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Nutrition Education Intervention and Improved Haemoglobin Level among In-School Adolescent Girls in Ogun State, Nigeria

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ABSTRACT

The study assesses the effectiveness of a nutrition education intervention on iron deficiency anaemia (IDA) among in-school adolescent girls, aged 10-19, in Ogun State, Nigeria. It uses a quasi-experimental design with pre- and post-intervention assessments. The study randomly assigns two public secondary schools in each district to either an intervention group, which received six weeks of nutrition education, or a control group, involving 277 participants across three senatorial districts. Findings at baseline indicated a high prevalence of IDA, with 84.48% of participants affected, including 59.6% with moderate anaemia. Knowledge about IDA was poor, with 83% lacking sufficient understanding, and dietary assessments revealed inadequate iron intake, particularly among the control group (56.2%). At the post-intervention, knowledge improved significantly, with 88.1% of the experimental group demonstrating good knowledge. Attitudes also shifted positively, with 87.4% of the experimental group displaying improved attitudes towards IDA. Conclusively, the intervention led to better dietary practices and higher average haemoglobin levels in the experimental group compared to controls. Hence, nutrition education enhances knowledge and dietary practices and increases access to iron-rich foods for improved health outcomes.

Keywords: *Nutrition, education intervention, haemoglobin, iron deficiency anaemia, dietary practices*

INTRODUCTION

Among adolescents, girls aged 10-19 are especially at risk, as they face increased iron requirements coupled with iron loss during menstruation. In Nigeria, the prevalence of IDA among adolescent girls ranges from 13.4% to 62.9%, with a national survey indicating that 60.5% of teenage girls are anemic (Nigeria Demographic and Health Survey, 2018).

Adolescents in low-income countries, including Nigeria, represent a significant portion of the population, with about one-quarter of Nigeria's over 200 million inhabitants being adolescents (UNICEF, 2020). Iron deficiency anemia has a detrimental effect on adolescents' economic and educational well-being. It has been linked to stunting, wasting, underweight, and poor cognitive performance, limited physical activity, and attention deficit hyperactivity disorders. Iron deficiency anemia is currently recognized as the primary cause of disability adjusted life years in adolescents. It is recognised 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 anemic. Adolescent iron deficiency and iron deficiency anemia (IDA) are therefore serious public health issues.

Therefore, addressing IDA through effective interventions is crucial for improving the health and well-being of adolescents. Nutrition education interventions have emerged as a promising strategy for preventing and managing IDA, particularly in resource-limited settings. These interventions aim to enhance knowledge and behaviours related to iron-rich foods and overall nutrition. School-based interventions, in particular, leverage the unique environment of educational institutions to reach a large number of adolescents, fostering positive health behaviours (Hawkes et al., 2015).

This study aims to evaluate the effect of a nutrition education intervention on improving haemoglobin levels among in-school adolescent girls aged 10-19 in Ogun State, Nigeria. Utilising a pre-post design, data will be collected before and after the intervention to assess changes in knowledge, dietary behaviors, and haemoglobin levels. The outcomes of this study will provide valuable insights into the effectiveness of nutrition education programs and contribute to the development of evidence-based policies for adolescent health in Nigeria and similar contexts.

Addressing IDA through nutrition education is a vital public health strategy. By improving nutritional knowledge and dietary practices, we can enhance the health and development of adolescent girls, ultimately reducing the prevalence of IDA and its associated complications.

Iron deficiency anaemia (IDA) is a significant global health issue, accounting for over 50% of all anaemia cases, characterized by low haemoglobin levels, primarily due to insufficient iron intake. In Nigeria, the dietary patterns of adolescents predominantly consist of plant-based foods, which are often low in bioavailable iron. This reliance on starchy staples significantly limits their intake of fruits and other micronutrient-rich foods, further exacerbating nutritional deficiencies.

The prevalence of IDA in Nigeria is particularly alarming among vulnerable groups such as children, adolescents, and pregnant women. The 2018 Nigeria Demographic and Health Survey reported that 58% of women aged 15-49 and 60.5% of girls aged 15-19 are anaemic. In Ogun State, the prevalence among women in the same age group is reported at

49%. These statistics indicate a concerning trend, largely attributed to inadequate consumption of iron-rich foods, which may stem from a lack of nutritional knowledge.

The Food and Agriculture Organisation (FAO) emphasises that nutritional inadequacies in Africa are more often a result of a lack of knowledge rather than food scarcity. Research has consistently shown that adolescents in developing countries possess a limited understanding and poor practices regarding healthy eating. During the adolescent growth phase, individuals are particularly susceptible to nutritional deficiencies, including iron deficiency, which can have lasting consequences. Studies indicate that girls are at a higher risk of developing IDA compared to boys, as evidenced by the correlation of serum ferritin levels with haemoglobin and the higher percentage of iron depletion observed in females. IDA often develops gradually and without obvious symptoms, making it difficult to detect until it becomes severe. The implications of IDA are particularly serious for adolescent females, affecting their health, economic opportunities, and social well-being.

Despite a desire among adolescents to adopt healthier eating habits, this intention does not always translate into action, leading to continued consumption of unhealthy foods and associated health problems. The role of nutrition education in improving knowledge and practices related to iron deficiency anaemia among female adolescents in Nigeria has not been thoroughly explored.

Thus, there is an urgent need to assess the impact of nutritional education on iron deficiency anaemia among adolescent girls in public secondary schools in Ogun State, Southwest Nigeria. Addressing this gap could be pivotal in transforming dietary behaviours, improving health outcomes, and ultimately combating the public health challenge that IDA represents (Akanbi et al., 2020; Kader et al., 2019).

Objective of the study

The study aims to evaluate the effect of the nutrition education intervention in improving haemoglobin level among in-school adolescent girls in Ogun State, Nigeria.

Research Hypothesis

The hypothesis of this study is as follows:

$H_0 1$: The nutrition education intervention has no significant effect on improving iron status among in-school adolescent girls in Ogun State, Nigeria.

Iron deficiency 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 educate on the prevention and treatment of iron deficiency anaemia among adolescents.

The proposed study aims to assess the effect of a nutrition education intervention on iron deficiency 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. 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 proposed 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 proposed 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 iron deficiency anaemia prevention and treatment in low- and middle-income countries.

Haemoglobin Concentration and Anaemia in Young Children

The literature presents a nuanced discussion regarding the appropriate haemoglobin (Hb) concentration values indicative of anaemia in young children. During the first year of life, Hb concentration undergoes rapid changes, initially decreasing in the first few months and then increasing. Anaemia is traditionally defined using reference limits for Hb < -2 standard deviations (SD) of the mean for specific population groups. The World Health Organisation (WHO) designates a Hb concentration of <110 g/L as the threshold for diagnosing anaemia in children aged 6-59 months. However, this value has been critiqued for being somewhat "arbitrary," as the definitions were not explicitly designed to reflect optimal human function (WHO, 2011).

Moreover, the use of Hb concentration as the sole biomarker for anaemia does not adequately differentiate between iron deficiency and other causes of anaemia, as Hb alone lacks specificity and sensitivity regarding iron status. The WHO values were first established in 1959 by the WHO Study Group on Iron Deficiency Anaemia, based on data from studies of apparently healthy individuals worldwide. These values were intended to serve as reference points considered the lower limits of normal for nutritional surveys (WHO, 2011).

Subsequent updates occurred in 1968, reflecting more recent data. The revised cut-offs were: children 6 months to 6 years, 110 g/L; children aged 6-14 years, 120 g/L; adult males, 130 g/L; non-pregnant females, 120 g/L; and pregnant females, 110 g/L. Notably, the values for children were influenced by the assumption that infants were routinely given iron-fortified cereals from 2-3 months of age (WHO, 2011).

While these WHO haemoglobin values have remained unchanged since 1968, a later WHO document classified anaemia based on severity, as shown in Table 2.1. Globally, the prevalence of anaemia among adolescents is reported at 15%, with 27% in developing countries compared to 6% in developed countries. In Nigeria, the situation is dire, with anaemia prevalence among women aged 15-49 years at 58%, and 60.5% among women aged 15-19 years (National Population Commission, 2018).

Table 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

Source: Adapted from WHO guidelines on haemoglobin concentrations for the diagnosis of anaemia.

Emerging Evidence on Normal Haemoglobin Levels

Recent studies suggest that the normal physiological Hb level for infants may be lower than the current WHO cut-off for children aged 6-59 months. For instance, a randomized controlled trial conducted in Honduras and Sweden proposed new -2 SD values for anaemia and iron deficiency based on exclusively or nearly exclusively breastfed infants. This study excluded iron-deficient infants based on reference limits for mean corpuscular volume (MCV), ferritin, and transferrin receptor (TfR) (Hernandez et al., 2015).

In the UK, researchers investigated the normal distribution of Hb and ferritin in a representative sample of children. The arithmetic mean Hb concentration at 8 months was reported at 117 g/L, with a fifth centile of 97 g/L. Notably, only 1.2% of the cohort met the criteria for iron deficiency, defined by plasma ferritin concentration <12 μg/L. The same cohort was followed up at ages 12 and 18 months, where a fifth percentile reference limit for defining anaemia was established at <100 g/L (Parker et al., 2016).

Further research has aimed to identify the Hb concentration threshold at which adolescents may be at risk for cognitive or physical impairments. The Avon Longitudinal Study of Pregnancy and Childhood (ALSPAC) noted slight developmental benefits in Hb levels above 95 g/L for infants at 8 months. A study in Costa Rica found that children aged 12-23 months with Hb <100 g/L exhibited lower mental and motor development scores compared to those with Hb >100 g/L, even after controlling for various factors (Smith et al., 2018).

The most appropriate Hb interpretive criteria for determining anaemia in infants remain inconclusive. However, accumulating evidence suggests that lower values than the current WHO recommendation should be considered for infants aged 6-12 months, reflecting the physiological lower limit without adverse effects on cognitive or motor development.

The Magnitude of Anaemia in Africa

The high incidence of anaemia poses a significant public health concern across many African nations. Pregnant women of reproductive age (WRA) represent the second most common demographic affected, following children under five years of age. In Central and West Africa, the rates are particularly alarming, with pregnant women affected by anaemia at a rate of 56% and non-pregnant WRA at 48%. East Africa follows closely with a 40% prevalence among non-pregnant women.

Despite some progress, a systematic review indicated that the prevalence of anaemia among adolescents in these regions has seen a decrease, from 52% to 48% in Central and West Africa, 40% to 28% in East Africa, and 33% to 28% in Southern Africa (WHO, 2020).

Magnitude of Anaemia in Nigeria

A recent study conducted in Nsukka, Nigeria, assessed the prevalence of stunting, thinness, vitamin A, and iron deficiencies among teenage students. Out of 400 randomly selected participants aged 12 to 18, findings indicated that 31.0% were thin, 33.3% stunted, and 64.0% anaemic. The study underscored the link between income levels and nutritional status, revealing that children from low-income households were more likely to experience vitamin A deficiency (VAD) compared to their counterparts from medium- and high-income households (Nwankwo et al., 2021).

Additionally, a systematic review revealed that among children aged 0 to 19 from multiple countries, the average prevalence of anaemia ranged from 25% to 53%, with iron deficiency from 12% to 29%. Inadequate dietary intakes reported varied widely, with 51% to 99% for zinc, 13% to 100% for iron, and 1% to 100% for vitamin A (UNICEF, 2020).

In Nigeria, the prevalence of anaemia has fluctuated over time, with a recent report indicating a decline from 45% to 21.7% in non-pregnant women of reproductive age and 44.6% to 42% in pregnant women between 2003 and 2014. While there has been a notable decrease, the prevalence of anaemia among pregnant women remains a serious public health issue (National Population Commission, 2018).

Consequences of Anaemia

Anaemia disproportionately affects the health and well-being of women and children, particularly among those of reproductive age. It is associated with increased risks of low birth weight and premature delivery. The economic and social ramifications are severe, as anaemia hampers work performance and productivity. Iron deficiency-related anaemia alone is estimated to cause over 90,000 deaths annually across all age groups. The combined economic losses attributed to decreased productivity and cognitive decline in ten developing nations have been estimated at nearly $17 per person (Balarajan et al., 2011).

Maternal and Child Mortality

The risk of maternal and infant mortality is significantly heightened by anaemia. A meta-analysis of approximately 12,000 children across six African nations indicated that a 1 g/dL increase in Hb concentration correlated with a 24% reduction in mortality risk (Schmidt et al., 2017). In Nigeria, a study found that 83.6% of severely anaemic children under five recovered, while 13.6% died. Factors such as coma, tachycardia, malnutrition, and lack of blood transfusions were associated with higher mortality rates (Nwankwo et al., 2021).

Cognitive Development

Research indicates that iron deficiency may place adolescents at an increased risk for cognitive impairments. A controlled study involving women aged 18 to 35 categorized participants as iron sufficient, non-anaemic but iron deficient, or with iron deficiency anaemia. The control group showed significantly higher cognitive performance at baseline compared to those with iron deficiency anaemia (Beard et al., 2015). Similar trends were observed in studies involving primary school-aged girls, where non-anaemic participants performed better on cognitive function tests.

Anaemia also adversely impacts children's cognitive development. A secondary data analysis indicated that children with iron deficiency anaemia exhibited detrimental effects on behavior, motor skills, and cognition, particularly among those from low socioeconomic backgrounds (Lozoff et al., 2016).

Causes of Anaemia

Anaemia arises from a multitude of factors, both nutritional and non-nutritional. Nutritional deficiencies due to inadequate dietary intake are the primary causes, while non-nutritional factors account for at least half of all anaemia cases globally. These include blood loss, chronic inflammation, infections, and other disease processes.

Nutritional Causes of Anaemia

Iron Deficiency Anaemia

Iron deficiency anaemia (IDA) results from insufficient iron to produce haemoglobin, which is critical for oxygen transport. IDA accounts for approximately half of all anaemia cases worldwide. A review indicated that the actual prevalence of iron deficiency is likely lower than previously thought, with about 25% of anaemia among children and 37% among women of reproductive age attributed to iron deficiency (Stoltzfus et al., 2013). Menstruation, pregnancy, and lactation increase the risk of IDA among women. During pregnancy, the increased plasma volume leads to a dilution of red blood cells, often resulting in lower Hb levels and heightened iron demand (Dijkhuizen et al., 2005).

Folic Acid and Vitamin B12 Deficiency
In addition to iron deficiency, inadequate levels of folate and vitamin B12 contribute to anaemia, resulting in megaloblastic anaemia. This type of anaemia impairs DNA synthesis and can be identified by elevated serum homocysteine levels. A study in Pakistan found high prevalence rates of folate and vitamin B12 deficiencies among women of reproductive age (Ali et al., 2017).

Non-Nutritional Causes

Infections and Infestations
Infections and chronic diseases can lead to anaemia through various mechanisms, including decreased iron absorption and increased iron sequestration. Soil-transmitted helminths, such as hookworms, are significant contributors to IDA, particularly in regions with poor sanitation. A study in Ethiopia found a high prevalence of intestinal helminth infections among pregnant women, with hookworm being the most common (Getachew et al., 2020).

Malaria
Malaria is recognized as a major cause of anaemia, especially in children and pregnant women. The WHO estimates over 219 million cases of malaria per year, leading to significant mortality. The impact of malaria on anaemia includes both reduced red blood cell production and increased destruction of red blood cells (WHO, 2020).

Genetic Disorders
Genetic conditions such as thalassemia and sickle cell disease also contribute to anaemia. A study in Cambodia found that haemoglobin disorders were prevalent among women of reproductive age, with thalassemia traits being among the most common (Chhoun et al., 2019).

Strategies to Address Iron Deficiency
Addressing iron deficiency and anaemia requires a multi-faceted approach involving various interventions. Key strategies include iron supplementation, food fortification, dietary diversification, and addressing preventable causes of iron losses.

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Iron Supplementation

Iron supplementation has proven effective in increasing iron stores and reducing the prevalence of anaemia. In pregnant women, iron-folic acid supplementation is foundational in many low-income countries, with evidence supporting its efficacy in preventing maternal anaemia (WHO, 2016).

Fortification of Food

Food fortification, especially of staple foods, is a sustainable approach to combat iron deficiency. The bioavailability of iron in fortified foods is crucial for ensuring its effectiveness in improving nutritional status (Burgess et al., 2018).

Food-Based Strategies

Food-based strategies emphasize improving dietary diversity and increasing the availability of iron-rich foods. These community-driven initiatives can effectively address multiple micronutrient deficiencies while being culturally acceptable and sustainable (Ruel et al., 2013).

Theoretical Review

Nutrition Education (NE) interventions are grounded in various behavioural theories, including Social Learning Theory, Phases of Transition Theory, Health Belief Model, and Social Action Theory (Gordon et al., 2017). Social Learning Theory emphasizes the role of cognitive processes and the social environment in shaping behaviors, while Phases of Transition Theory focuses on tailoring messages to individuals at different readiness stages (Prochaska & DiClemente, 1983). The Health Belief Model posits that people's perceptions of health risks and benefits influence their health behaviors (Rosenstock, 1974), and Social Action Theory examines how intentions and social influences affect decision-making (Ajzen, 1991). Despite challenges in applying these theories universally, incorporating eclectic approaches allows educators to address various motivators and barriers in NE projects (FAO, 2019).

Empirical Review

Nutrition Education (NE) and communication are integral components of various nutrition intervention strategies, including breastfeeding promotion, food production, food assistance, food fortification, supplemental feeding, and nutrition-related health services (Hawkes & Ruel, 2006). Traditional NE approaches often consist of one-way communication, primarily involving health discussions at centers, which have proven ineffective in significantly enhancing nutritional status or behavior (Mason et al., 2015). This ineffectiveness can be largely attributed to poor communication techniques and inappropriate message content. A more effective approach emphasizes two-way communication, enabling the exchange of nutrition-related knowledge, values, and practices, thereby fostering active involvement and leading to sustainable behavioural changes (Hawkes & Ruel, 2006; Tufte, 2001). Various NE strategies, such as development-support communication, social marketing, and social mobilization, have been developed and successfully implemented over the years (Bennett, 2010).

Effects of Nutrition Education

Numerous experimental studies have confirmed the positive impact of nutrition education on dietary modification, nutrient intake, and overall iron status. For instance, dietary counseling has been shown to enhance mothers' awareness and consumption of iron-rich foods, such as fish (Kader et al., 2019). Furthermore, a study in Tanah Merah, Malaysia, explored the effects of nutrition education and supplementation on the knowledge, attitudes, and haemoglobin status of adolescents. The study involved 288 secondary school students who were assigned to four treatment groups: nutrition education, supplementation, a combination of both, and a control group. Results indicated significant changes in haemoglobin levels across the groups after three months, with the nutrition education group demonstrating notable improvements in attitudes and knowledge (Zainal et al., 2020).

In Nigeria, a three-month nutrition education intervention for pregnant women resulted in a significant increase in their understanding of the importance of consuming fruits and vegetables, correlating with an increase in their dietary intake (Akanbi et al., 2020). Similarly, a study in Tanah Merah assessed the awareness of iron deficiency among school-age adolescents. The nutrition education group exhibited a marked increase in awareness, unlike the non-nutrition education group, which showed no significant improvement (Zainal et al., 2020).

Another study in India utilized a 30-minute lecture with visual aids to enhance nutrition knowledge among post-adolescent girls. Before the intervention, 30% of participants had low nutrition knowledge; however, one month post-intervention, 95.5% achieved high knowledge scores (Verma et al., 2018). This study highlights the effectiveness of targeted educational interventions in addressing micronutrient deficiencies. Further evaluations showed that nutrition education significantly improved knowledge retention among participants over time (Verma et al., 2018).

In a comparative study in Malaysia among teenagers with anemia, a one-hour weekly nutrition education session for three months led to a significant increase in knowledge and positive attitudes regarding nutrition (Kader et al., 2019). Additionally, a study conducted in Kenya revealed a strong positive correlation between nutrition knowledge and nutrient intake among elementary school students, emphasizing the role of education in improving haemoglobin levels (Musa et al., 2021).

A study in Sierra Leone assessed knowledge, attitudes, and behaviors related to anemia among pregnant women, revealing that many women lacked awareness of the nutritional causes and preventive measures for anemia (Sankoh et al., 2020). Similarly, a quasi-experimental design in Southern Benin demonstrated that a four-week nutrition education program significantly improved knowledge and dietary habits, resulting in higher haemoglobin and serum ferritin levels in the intervention group compared to the control group (Dossa et al., 2021).

Despite the evident benefits of nutrition education, it remains inadequately integrated into public health agendas. In Nigeria, a substantial percentage of pregnant women reported not receiving any nutrition-related education during antenatal care visits (Akanbi et al., 2020). This underscores the necessity for comprehensive nutrition education interventions to address the nutritional needs of vulnerable populations.

Nutritional Interventions

The adolescent stage is a crucial period for interventions aimed at enhancing nutritional status and fostering healthy eating practices. Research indicates that nutritional status during this phase significantly influences health outcomes throughout the life cycle (Pérez-Escamilla et al., 2017). Effective, cost-effective anemia prevention and management strategies are essential for addressing iron deficiency anemia during adolescence.

School-based interventions are particularly valuable for improving adolescent health, providing a platform for reaching young individuals and their families. Given that many adolescents attend school, educational programs can extend their impact beyond the student body to influence community members and parents (Pérez-Escamilla et al., 2017). Furthermore, improving nutritional health among adolescent girls is critical for their reproductive health and overall well-being.

Nutrition education, as a behavioural change strategy, plays a pivotal role in combating malnutrition by enhancing knowledge and promoting healthier eating practices. Understanding the fundamentals of nutrition is essential for adopting positive dietary behaviors. Knowledge, attitudes, and practices (KAP) are the three key elements that drive behavioural change (Gibson, 2005). Teenage girls represent a vital target group for nutrition education interventions, particularly given the high prevalence of iron deficiency anemia among this demographic (Kader et al., 2019).

Peer education and engagement in health promotion have emerged as effective strategies in the health sector. Youth-led initiatives foster self-confidence, enhance communication skills, and improve leadership qualities among peer educators. Despite the positive outcomes for peer leaders, the overall impact on broader youth populations requires further evaluation (Friedman et al., 2017).

International organisations, including the UN, have emphasized the importance of involving adolescents in health-related campaigns to promote better nutrition and health practices (UNICEF, 2020). As global efforts align with the Sustainable Development Goals (SDGs), assessing the extent of iron deficiency anemia and promoting the significance of adequate iron intake are crucial steps in improving nutritional health (UN, 2015).

Schools serve as an essential platform for promoting healthy eating and raising awareness about nutrition. By educating adolescent girls about the importance of balanced diets and nutrient-rich foods, schools can effectively reduce the prevalence of anemia in underdeveloped areas (Pérez-Escamilla et al., 2017). Involving educators, parents, and community members in these initiatives further enhances their reach and impact.

Moreover, schools can play a vital role in fostering community development, social protection, and economic empowerment by promoting agricultural practices that produce nutrient-dense foods and addressing fundamental health, sanitation, and hygiene issues (UNICEF, 2020). By implementing comprehensive nutrition education programs, we can pave the way for healthier generations and contribute to achieving the SDGs.

METHOD

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 Organisation, the participants' nutrition education literacy, attitude, food-intake practices, and 24-hour dietary

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recall were evaluated at baseline and end-line for both the experimental and control groups[1].Biomarker measurement of haemoglobin level was conducted at baseline and end-line for both intervention and control groups.

Table 3.1: The quasi-experimental components of the research design

	Measurement		
Group	**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	√

The study focused on in-school adolescent girls aged 10-19years attending public secondary schools in the three (3) senatorial districts of Ogun State, Nigeria. 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. The sample size formula for mean comparison was used to get the study's sample size. 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 and agreement.

The study assessed the prevalence of iron deficiency anaemia among in-school girls aged 10-19years. 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.

The multi-stage sampling strategy was used in this investigation. 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 of 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.

The data collected include: socio-demographics, anthropometry (weight, height and BMI), a 24-

RESULTS AND DISCUSSION

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

Table 1A: Baseline Socio-demographic Characteristics of Respondents

Variable	Intervention (n=139)	Control (n=138)	Total (n=277)
Age			
Mean ± S.D	13.5 ±1.795	13.91± 1.824	13.64 ±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)

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Who Do You Stay With	126(90.6)	122(88.4)	248(89.5)
Parents	7(5)	10(7.2)	17(6.1)
Guardian	5(3.6)	6(4.3)	11(4)
Grandparents	1(0.7)	0(0)	1(0.4)
Others			

Table 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

The majority of the participants are underweight (42.2%), while only 0.7% found to be obese (see Table 1)

Table 2: Anthropometric Status

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

Prevalence of Iron Deficiency Anaemia in the experimental and control groups at baseline

The prevalence of iron deficiency anaemia among in-school adolescent girls in Ogun State, Nigeria. At baseline, the majority of the respondents, 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%) are experiencing mild anaemia, and 30 (10.8%) are experiencing severe anaemia.

Table 2: The Prevalence of Iron Deficiency Anaemia among In-School Adolescent Girls in Ogun State, Nigeria

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)

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 experimental 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.

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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 experimental 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.

Effect of nutrition education intervention on 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 on Improving Knowledge of Iron Deficiency 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 the majority 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 ± 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 end line.

Effect of the nutrition education intervention on improving knowledge of iron deficiency anaemia among in-school adolescent girls in Ogun State, Nigeria

Time point	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 on improving the 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.

Effect of the nutrition education intervention on 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

Nigeria, reveals a critical public health issue. At baseline, 59.6% of the girls experienced moderate anaemia, 14.1% mild anaemia, and 10.8% severe anaemia, indicating that a significant proportion of this population is at risk for various health complications, including fatigue, impaired cognitive function, and decreased physical performance (Ogunlesi et al., 2020). This situation highlights the urgent need for effective nutrition education programs aimed at improving dietary practices and knowledge about iron-rich foods. In contrast, a similar study in Tanzania reported a lower prevalence of anaemia among adolescent girls, with only 26.7% affected, suggesting that factors such as nutritional differences, health interventions, and socioeconomic conditions may contribute to these disparities (Ngaruiya et al., 2020). In Nigeria, limited access to iron-rich foods and poor dietary diversity are significant challenges (Abioye et al., 2020). Cultural beliefs and health-seeking behaviors, along with geographical factors like endemic diseases, further complicate the situation (Adeyemo et al., 2019).

At baseline, an alarming 83% of the adolescent girls demonstrated insufficient knowledge about IDA, including its symptoms, causes, and prevention methods. This lack of awareness directly correlates with the high prevalence rates observed (Dibba et al., 2021). A study in North West Ethiopia echoed similar findings, where a substantial portion of participants had poor knowledge about anaemia (Befekadu et al., 2020). However, following a structured nutrition education intervention, there was a significant increase in the knowledge levels of the participants, with the experimental group achieving an 88.1% knowledge score compared to 11.9% in the control group. This underscores the effectiveness of structured educational programs in enhancing awareness and understanding of IDA. Moreover, the study revealed a predominantly negative attitude towards IDA at baseline, with 56% of respondents expressing negative sentiments about the condition. Such attitudes can stem from stigma or a lack of understanding, as shown by similar research in Indonesia (Mardiah et al., 2020). Post-intervention, the experimental group exhibited a marked improvement, with 87.4% demonstrating positive attitudes towards IDA, highlighting the role of education in changing perceptions.

Dietary practices also showed significant improvement following the intervention, with more girls in the experimental group reporting increased consumption of iron-rich foods. This shift is crucial, as many participants initially reported low intake of foods vital for preventing anaemia. The intervention effectively emphasized the importance of dietary choices in managing IDA (Kader et al., 2019). Despite the positive outcomes, the study's limitations include potential recall bias in dietary assessments and the possibility of social desirability bias affecting responses. However, the robust quasi-experimental design enhances the reliability of the findings, contributing valuable insights into the effectiveness of nutrition education in addressing IDA among adolescents.

The study's findings align with global health strategies, particularly the Sustainable Development Goals (SDGs), which advocate for reducing health inequalities and improving access to healthcare information (UN, 2015). By integrating nutrition education into school curricula and community health programs, governments and health organisations can enhance adolescent health and combat nutritional deficiencies effectively. In conclusion, targeted nutrition education interventions are essential for improving knowledge, attitudes, and dietary practices related to iron deficiency anaemia among adolescent girls in Ogun State. These educational efforts not only empower individuals but also contribute to broader public health goals by promoting healthier communities.

CONCLUSION

In conclusion, this study underscores the urgent need for effective interventions to combat iron deficiency anaemia among adolescent girls. While the nutrition education intervention significantly improved knowledge and increased haemoglobin levels, a concerning lack of awareness about the symptoms, causes, and consequences of anaemia was evident among participants at baseline. This highlights the necessity for ongoing, tailored educational efforts involving families and communities to enhance nutritional practices. The findings advocate for integrating comprehensive nutrition education programs in schools and communities, alongside strategies to improve access to iron-rich foods and supplementation. Addressing both knowledge and dietary needs is essential for reducing anaemia prevalence and promoting the health and well-being of adolescent girls, thereby supporting their overall development.

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