81.3)	121(87.7)	234(84.5)	
Cereals	19(13.7)	12(8.7)	31(11.2)	
Legumes	1(0.7)	4(2.9)	5(1.8)	
Carbohydrates	1(0.7)	4(2.9)	5(1.8)	
Do You Usually Eat Fresh Vitamins C: Orange Lemon Pineapple Watermelon Mango Or Juice Made From Them				0.265
Yes	117(86.7)	126(92)	243(89.3)	
No	14(10.4)	7(5.1)	21(7.7)	
Others	4(3.0)	4(2.9)	8(2.9)	
If Yes Do You Eat Them (Fresh Citrus Fruits) Everyday				0.006
Yes	48(41)	95	143(52.6)	
No	57(48.7)	33	90(33.1)	
Not sure	12(10.3)	0	12(4.4)	
When Do Usually Eat Fresh Citrus Fruits				0.001
Before meals	30(22.2)	49(35.8)	79(29)	
During meals	4(3)	5(3.6)	9(3.3)	
After meals	18(13.3)	3(2.2)	21(7.7)	
	83(16.5)	80(58.4)	163(60)	

Anytime				
Do You Usually Drink Coffee Or Tea				0.002
Yes	10(7.4)	112(81.8)	122(41.2)	
No	125(92.6)	25(18.2)	150(58.8)	
others	0(0)	0(0)	0(0)	
If Yes Do You Drink Coffee/Tea				0.007
Everyday	0(0)	103(91.2)	103(84.4)	
Yes	3(30)	4(3.5)	7(5.7)	
No	7(70)	5(5.3)	12(9.8)	
Not sure				
When Do You Usually Drink Coffee/Tea				0.031
Two hours before meal	0(0)	24(17.5)	24(16.3)	
During meals	6(60)	24(17.5)	30(20.4)	
Two hours or more after meal	0(0)	9(6.6)	9(6.1)	
Right before meal	0(0)	17(12.4)	17(11.5)	
Right after meal	2(20)	20(14.6)	22(14.9)	
Never	0(0)	22(16.1)	22(14.7)	
Others				

Dietary Intake of Iron and Other Relevant Nutrients among In-School Adolescent Girls in Ogun State, Nigeria

The analysis of dietary intake post study by study group is shown in table 4.14A. The comparison of two groups shows several key trends and changes in nutrient intake.

Iron Intake: The intervention group demonstrated better iron intake, with a decrease in the proportion of girls with inadequate iron intake (44.4%) compared to the control group (56.2%). Additionally, a higher percentage of girls in the intervention group had adequate iron intake (33.3% vs. 27%), suggesting that the intervention positively influenced iron consumption.

Calorie Intake: Both groups had a high prevalence of inadequate calorie intake. However, the intervention group showed a slight improvement, with 51.9% having inadequate intake compared to 59.9% in the control group.

Protein Intake: Protein intake was generally adequate in both groups, though the control group had a slightly higher proportion of girls with adequate intake (56%) compared to the intervention

group (48.1%). This suggests that while the intervention improved some dietary aspects, protein intake was relatively better in the control group.

Carbohydrate Intake: Carbohydrate intake improved significantly in the intervention group, with 44.4% of participants achieving adequate intake compared to 32.8% in the control group, indicating the effectiveness of the intervention in enhancing carbohydrate consumption.

Total Fibre Intake: The intervention group had better fibre intake, with a lower percentage of girls having inadequate intake (63%) compared to the control group (53.7%). Despite this improvement, the overall rate of inadequate fibre intake remained high in both groups.

Vitamin C Intake: A greater proportion of girls in the intervention group had adequate vitamin C intake (33.3%) compared to the control group (26.3%). This suggests that the intervention encouraged better vitamin C consumption, which is essential for iron absorption.

Calcium Intake: Calcium intake was higher in the intervention group, with 56.3% achieving adequate intake compared to 44.5% in the control group, indicating an improvement in calcium consumption due to the intervention.

Vitamin D and B12 Intake: The intervention group had a lower prevalence of inadequate intake for both vitamins compared to the control group, demonstrating a positive influence of the intervention on vitamin D and B12 consumption.

Potassium and Magnesium Intake: Although the intake of potassium and magnesium remained low in both groups, the intervention group showed slightly better magnesium intake (47.4% adequate) compared to the control group (38.7%).

Zinc Intake: The intervention group had a lower proportion of participants with inadequate zinc intake (37%) compared to the control group (59.9%). Additionally, a higher percentage of the

intervention group had adequate zinc intake (22.2% vs. 16.8%), highlighting the intervention's role in improving zinc consumption.

Overall, the intervention led to improvements in the intake of key nutrients, particularly iron, carbohydrates, vitamin C, calcium, and zinc, reinforcing its effectiveness in enhancing dietary practices among adolescent girls.

Table 4.14A: Dietary Intake of Iron and Other Relevant Nutrients among In-School Adolescent Girls in the Control Group Ogun State, Nigeria

Nutrient	Inadequate (<60%)	Adequate (60-80%)	Excess (>80%)
Iron (mg)	77(56.2)	37(27)	23(16.8)
Calories (kcal)	82(59.9)	28(20.4)	27(19.7)
Macro-nutrients			
Protein (g)	36(26.3)	77(56)	24(17.5)
Carbohydrate (g)	30(21.9)	45(32.8)	62(45.3)
Total Fibre (g)	101(53.7)	26(19)	10(7.3)
Vitamin C (mg)	74(54)	36(26.3)	27(19.7)
Calcium (mg)	52(37.9)	61(44.5)	24(17.5)
Vitamin D (mg)	55(40.1)	56(40.9)	26(18.9)
Vitamin B12(mcg)	41(29.9)	65(47.4)	31(22.6)
Potassium (mg)	35(25.5)	56(40.9)	46(33.6)
Magnesium (mg)	47(34.3)	53(38.7)	37(27)

Zinc (mg)	82(59.9)	32(23.4)	23(16.8)
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Table 4.14B: Dietary Intake of Iron and Other Relevant Nutrients among In-School Adolescent Girls in the Intervention Group Ogun State, Nigeria

Nutrient	Inadequate (<60%)	Adequate (60-80%)	Excess (>80%)
Iron (mg)	60(44.4)	45(33.3)	30(22.2)
Calories (kcal)	70(51.9)	38(28.1)	27(20)
Macro-nutrients			
Protein (g)	38(28.1)	65(48.1)	32(23.7)
Carbohydrate (g)	22(16.3)	60(44.4)	53(39.3)
Total Fibre (g)	85(63)	37(27.4)	13(9.6)
Vitamin C (mg)	65(48.1)	45(33.3)	25(18.5)
Calcium (mg)	39(28.9)	76(56.3)	20(14.8)
Vitamin D (mg)	45(33.3)	55(40.7)	35(25.9)
Vitamin B12(mcg)	33(24.4)	65(48.1)	37(27.4)
Potassium (mg)	35(25.9)	76(56.3)	24(17.8)
Magnesium (mg)	42(31.1)	64(47.4)	29(21.5)
Zinc (mg)	50(37)	55(40.7)	30(22.2)

Research Question Six: What is the effect of nutrition education intervention in improving iron status among in-school adolescent girls in Ogun state, Nigeria

Effect of Nutrition Education on Haemoglobin level

The mean increase in haemoglobin levels in the experimental group suggests that the nutrition education program had a positive impact on improving participants' haemoglobin status.

The intervention groups saw substantial improvements after the intervention. Before the intervention, 57.6% of the girls had moderate anaemia, and 12.9% had severe anaemia. Following the intervention, moderate anaemia dropped to 31.9%, and severe anaemia declined sharply to just 3.7%. These reductions suggest a positive impact of the intervention in reducing more severe forms of anaemia. Additionally, the number of girls with mild anaemia increased from 12.2% to 49.6%. While this may seem concerning at first glance, it likely reflects a shift from more severe forms of anaemia to a milder, less dangerous state. There was also a slight decrease in the proportion of non-anaemic girls, from 17.3% to 14.8%.

At baseline, the control groups had 13.8% who were non-anaemic, 15.9% of girls with mild anaemia, 61.6% with moderate anaemia, and 8.7% with severe anaemia. After the intervention, the distribution in the control group remained largely the same for mild anaemia, which only

slightly decreased to 15.3%. However, severe anaemia increased significantly from 8.7% to 14.6%, indicating deterioration in the health status of some participants. The proportion of non-anaemic girls in the control group also dropped slightly from 13.8% to 11.7%, reflecting a small decline in overall health.

Looking at the total results across both groups, the proportion of participants with mild anaemia increased from 14.1% at baseline to 32.4% post-intervention, driven primarily by the improvements seen in the intervention group. Moderate anaemia decreased overall from 59.6% to 45.2%, while severe anaemia saw a small reduction from 10.8% to 9.2%. This suggests that while more girls moved into the mild anaemia category, the intervention was successful in reducing moderate and severe anaemia, which are more critical forms of iron deficiency.

At baseline, the mean value for the intervention group was 102.56 ± 17.06 , while the control group had a mean value of 103.07 ± 15.59 . The independent t-test result showed a t-value of -0.260 and a p-value of 0.815, indicating no significant difference between the groups before the intervention. After the intervention, the mean value in the intervention group increased to 103.27 ± 16.05 , while the control group had a reduced mean value of 96.05 ± 15.04 . The t-test for this comparison resulted in a t-value of 3.83 and a p-value of 0.011, demonstrating a statistically significant improvement in the intervention group compared to the control group.

The intervention groups demonstrated significant improvements in anaemia status, with decreases in moderate and severe anaemia and a small increase in the number of non-anaemic participants. The control groups, however, showed worsening anaemia outcomes, particularly

with an increase in severe anaemia. This suggests that the intervention had a positive impact on reducing iron deficiency anaemia among the participants who received it, while the control groups saw no such improvements.

Table 4.15: Effect of nutrition education intervention in improving iron status among in-school adolescent girls in Ogun State, Nigeria

Time point	Intervention (Mean± S.D)	Control (Mean S.D)	T- test	P-Values
Baseline	102.56 ± 17.06	103.07 ± 15.59	-0.260	0.815
After Intervention	103.27 ± 16.05	96.05 ± 15.04	3.83	0.011*

Effect of the Nutrition Education Intervention in Improving Knowledge of Anaemia among In-School Adolescent Girls in Ogun State, Nigeria

At baseline, both the control and experimental groups had relatively low level of knowledge. In the control group, 84.8% (117 girls) had poor knowledge, while only 15.2% (21 girls) had good knowledge. Similarly, in the experimental group, 81.3% (113 girls) had poor knowledge, and 18.7% (26 girls) had good knowledge. Overall, across both groups, 83% of the girls had poor knowledge, while only 17% demonstrated good knowledge, indicating that most of the girls lacked a strong understanding of iron deficiency anaemia before the intervention.

After the intervention, there was remarkable improvement, especially in the experimental group. In the control group, the number of girls with poor knowledge decreased to 48.2% (66 girls), while 51.8% (71 girls) now had good knowledge. However, the most striking change occurred in the experimental group, where only 11.9% (16 girls) still had poor knowledge, and a substantial 88.1% (119 girls) demonstrated good knowledge.

The table 4.15 presents the comparison of means and standard deviations (Mean \pm S.D) for the intervention and control groups at baseline and after intervention, along with the corresponding t-test values and p-values. At baseline, the intervention group had a mean value of 1.55 ± 1.83 ,

while the control group had a mean of 1.44 ± 1.79 . The t-test value for this comparison was 0.506 with a p-value of 0.613, indicating no significant difference between the groups before the intervention. After the intervention, the intervention group showed a marked increase to 6.48 ± 1.87 , while the control group increased to 4.67 ± 3.05 . The t-test value for this comparison was 5.890, with a highly significant p-value of <0.001 , suggesting a statistically significant difference between the intervention and control groups following the intervention.

The intervention effectively improved knowledge about iron deficiency anaemia as reflected in the significantly higher knowledge scores in the experimental group compared to the control group at the endline.

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Table 4.16: Effect of the nutrition education intervention in improving knowledge of iron deficiency anaemia among in-school adolescent girls in Ogun state, Nigeria

Timepoint	Intervention	Control	T test	P Value
Baseline	1.55 ± 1.83	1.44 ± 1.79	0.506	0.658
After Intervention	6.48 ± 1.87	4.67 ± 3.05	5.890	0.000*

Effect of the nutrition education intervention in improving attitude of IDA among in-school adolescent girls in Ogun state, Nigeria

At baseline, a large proportion of the girls in both the control and experimental groups had a negative attitude towards iron deficiency anaemia. In the control group, 68 (49.3%) of the girls had a negative attitude, while 70 (50.7%) had a positive attitude. In the experimental group, the negative attitude was more pronounced, with 87 (62.6%) girls showing a negative attitude compared to 52 (37.4%) with a positive attitude. Overall, the total number of participants with a negative attitude at baseline was 155 (56%), compared to 122 (44%) with a positive attitude.

After the intervention, there was a significant improvement in the attitude of the girls, particularly in the experimental group. In the control group, the proportion of girls with a negative attitude reduced to 42 (30.7%), while those with a positive attitude increased to 95 (69.3%). The intervention group exhibited an even more remarkable change, with only 17 (12.6%) girls maintaining a negative attitude, and the majority, 118 (87.4%), developing a positive attitude towards iron deficiency anaemia. The total number of participants with a positive attitude after the intervention rose to 213 (78.3%), with only 59 (21.7%) retaining a negative attitude.

This shift is further supported by the data presented in Table 4.16, At baseline, the mean value for the intervention group was 13.25 ± 2.44 , while the control group had a mean value of 12.99 ± 2.28 . The independent t-test yielded a t-value of 0.92 and a p-value of 0.360, indicating no statistically significant difference between the groups before the intervention. After the intervention, the mean value in the intervention group increased to 14.57 ± 2.94 , while the control group had a mean value of 13.97 ± 2.81 . The t-test for this comparison resulted in a t-value of 1.72 and a p-value of 0.087, suggesting that although there was an increase in the intervention group, the difference between the two groups was not statistically significant.

Overall, the intervention was effective in shifting the attitudes of the participants, particularly in the experimental group, where the positive attitudes significantly increased, indicating the success of the nutrition education program in improving their outlook on iron deficiency anaemia.

Table 4.17: Effect of the nutrition education intervention in improving attitude of IDA among in-school adolescent girls in Ogun State, Nigeria

Time point	Intervention (Mean SD)	Control (Mean SD)	T-test	P value
Baseline	13.25±2.44	12.99 ± 2.28	0.92	0.360
After Intervention	14.57 ± 2.94	13.97 ± 2.81	1.72	0.087

4.3 Discussion of Findings

The prevalence of iron deficiency anaemia among in-school adolescent girls in Ogun state, Nigeria shows that at baseline 59.6% were experiencing moderate anaemia, 14.1% experiencing mild anaemia, and 10.8% experiencing severe anaemia and at baseline most were experiencing moderate anaemia (45.2%). This finding is a critical public health issue, as anaemia can lead to various health complications, including fatigue, impaired cognitive function, and decreased physical performance^{1,2}. The findings suggest that a large proportion of adolescent girls in this region are at risk, which may have long-term implications for their health and development. This study is in contrast with a study conducted among adolescent girls in Tanzania which found that the prevalence of anaemia among adolescent girls was 141 (26.7% (95% CI: 22.70, 30.5), of which 16.3% were mildly and 10.4% were moderately anaemic. No girls reported having severe anemia³. This can be attributed to several factors, including nutritional differences, health interventions, and socioeconomic conditions. In Nigeria, limited access to iron-rich foods, poor dietary diversity, and socioeconomic challenges likely contribute to higher anaemia rates^{4,5}. Additionally, cultural practices surrounding food consumption and health-seeking behaviour, as well as geographical factors such as endemic diseases, may further explain the disparities in anaemia prevalence between the two regions^{6,7}.

At baseline, the study indicated that a substantial majority of the respondents demonstrated poor knowledge about iron deficiency anaemia, with 83% of the girls showing insufficient understanding. This lack of awareness is worrisome, as it suggests that many girls were unaware of the symptoms, causes, and preventive measures related to anaemia, which could contribute to the high prevalence rates observed. This is supported by a study conducted in North-West Ethiopia, more than three-fourths, 332 (78.5%), of the participants had not heard about anaemia. Majority 240 (56.7%) of participants had poor knowledge on anaemia. Around 43.3% adolescent girls had good knowledge about anaemia. Of all study participants, only 162 (38.3%) had good knowledge on the causes of anaemia, 178 (42%) on signs and symptoms of anaemia, 196 (46.3%) on consequences of anaemia, and 183 (38.5%) on prevention of anemia⁸. However, following the intervention, there was a marked improvement in knowledge levels among the participants. The endline data showed a significant increase in the number of girls who had a good understanding of iron deficiency anaemia, with the experimental groups achieving a statistically significant higher knowledge score (88.1%) compared to the control group (11.9%). The act of participating in a study that assesses knowledge may itself stimulate interest and inquiry about the topic, leading participants to seek out information and learn more about iron deficiency anaemia, even if they were not part of the intervention as it was in case of the control group slight increase in knowledge at baseline⁹. The similarities in findings between this study and the Ethiopian study may be due to a general lack of structured health education on IDA among adolescents in different settings. The differences observed post-intervention highlight the effectiveness of structured awareness programs in improving knowledge levels. Despite the valuable insights gained, the study had some limitations. Self-reported dietary intake data may have been affected

by recall bias or social desirability bias. Additionally, the short study duration limited the assessment of long-term changes in dietary habits. The findings may also not be generalizable beyond the study population due to contextual differences in dietary practices and access to nutrition education.

At baseline, the data indicated a predominantly negative attitude towards iron deficiency anaemia, with 56% of respondents expressing negative sentiments about the condition. This negative attitude could stem from a lack of understanding, stigma associated with anaemia, or cultural beliefs that downplay the seriousness of nutritional deficiencies. This is supported by a study conducted in Indonesia where (42.3%) of the high school female students showed poor attitude level. However, following the educational intervention, there was a notable improvement in attitudes among the participants¹⁰. At post intervention, the intervention groups demonstrated a significantly higher percentage of positive attitudes (87.4%) compared to the control groups (69.3%).

Findings at baseline, the data revealed that many adolescent girls exhibited poor dietary practices concerning iron intake. For instance, a significant portion of respondents reported low consumption of iron-rich foods such as liver, kidney, and other meats, which are crucial for preventing anaemia. This lack of awareness and poor dietary choices likely contributed to the high prevalence of iron deficiency anaemia observed in the population. This finding is supported by a study conducted in Indonesia where (46.2%) of female students had poor practice¹⁰. Following the intervention, there was a marked improvement in the dietary practices of the participants. The post intervention data indicated that a greater number of girls in the

intervention groups reported consuming iron-rich foods more frequently compared to the control group. For example, the intervention groups showed a higher percentage of girls who acknowledged eating iron-rich foods, reflecting a positive change in their dietary habits. This shift can be attributed to the educational content provided during the intervention, which emphasized the importance of incorporating iron-rich foods into their diets and the role of nutrition in preventing anaemia.

The study showed that a considerable proportion of the girls (56.3%) have inadequate iron intake, which is a major concern about the essential role of iron in preventing anaemia.

Findings showed that t-test results showed no significant difference in baseline haemoglobin levels between the control and experimental groups ($p = 0.815$). However, at post intervention, there was a statistically significant increase in haemoglobin levels in the experimental groups compared to the control groups ($p = 0.011$). This suggests that the nutrition education program had a positive impact on improving haemoglobin levels in the experimental group. This is supported by a study conducted in Ethiopia where it showed there was a significant change in both haemoglobin level and proportion of anaemia in the experimental groups. The mean haemoglobin level within experimental groups before and after intervention was (12.08 ± 1.15 , 12.53 ± 1.18) with p value of 0.01. The prevalence of anaemia among intervention group declined from 14.7 % at the baseline to 9.2% after intervention. At the end of the trial, women in the intervention group had significantly better haemoglobin level than women in the control group ($\beta = 0.50$, $p < 0.01$)¹¹. The effectiveness of these interventions highlights the importance of incorporating them into broader public health policies. Governments and health organizations

should emphasize nutrition education as a central element of strategies to reduce anaemia and enhance overall adolescent health. This could include integrating nutrition education into school curricula, community health programs, and maternal and child health initiatives.

The study also showed that there was no significant difference in knowledge scores between the control and intervention groups ($p = 0.658$). However, at the post-intervention, the experimental group had significantly higher knowledge scores compared to the control group ($p = 0.000$). This indicates that the intervention was effective in improving knowledge about iron deficiency anaemia in the experimental group. This is also supported by a study conducted in Nigeria where there was no statistically significant difference in mean knowledge score at baseline ($p=0.07$).

However, there was a statistically significant difference in the mean scores of intervention and control groups post-intervention. In the intervention group, there was a statistically significant difference in the mean knowledge scores among at least two phases ($F [3, 196] = [81.906]$, $p < 0.001$), Effect Size=0.56¹². This intervention aligns with global health strategies that emphasize the role of education in combatting nutritional deficiencies. The Sustainable Development Goals (SDGs), particularly SDG 3, advocate for the reduction of health inequalities and improved access to healthcare information. Educational interventions in public health have been shown to be effective in empowering communities, improving health outcomes, and ultimately contributing to the broader goal of reducing the prevalence of preventable conditions like anaemia¹⁵.

Some limitations of the study included potential recall bias in self-reported responses and the possibility of contamination, as participants in the control group might have accessed information through peer interactions. Additionally, social desirability bias could have influenced responses.

The study's strengths include its robust quasi-experimental design, which allowed for a clear assessment of the intervention's impact. The use of both baseline and post-intervention assessments strengthened the reliability of the findings. Additionally, the study contributes valuable insights into adolescent nutrition education and its role in addressing iron deficiency anaemia.

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Chapter Five

Conclusion

5.1. Summary of Findings

The study aimed to assess the effectiveness of nutrition education intervention on iron deficiency anaemia among in-school adolescent girls aged 10-19 years in public secondary schools in Ogun State, Nigeria. This study is a quasi-experimental approach, with pre-and post-intervention assessments. The study involved an intervention group that receives the nutrition education intervention with a 6-weeks nutrition education classes training and a control group that does not. The study was carried out in the three (3) senatorial districts of Ogun State. Multi-stage sampling technique was employed in this study. Two (2) public secondary schools were selected per senatorial district. The two (2) schools were randomly assigned by the ballot system as Intervention and Control group. A total of 277 participants were involved, with a focus on

understanding their baseline knowledge, attitudes, and practices regarding iron deficiency anaemia.

Questionnaires were developed to collect data on Knowledge, Attitude and practice (KAP) on iron deficiency anaemia and a 24-hour dietary recall questionnaire adapted from Guidelines for assessing Nutrition-related Knowledge, Attitudes and Practice Manual by Food and Agriculture Organization of the United Nations while the Dietary diversity questionnaire was adapted from Guidelines for measuring household and individual diversity by FAO, 2013. Anthropometry measurements and biochemical assessment was done on a participants.

At baseline, the study revealed a high prevalence of iron deficiency anaemia among in-school adolescent girls in Ogun State, Nigeria, with approximately 84.48% experiencing some level of anaemia, 59.6% moderate, 14.1% mild, and 10.8% severe. Knowledge about iron deficiency anaemia was predominantly poor, with 83% of respondents demonstrating insufficient understanding, and many were uncertain about their anaemia status. Dietary assessments indicated inadequate iron intake, with 56.2% of the control group and 44.4% of the intervention group consuming insufficient iron. The attitude of in-school adolescent girls towards iron deficiency anaemia was generally negative, with 56% exhibiting a negative attitude and only 44% showing a positive attitude. Many girls were uncertain about their anaemia status, with 71.2% expressing uncertainty. In terms of practices, dietary assessments indicated inadequate iron intake, with 56.2% of the control group and 44.4% of the intervention group consuming insufficient iron.

At post-intervention, the prevalence of anaemia remained a concern, but the nutrition education intervention significantly improved knowledge and dietary practices. Post-intervention, 69.9% of girls showed good knowledge about iron deficiency anaemia, with the experimental group

achieving 88.1% good knowledge. The attitude towards iron deficiency anaemia improved significantly, with a higher percentage of girls displaying a positive attitude; 78.3% overall, and 87.4% in the experimental group. The post-intervention data also showed distinct improvements in practices, as the experimental group demonstrated better dietary habits and a reduction in inadequate iron intake. Additionally, the intervention led to improved dietary habits, as evidenced by a decrease in inadequate iron intake among the intervention group. There is a statistically significant difference in haemoglobin levels between the control and experimental groups at the end-line, with the experimental group showing higher haemoglobin levels on average. Dietary assessments indicated that the experimental group had better iron intake compared to the control group, highlighting the potential impact of education on dietary choices. The study concludes that while nutrition education can enhance knowledge about iron deficiency anaemia, additional strategies are necessary to improve actual health outcomes, such as increasing access to iron-rich foods and addressing socioeconomic barriers. Recommendations include ongoing education, community involvement, and further research to develop comprehensive approaches to combat iron deficiency anaemia among adolescent girls.

5.2 Conclusion

In conclusion, this study highlights the critical need for effective interventions to address iron deficiency anaemia among adolescent girls. The findings indicate that while the nutrition education intervention significantly improved knowledge about iron deficiency anaemia, and lead to a corresponding increase in haemoglobin levels among participants. A major concern revealed by the study is poor knowledge regarding the symptoms, causes, and consequences of iron deficiency anaemia among the majority of respondents at baseline. This gap in knowledge emphasizes the importance of continuous educational efforts tailored to the specific needs of

adolescent girls, as well as the involvement of families and communities in promoting better nutritional practices.

Overall, the results advocate for the integration of comprehensive nutrition education programs within the school system and communities, alongside strategies to improve access to iron-rich foods and supplementation. By addressing both knowledge and practical dietary needs, stakeholders can work towards reducing the prevalence of iron deficiency anaemia and enhancing the health and well-being of adolescent girls, ultimately contributing to their overall development and future potential.

5.3 Recommendation

Based on the results of the study, the following recommendations are proposed to address iron deficiency anaemia among adolescent girls:

Integration of Iron Deficiency Anaemia Education into School Curricula: Given the significant improvement in knowledge post-intervention, it is recommended that iron deficiency anaemia education be incorporated into school health programs. This will ensure sustained awareness and long-term knowledge retention among adolescent girls.

Training of Teachers and School Health Officers: Teachers and school health personnel should be trained to educate students about iron-rich diets, risk factors for anaemia, and the importance of seeking early medical intervention. This will ensure that knowledge dissemination continues beyond the study period.

Parental and Community Engagement: Awareness programs should extend beyond schools to include parents and community members, as they play a crucial role in shaping adolescents'

dietary habits. Community-based nutrition workshops and advocacy efforts can help reinforce the knowledge gained through school interventions.

Access to Iron-Rich Foods: Facilitate access to affordable iron-rich foods through partnerships with local farmers, markets, and food suppliers. Initiatives could include community gardens, food distribution programs, or subsidies for purchasing iron-rich foods.

Regular Health Screenings: Establish regular health screenings in schools to monitor the nutritional status and haemoglobin levels of adolescent girls. Early detection of anaemia can lead to timely interventions and treatment.

Supplementation Programs: Initiatives for iron supplementation can help address the immediate needs of those already affected. Given the high prevalence of anemia identified in the study, such programs can significantly contribute to improving the health outcomes of adolescent girls, enhancing their physical and cognitive development.

Encouragement of Healthy Eating Practices: Promoting accessibility to iron-rich foods through cooking classes or school meal programs helps improve dietary intake. This not only addresses the nutritional deficits identified in the study but also makes healthy eating enjoyable and culturally acceptable, increasing the likelihood of adherence.

Expansion of the Intervention to Other Age Groups and Regions: Since the intervention was effective, it should be scaled up to other schools and regions, including rural and underserved communities where anaemia prevalence may be higher. Expanding the study to younger age groups may also help instil preventive behaviours early.

5.4 Contribution to Knowledge

The study contributes to the existing body of knowledge on iron deficiency anaemia and nutrition education in several significant ways:

Understanding Knowledge Gaps: The study provides valuable insights into the baseline knowledge of adolescent girls regarding iron deficiency anaemia in Ogun State, Nigeria. It highlights the prevalent lack of awareness about the condition, its symptoms, causes, and prevention methods, thereby identifying critical areas for educational intervention.

Effectiveness of Nutrition Education: By demonstrating that a structured nutrition education intervention can significantly improve knowledge about iron deficiency anaemia, the study underscores the importance of educational programs in promoting health awareness among adolescents. This finding supports the notion that targeted education can lead to better understanding and potentially influence dietary behaviours.

Link between Knowledge and Dietary Intake: The study establishes a connection between improved knowledge and dietary intake of iron among the intervention group. It shows that while knowledge correlate with better dietary practices, suggesting that education can play a role in influencing food choices.

Context-Specific Insights for Policymakers and Educators: The study generates contextually relevant evidence for policymakers, educators, and public health practitioners in Nigeria and similar settings. It highlights the need for integrating iron deficiency anaemia education into school health programs and designing nutrition interventions that target adolescents.

5.5 Suggested Area for Further Research

Based on the findings and implications of the study, the following areas for further research are suggested:

Impact of Socioeconomic Factors: Investigate how socioeconomic status influences dietary choices and knowledge about iron deficiency anaemia. Understanding these dynamics can help tailor interventions to address specific barriers faced by different socioeconomic groups.

Effectiveness of Different Educational Approaches: Compare the effectiveness of various educational methods (e.g., workshops, interactive sessions, digital platforms) in improving knowledge and dietary practices related to iron deficiency anaemia. This can help identify the most impactful strategies for engaging adolescents.

Nutritional Interventions beyond Education: Investigate the effectiveness of combined interventions that include nutrition education, food supplementation, and access to iron-rich foods. This research can help develop comprehensive strategies to combat iron deficiency anaemia.

Evaluation of Policy Impact: Research the impact of existing public health policies and programs aimed at reducing iron deficiency anaemia among adolescents. Evaluating their effectiveness can provide insights for policy improvements and resource allocation.

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Study ID: Appendix A

Informed Consent Form

Name and Affiliation of Researcher

This study is being conducted by Olusola Olamide OYEWOLE, Department of Public Health, Faculty of Basic Medical and Applied Sciences, Lead City University, Ibadan, Oyo State, Nigeria.

Title of Research:

Assessment of the effect of nutrition education intervention on iron deficiency anaemia among in-school girls aged 10-19years in Ogun State, Nigeria.

Purpose(s) of Research

The purpose of this research is to determine the effectiveness of nutrition education intervention on iron deficiency anaemia among in-school adolescent females (10-19years) in Ogun State, Nigeria.

Procedure of the research, what shall be required of each participant and approximate total number of participants that would be involved in the research:

A total of 276 in-school girls aged 10- 19 years will be recruited into the study. The study will be conducted in three phases:

Phase 1: You will be interviewed using a validated structured questionnaire. Your blood sample will also be collected to determine the haemoglobin level for iron deficiency and iron deficiency anaemia.

Phase 2: A Nutrition Education training will be conducted per week for 1-hour for a period of 6-weeks among the intervention group only while the control group will be trained after the post-intervention.

Phase 3: A 6-weeks follow-up will be conducted after the end of the intervention for the intervention group. The same validated questionnaire will be administered to the control and experimental group after the intervention. Your blood sample will also be collected to determine the haemoglobin level for iron deficiency anaemia.

Expected Duration of Research and Participant(s) Involvement

This research will be expected to run for a period of 14 weeks.

Risk(s)

No disadvantages or harm are expected for you because of your participation in the study. Answering the questions takes like half an hour; if you become tired we do not have to complete the interview or we can re-schedule the interview to another day.

Cost of participating, if any, of joining the research

Your participating in this research will cost you nothing but small amount of your time.

Benefit(s)

The goal of this research is to assess the influence of nutrition education on knowledge, attitude and practices to combat iron deficiency anaemia among in-school adolescent females (10-19years) in public secondary schools in Ogun State. The findings of this research would improve knowledge, attitude and practice to combat iron deficiency anaemia among in-school adolescent females (10-19years) in Ogun State, Southwest Nigeria.

Confidentiality

All information collected in the study would be given code number and no name will be collected. You are however, assured that your response will be treated in utmost confidentiality and for only academic and research purpose.

Voluntariness: Your participation in this research is entirely voluntary.

Consequence of participant’s decision to withdraw from research:

You are very free to withdraw at any stage of the research if you so wish as there are no conflict of interest whatsoever.

Statement of person giving consent:

I have read the description of the research. I understand that my participation in this research is voluntary. I know the purpose, methods, risks and benefits of the research study to judge that I want to participate in it. I understand that I may freely stop being part of the study at any time. I have a copy of the consent form.

Name

Signature.....

Date.....

Detailed Contact Information

This research has been approved by the Ethics committee of Lead City University, Ibadan and Permission given by the Ogun State Ministry of Education, Oke-Mosan, Abeokuta, Ogun State.

In addition, if you have any question about your participation in this research, you can contact the Principal Investigator,

Name: OYEWOLE, Olusola Olamide

Department: Public Health, Lead City University Ibadan, Oyo State

Phone number: 08037286479 Email Address: olusolaoyewole1@gmail.com

If you wish to participate in this study, please sign in the space provided below. Your signature will indicate willingness to participate.

Thanks.

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**Study ID: Appendix B
Questionnaire**

**Assessment Of the Effect of Nutrition Education Intervention on Iron Deficiency Anaemia
Among In-School Adolescent Girls (10-19years) In Ogun State**

Serial No:

Introduction

Dear Sir/Ma,

This is a research study to investigate the effects of nutrition education intervention on iron deficiency anaemia among in-school adolescent girls (10-19years) in Ogun State, Nigeria. Iron deficiency anaemia is a condition in which anaemia occurs due to lack of available iron to support normal red cell.

This research is being conducted as part of PhD thesis and it is strictly for research purpose. Participation is voluntary. Your identity, responses and opinions will be kept confidential and no name is required in filling the questionnaire. You are requested to please give the honest responses to the questions as much as possible as utmost confidentiality is assured. No answer will be judged right or wrong.

I accept to participate in this research _____ / _____ (Signature/Date)

Thank you.

Olusola Oyewole
Department of Public Health
College of Public Health
Lead City University
E-mail: olusolaoyewole1@gmail.com
Phone: 08037286479

For official use only

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Participant ID:

Data Collector ID:

Date: (dd/mm/yyyy)

Telephone number:

Kindly indicate in the box which of the assessment is being completed

Assessment **Baseline** [] **End line (12 weeks)**[]

Section A (Personal characteristics of the Respondents)

1. Age: _____ (Years)
2. Class: JSS 1 [] JSS 2 [] SSS 1 [] SSS 2 []
3. Religion: Christianity [] Islam [] Traditional [] None []
4. Place of Residence: (Specify): _____
5. What is the highest level of education of your mother? None [] Primary [] Secondary [] Tertiary []

6. What is the highest level of education of your father? None Primary Secondary Tertiary
7. Who do you stay with? Parents Guardian Grandparents Others (Specify):

8. Type of family: Nuclear Extended
9. Father's occupation: Artisan Trading/Business Farming Civil servant Others (Specify)_____
10. Mother's occupation: Artisan Trading/Business Farming Civil servant Others (Specify)_____
11. Guardian's occupation: Artisan Trading/Business Farming Civil servant Others (Specify)_____
12. Grandparent's occupation: Artisan Trading/Business Farming Civil servant Others (Specify)_____

SECTION B: Anthropometry Measurements (To be measured and filled by the Research Assistant)

13. Weight: _____(kg) Height: _____(m) Body mass index (BMI) _____ (kg/m²)

Section C: Biochemical measurements (To be filled by the Phlebotomist)

14. Haemoglobin level _____ (g/dl)

Section D: Knowledge about anaemia and sources of iron rich foods

For questions 15 to 27 please tick (✓) as appropriate

15. Have you heard about iron deficiency anaemia? Yes No Not sure
16. Do you know/identify symptoms of anaemia? Yes No Not sure
17. If yes, what are the symptoms? Weakness/fatigue Pallor Unusual rapid heartbeat
Shortness of breath Difficulties in concentration Headache
Others _____
18. Do you know the causes of anaemia? Yes No Not sure

19. If yes to 18, what causes anaemia? Lack of iron in the diet Eat too little
 Sickness/infection Heavy menstrual bleeding
 Other _____
20. Do you know how to prevent anaemia? Yes No Not sure
21. If yes to question 20, how do you prevent anaemia? Eat iron rich foods Eat vit. C rich foods during or right after meals Take iron supplements Treat other causes of anaemia
 Others _____
22. Do you know the consequences of having iron deficiency anaemia? Yes No Not sure
23. If yes to 22, what are the consequences of anaemia? Physical development delay Learning difficulties Poor reproductive health in women Delayed brain development
 Other _____
24. Do you know/can mention iron rich foods? Yes No Not Sure
25. If yes to question 22, mention anyone you know:

26. Do you know about foods that helps iron absorption? Yes No Not Sure
27. If yes, mention anyone you know:

28. Do you know about beverages that decrease iron absorption when taken with meals? Yes
 No Not Sure
29. If yes, mention anyone you know:

Section E: Attitude towards anaemia and sources of iron rich foods

30. How likely do you think/ you are anaemic/ iron-deficient? Not likely Uncertain Likely
31. If you chose not likely to question 28, why?

32. How serious an issue do you think anaemia is? Not serious Serious Uncertain

Please Tick where appropriate

Attitude	Strongly Agree	Agree	Disagree	Strongly Disagree
33 Do you think anaemia can be prevented with the use of iron supplement alone				
34 Do you think it's good to prepare meals that are rich in irons				
35 do you think it is good to prepare meals that are rich in iron				
36 Are you confident when preparing meals that are rich in iron				
37 do you like the taste of iron rich food items				

Section F: Food - intake practice

In this section, I would like to ask you about particular dish you may eat on their own or as part of a dish.

38. Yesterday during the day or the night, did you eat any of the following? *Please tick all the food you ate.* Liver Kidney Heart Beef Chicken Goat Fish Seafood, prawns, crayfish Sweet potato Soyabeans Fortified breakfast cereals Whole wheat flour Others _____

39. Do you usually eat fresh Vitamin C fruits: Orange, Lemon, Pineapple, Watermelon, Mango or juice made from them? Yes No Others _____

40. If yes, do you eat them (fresh citrus fruits) every day? Yes No Not sure

41. When do you usually eat fresh citrus fruit? Before meals during meal after meal anytime

42. Do you usually drink coffee or tea? Yes No Others _____

43. If yes, do you drink coffee/ tea every day? Yes No Not Sure

44. When do you usually drink coffee/ tea? 2 hours before meal during meals 2 hours or more after meal Right before meal Right after meal Never Others _____

SECTION G: 24-HOUR DIETARY RECALL QUESTIONNAIRE

Serial No:

Please describe the foods (meals and snacks) that you ate yesterday during the day and night, whether at home or outside the home. Start with the first food eaten in the morning.

24-Hour Dietary Recall

Type of Food Consumed	Portion size
... Before breakfast?	
... For breakfast?	
... Between breakfast and lunch?	
... For lunch?	
... Between lunch and dinner?	
... For dinner?	

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... After dinner?

During the last day or night, did you eat any fruit, vegetables or snacks which you did not mention? If yes, specify:

Thank you so much for your participation in this study.

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Biodata

A. Personal Data

Name: Olusola Olamide, OYEWOLE
Sex: Female
Date of Birth: 26th November 1985
Marital Status: Married
State of Origin: Ogun
Local Government: Abeokuta North
Nationality: Nigerian
Religion: Christianity
Discipline: Public Health
Number of Children: 2
Address: 3, Lipede Estate, Onikoko, Abeokuta
Telephone: +2348037286479
Email: olusolaoyewole1@gmail.com

B. Educational Institutions Attended with Dates

Doctor of Philosophy	in view
M.Sc. Medical Microbiology and Public Health	2018
Bachelor's Degree in Science, Microbiology	2008

C. Working Experience

Society for Family Health, Nigeria	2025
Ogun State Government, Oke-Mosan, Abeokuta (Scientific Officer)	2010 to 2025

D. Professional Membership: Nil

E. Publications:

Risk Mapping and Characterization of Vibrio cholerae Strains in communities affected with cholera outbreak in Abeokuta, Ogun State, Nigeria. Dissertation submitted to the Department of Microbiology, College of Biosciences, Federal University of Agriculture, Abeokuta in partial

fulfilment for the award of Master of Science (M.Sc) in Medical Microbiology and Public Health. 2017.

Olufunke Shittu; Olusola Oyawole; Kolapo Fasina; John Oyedepo; Adediwura Arowosegbe; David Ajiboye; Uwemedimo Ekpo. *Multidrug resistant toxigenic O1 El Tor and Non-O1/Non-P139 Vibrio cholerae strains in water sources of communities affected with 2013 cholera outbreak in Abeokuta, Nigeria*. Journal of Water and Health.

Bioassay of Probiotics using fermented corn flour for the isolation of Lactic Acid Bacteria. A project submitted to the Department of Microbiology, College of Natural Sciences, University of Agriculture, Abeokuta in partial fulfillment for the award of Bachelor of Science (B.Sc) in Microbiology, 2007.

F. Major Conferences Attended:

8th Nigeria Family Planning Conference, Abuja, Nigeria. December 2024. Abstract presented: Olusola Oyewole, Ogunsola E. A. *Leveraging on Vocational Skills and Mum's sessions to break barrier to access of SRH by adolescent girls 15-19years in Ogun State, Nigeria*.

7th Nigeria Family Planning Conference, Abuja, Nigeria. December 2022

1st African and 2nd National Conference on Adolescents health and Development. Abuja 2021

1st National Conference on Adolescents Health and Development of Adolescents in Nigeria, Ibadan. April 2019. Abstract presented: Oyawole Olusola; Ojelade Olubunmi and Timothy Rotimi. *Awareness and Use of National Guidelines for the Integration of Youth Friendly Services by Public Health Workers in Ogun State*.

Ojelade O, Oyeyemi A., Oniyitan A., Akinsanya J. and Oyawole O. *Leveraging on cultural events for promotion of family planning as a social norm*. 5th Nigeria Family Planning Conference 2018, Abuja. December 2018.pg 8.

G. Referees

Dr. Elijah Ogunsola

Executive Secretary

Ogun State Primary Health Care Board

07036775698

Dr. Olubunmi Ojelade

Diamonds and Pearls Health, Education and Social Development Initiative

09068849504



Signature

30/7/2025

Date

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The University Compliance Certification

This is to certify that this thesis by Olusola Olamide OYEWOLE with matriculation number LCU/PG/001558 in the Department of Public Health, Faculty of Basic Medical and Health Sciences, Lead City University, Ibadan, Oyo State is in full compliance with the approved university format.



30th July, 2025

Signature

Date

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