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INFLUENCE OF IRON ON COGNITIVE DEVELOPMENT: AN AWARENESS -BASED CROSS-SECTIONAL STUDY

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ABSTRACT

Objectives: To evaluate the impact of iron deficiency on cognitive function among pediatric patients using Malin's Intelligence Scale for Indian Children (MISIC), assess laboratory parameters related to iron deficiency, and evaluate the knowledge, awareness, and perception of the effects of iron on cognition among healthcare students through a questionnaire-based survey. The study also aimed to create awareness regarding the importance of iron in cognitive development. **Results:** The study included 97 pediatric participants and 297 healthcare students. The findings demonstrated that iron deficiency was associated with reduced cognitive performance in children. The awareness survey revealed gaps in knowledge regarding the role of iron in brain development and cognition. Following the awareness intervention, participants showed improved understanding of the importance of adequate iron intake, particularly during pregnancy and childhood. **Conclusion:** Iron plays a vital role in cognitive development, myelination, and overall brain function. Early identification and management of iron deficiency, along with educational interventions, can help improve cognitive outcomes and increase public awareness. Promoting dietary iron intake and preventive strategies is essential for supporting healthy cognitive development in children.

KEYWORDS: Iron deficiency, Cognitive development, Awareness, Pediatrics, MISIC, Iron deficiency anemia, Cross-sectional study, Myelination, Brain development, Healthcare students.

INTRODUCTION

Iron is an essential micronutrient required for several important physiological functions in the human body. It plays a crucial role in oxygen transport, energy metabolism, immune function, and cell growth. The average daily dietary intake of iron is about 10–15 mg, but only 1–2 mg is absorbed through the intestine. Approximately 70% of the body's iron is present in hemoglobin within red blood cells, while the remaining iron is stored in tissues such as the liver, bone marrow, and muscles in the form of ferritin and hemosiderin. Iron exists in two forms: heme iron, which is mainly found in animal foods and is easily absorbed, and non-heme iron, which is found in plant foods and has lower absorption rates.

Iron performs several important functions in the body. It helps hemoglobin transport oxygen from the lungs to tissues and supports myoglobin in supplying oxygen to muscles. Iron also plays a role in the production of ATP (energy) through cytochrome enzymes and is necessary for DNA, RNA, and amino acid synthesis. In addition, it supports the immune system, promotes overall growth and development, and contributes to brain function, including concentration, attention, and the production of neurotransmitters such as dopamine and serotonin.

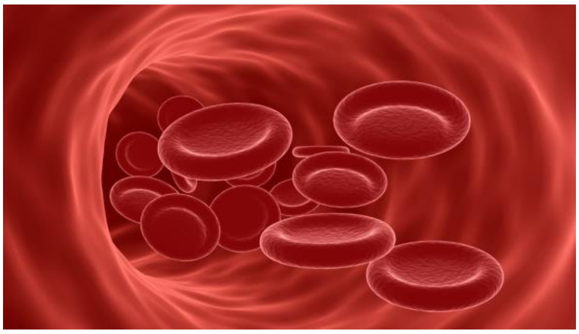


Fig 1: Iron in blood.

Iron absorption mainly occurs in the duodenum and upper jejunum of the small intestine. The efficiency of absorption depends on the form of iron and certain dietary factors. Vitamin C and animal proteins enhance iron absorption, while substances such as phytic acid, polyphenols, calcium, and oxalates can inhibit it. After absorption, iron is transported in the blood by the protein transferrin and stored primarily as ferritin. The body carefully regulates iron balance because both deficiency and excess iron can be harmful.

Iron deficiency is one of the most common nutritional deficiencies worldwide and can lead to iron deficiency anemia, a condition characterized by low hemoglobin levels. According to the World Health Organization (WHO), anemia is defined as hemoglobin levels below 13 g/dL in men and 12 g/dL in women. Common symptoms include fatigue, weakness, pale skin, dizziness, shortness of breath, cold hands and feet, and increased heart rate. Iron deficiency is particularly common in children and pregnant women, where it can significantly affect growth and development.

During pregnancy, the demand for iron increases due to the expansion of maternal blood volume, placental development, and fetal growth. Iron deficiency during pregnancy can lead to maternal illness, premature birth, low birth weight, and intrauterine growth restriction. It may also affect the neurological development of the fetus, resulting in long-term cognitive and behavioural problems.

Table 1: Hemoglobin limits specified by WHO.

Groups by age and gender	Hemoglobin (g/dl)
Children aged between 6-59 months	11
Children aged between 5-11years	11.5
Children aged between 12 -14 years	12
Girls aged >15 years	12
Boys aged >15 years	13

Iron also plays a crucial role in myelination, the process of forming a protective myelin sheath around nerve fibres (axons). Myelin allows nerve impulses to travel quickly and efficiently through the nervous system. In the central nervous system (CNS), myelin is produced by oligodendrocytes, while in the peripheral nervous system (PNS) it is produced by Schwann cells. Myelination begins during fetal development and continues throughout childhood.

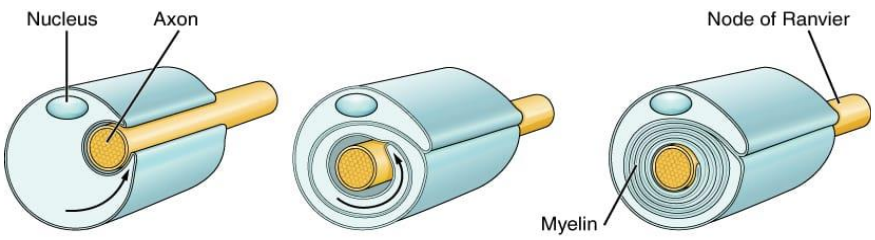


Fig 2: Formation of Myelin sheath.

Iron is necessary for the proper functioning and maturation of oligodendrocytes and for the synthesis of lipids and cholesterol that form the myelin sheath. When iron levels are insufficient, myelin production slows, leading to reduced myelinated nerve fibers and impaired nerve conduction. As a result, iron deficiency can negatively affect brain development, cognitive function, and motor skills, especially during early childhood.

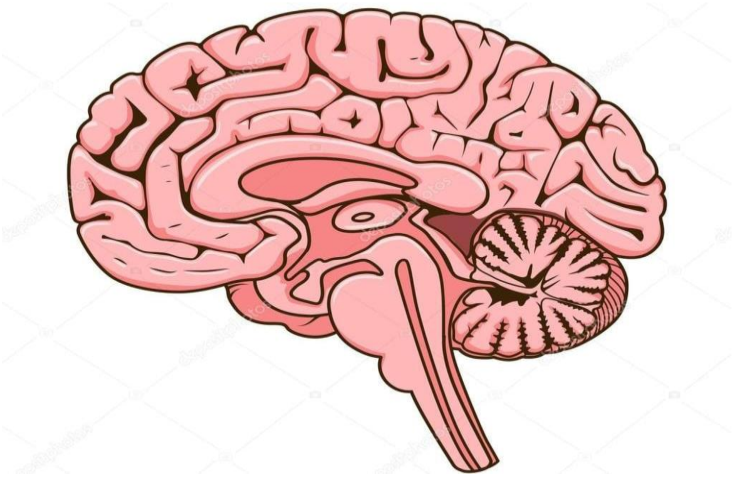


Fig 3: Human Brain.

Cognition refers to mental processes involved in learning, memory, reasoning, problem-solving, and decision-making. Proper brain development is essential for these cognitive abilities. Intelligence is commonly measured using Intelligence Quotient (IQ) tests, which assess an individual's ability to acquire and apply knowledge. One widely used assessment tool for Indian children is Malin's Intelligence Scale for Indian Children (MISIC), adapted from the Wechsler Intelligence Scale. It evaluates cognitive abilities through various verbal and performance tests such as information, arithmetic, vocabulary, digit span, block design, and picture completion.

Table 2: IQ Range.

IQ RANGE	IQ CLASSIFICATION
130 and above	Extremely high
120 – 129	Very high
110 – 119	High average
90 – 109	Average
80 – 89	Low average
70 -79	Very low
69 and below	Extremely low

INTELLIGENCE QUOTIENT

Intelligence can be defined as the capacity to acquire and apply knowledge.

A total score obtained from a series of standardized tests or subtests intended to evaluate human intelligence is known as an intelligence quotient (IQ).

According to wechsler (1943) "intelligence is the aggregate or global capacity of the individual to act purposefully, to think rational and to deal effectively with the environment."

Assessment of intelligence

Intelligence of the individual is assess by using intelligence test. There are millionsof millon scales are used to assess the congnitive funtions of the begins with different age group. The test was carried out by using the assessment test kits with manual by using the response of individual who had participated in test.[12]

Some of the cognitive assessment scale for pediatrics are as follows.

1. Wescheler intelligence scale for children
2. Binet kamet tests for intelligence
3. Bhatia battery test of intelligence[11]
4. Vineland social maturity scale (VSMS) test[13]
5. Stanford binet test[13]

MALIN'S INTELLLIGENCE SCALE FOR INDIAN CHILDREN

Malin's intelligence scale for Indian children (MISIC) is a adopted from American (David wescheler in 1949) wescheler intelligence scale for children (WISC) for Indian children (ages 6 – 15 years 11 months) by Dr. Arthur J. Malin in 1969.[14]

MISIC has 6 verbal subtests and 5 performance subtests.[12] Its updated versions of edition WISC – 5.

FORMULAE

$$IQ = \frac{\text{MENTAL AGE} \quad * 100}{\text{CHRONOLOGICAL AGE}}$$

MISIC

$$IQ = \frac{\text{VERBAL QUOTIENT + PERFORMANCE QUOTIENT}}{2}$$

MISIC – subtests

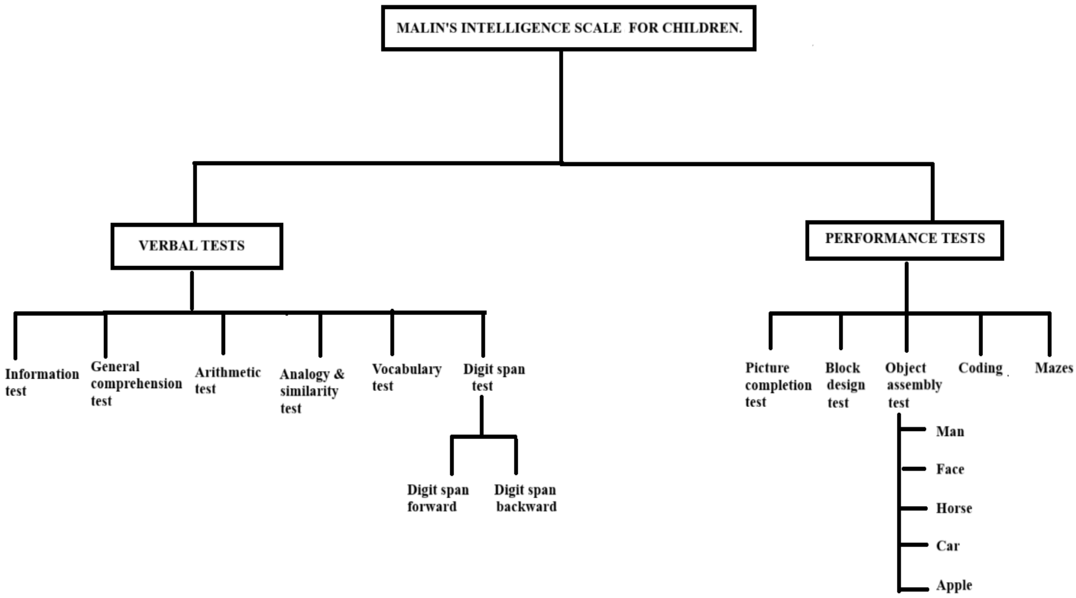


Table 3: MISC Subtest.

AWARENESS PURPOSE

As we conduct the study on effects of iron on cognition for paediatrics, we get the people who has normal iron have normal IQ (normal cognitive function) there is no much knowledge about importance of iron during pregnancy. So our aim is to give awareness for iron importance among pregnant women.

As per WHO, global target for anemia reduction as part of the comprehensive implementation plan on maternal, infant and young child nutrition. WHO's Anemia Action Alliance unites partners to deliver interventions like Iron Folic Acid (IFA) supplementation and hookworm treatments to pregnant women.

Several health programs which conducted in India are,

- Anemia Mukt Bharat (AMB).
- Weekly Iron Folic acid Supplementation (WIFS).
- National Food Fortification Programme.

Our aim is to increase iron through food items like follows,

Table 4: Iron rich food items.

Veg foods	Non-veg foods
Spinach	Chicken liver
Amaranth leaves	Egg

Drumstick leaves	Mutton
Lentiles	Clams and Oysters
Dates and Raisins	Beef

METHODOLOGY

STUDY TYPE

The study consisted of two phases:

Phase I: Prospective observational study.

Phase II: Cross-sectional questionnaire-based survey with an awareness intervention.

STUDY PERIOD

A total study duration of 10 months, conducted from November 2025 to August 2026.

Phase I: November 2025 – April 2026

Phase II: May 2026 – August 2026

STUDY PLACE

Phase I: Arunai Medical College and Hospital, Tiruvannamalai, Tamil Nadu.

Phase II: Arunai College of Pharmacy, Tiruvannamalai, Tamil Nadu.

STUDY REQUIREMENT

- Recruitment of participants with the assistance of physicians (Phase I) and faculty members (Phase II).
- Collection of demographic details including age, gender, medication history (Phase I), and academic level (Phase II).
- Well-designed and validated questionnaire for the survey study.
- Student/patient consent form obtained before participation.
- Awareness presentation and pamphlet on the effects of iron deficiency on cognitive function.
- Selection of participants based on inclusion and exclusion criteria.

SAMPLE SIZE

Phase I: A total of 97 pediatric participants were selected using random sampling based on willingness to participate.

Phase II: A total of 297 students meeting the inclusion criteria were recruited voluntarily for the questionnaire survey.

INCLUSION CRITERIA

Phase I: Pediatric patients aged 6 to 15 years 11 months.

Patients admitted to the pediatric ward.

Patients/parents willing to provide informed consent.

Phase II

- Students aged 16 to 25 years.
- Students from healthcare professions.
- Students willing to participate in the study.

EXCLUSION CRITERIA

Phase I

- Pediatric patients above 16 years.
- Patients admitted to the Pediatric Intensive Care Unit (PICU).
- Patients/parents unwilling to participate.

Phase II

- Students below 16 years or above 25 years.
- Students not belonging to healthcare professions.
- Students unwilling to participate.

STUDY METHOD

- ❖ **Phase I –** Prospective Observational Study
- ➢ Participants were selected according to the inclusion and exclusion criteria.
- ➢ The study procedure was explained, and informed consent was obtained.
- ➢ Patient demographic and clinical data were collected using a structured data collection form.
- ➢ Iron status and cognitive assessment data were recorded.
- ➢ Data were compiled for statistical analysis.
- ❖ **Phase II** – Cross-sectional Survey and Awareness Program
- ➢ Eligible students were selected based on the inclusion and exclusion criteria.
- ➢ The purpose of the study was explained, and informed consent was obtained.
- ➢ A pre-validated questionnaire was administered to assess knowledge and awareness regarding iron deficiency and cognitive function.
- ➢ An awareness presentation and educational pamphlet were provided.

- ➢ A feedback questionnaire (post-awareness assessment) was collected.
- ➢ Data were analysed to evaluate changes in awareness and knowledge.

STUDY TOOLS USED

- ✓ Patient/Student informed consent form.
- ✓ Patient data collection form.
- ✓ Validated questionnaire.
- ✓ Awareness presentation.
- ✓ Awareness pamphlet.

KEY WORD USED

Cognitive function, Iron, Anemia.

DESIGNING OF QUESTIONNAIRE FORM

The questionnaire form was designed based on our study. Questionnaire form includes the students name, age, gender, academic level, questions of the survey study and feedback questions.

OBSERVATIONS AND RESULT

PHASE 1

Totally 97 participants were enrolled in this study based on the inclusion and exclusion criteria.

1. PATIENT DEMOGRAPHIC DATA

GENDER-WISE DISTRIBUTION

The study population consisting of 59 males (60.8%) and 38 females (39.1%). Majority of participants were females.

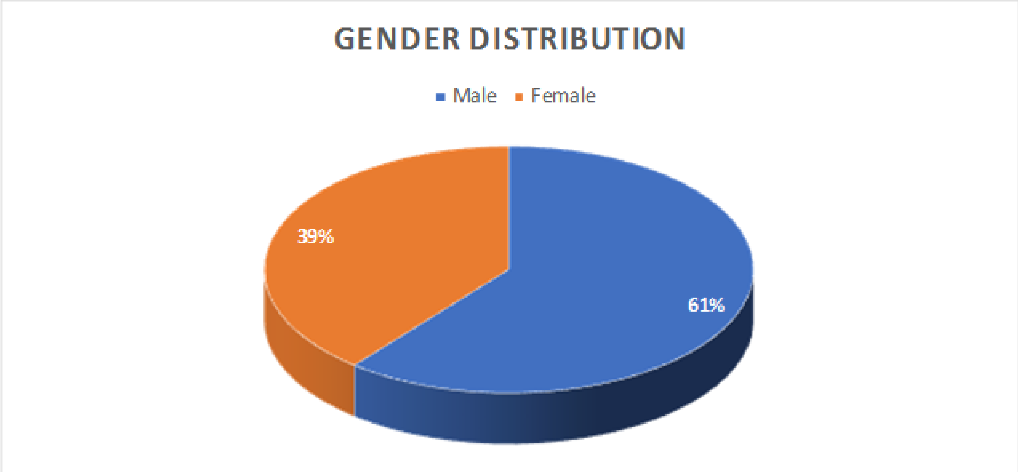


Fig 4: Gender wise distribution of participants.

AGE WISE DISTRIBUTION

Majority of the participants were in the age group of 12 to 13 years (25.7%) and the age group of 6 to 7 years participants were least number with the percentage of (15.4%).

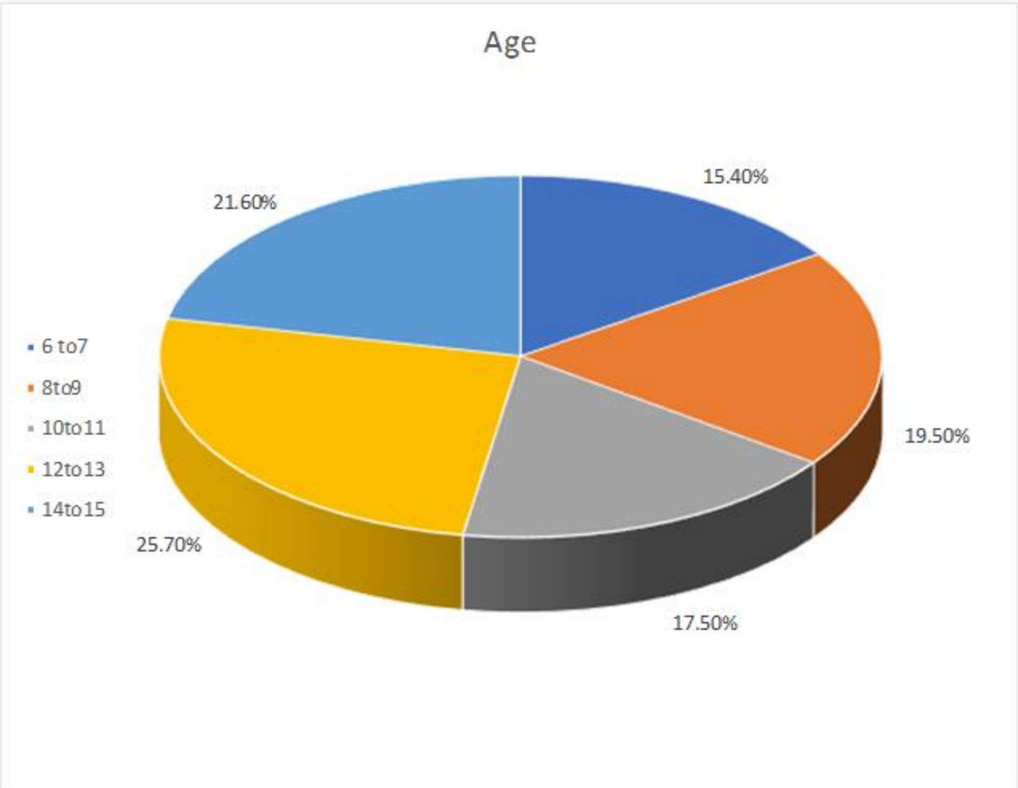


Fig 5: Age wise distribution of participants.

2. IRON DEFICIENCY ANEMIA PREVALANCE

From 97 participants, 38(40.2%) participants had iron deficiency with anemia and remaining 58(59.7) participant had iron deficiency without anemia.

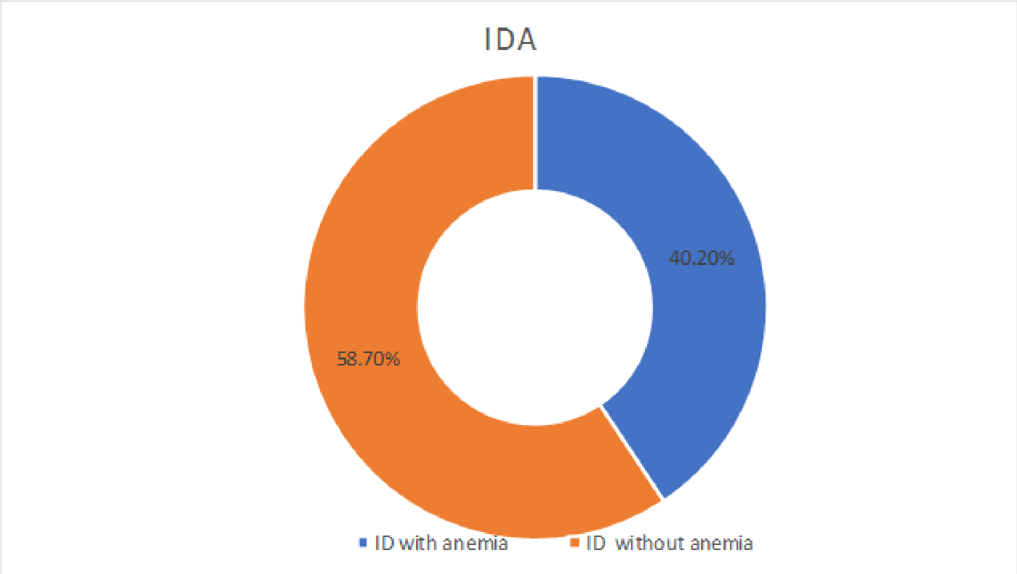
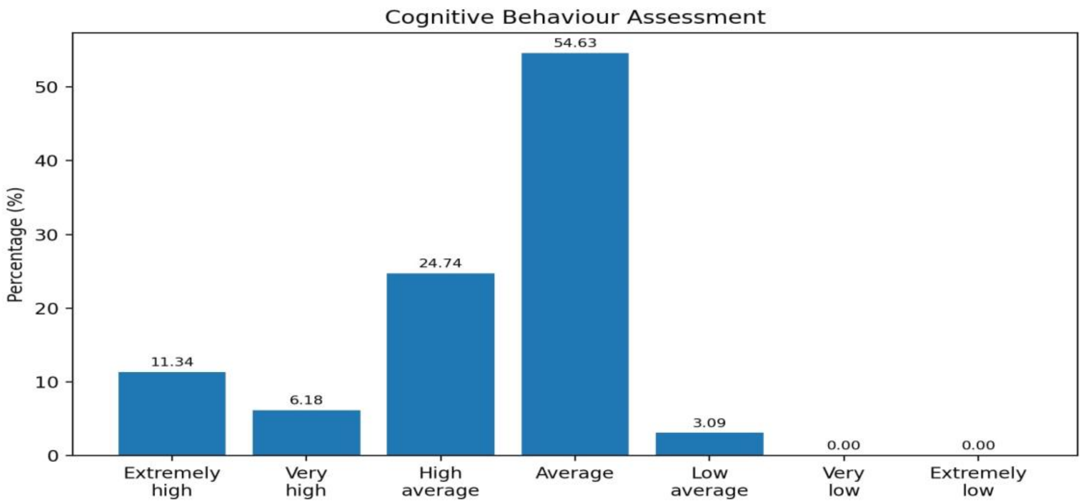


Fig 6: IDA prevalence of the participants.

ASSESSMENT RESUT OF COGNITIVE BEHAVIOUR

More number of the participants were under the norm average (53 participants) followed by high average (24 participants), extremely high(11participants) and other category had single digit participants.



IQ category

Fig 7: A graphical representation between percentage and IQ category.

PHASE 2

PATIENT DEMOGRAPHIC DATA

❖ **Age wise distribution**

Majority of the participants were in the age group of 19 years old with the percentage of 32.99% and the age group of 25 years old participants were least number with the percentage of 0.33%.

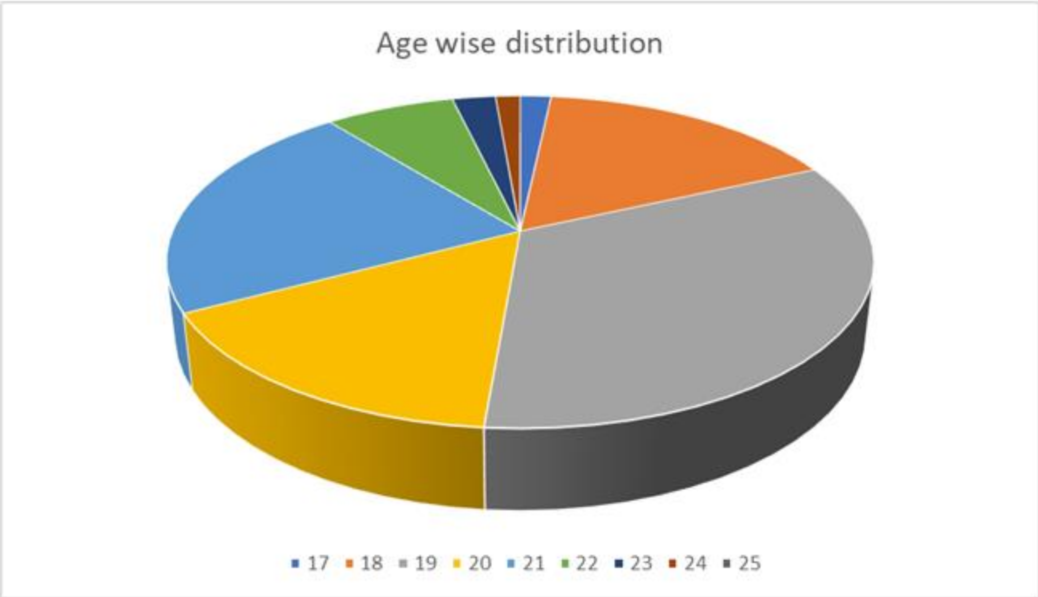


Fig 8: Age wise distribution.

❖ **Gender wise distribution**

The participants consisting of 111 males (37.37%) and 187 females. Majority of participants were females (62.96%).

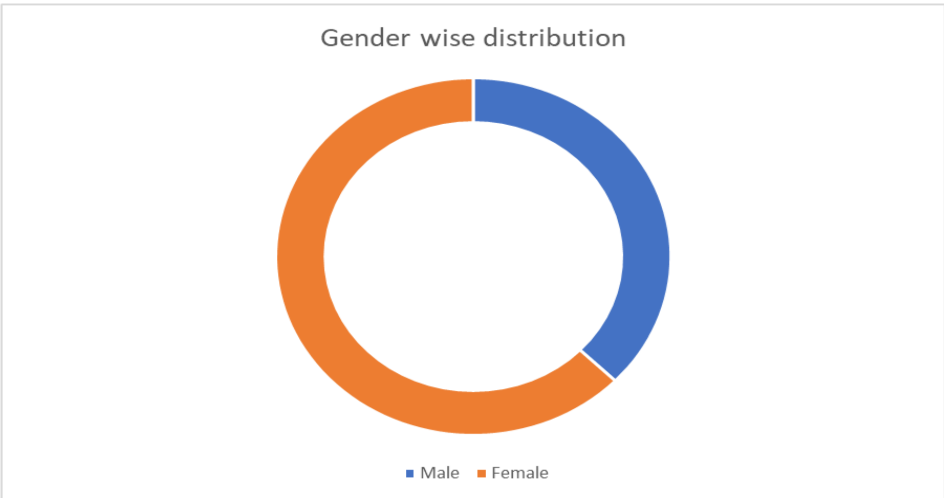


Fig 9: Gender wise distribution.

QUESTIONNAIRE

1. what is the 2nd most micronutrient deficiency in the world ?
2. Do you know about IQ ?
3. Abbreviate the term "IQ".
4. Do you know about myelination?
5. Do you know about the cognitive function ?
6. Do you know about anemia ?
7. Do you know about IQ scale?
8. Does IQ affect the academic score?
9. What is the normal hemoglobin value in adult?
10. What is normal IQ value ?
11. Does brain development affects IQ ?
12. Do you know the effects of iron on pregnancy?
13. What are the symptoms for anemia?
14. What is the function of neurotransmitter?

Table 7: Tabulation of result.

Question No:	Percentage of participants aware about the questionnaire topic (%)	Percentage of participants unaware about the questionnaire topic (%)
1.	53.19	46.79
2.	74.07	25.92
3.	79.79	20.20
4.	55.55	44.44
5.	52.86	47.13
6.	89.83	10.77
7.	56.56	43.43
8.	59.93	40.06
9.	73.40	26.59
10.	63.29	36.70
11.	52.86	47.13
12.	74.07	25.92
13.	70.37	29.62
14.	76.09	23.19

DISCUSSION

Based on the findings of this study, iron deficiency was found to be highly prevalent among the pediatric participants, indicating that it remains a significant nutritional concern. Among the 97 children included in Phase I of the study, 38 (40.2%) had iron deficiency with anemia, while 58 (59.7%) had iron deficiency without anemia. This suggests that many children may have inadequate iron stores even before developing clinical anemia, emphasizing the importance of early screening and intervention. The majority of participants were categorized under the average IQ range, while fewer children were found in the high-average or extremely high IQ categories. These findings support the concept that adequate iron status is important for normal cognitive development, as iron plays a vital role in myelination, neurotransmitter synthesis, oxygen transport, and overall brain development.

The results are consistent with previous literature, which has demonstrated that iron deficiency can impair attention, memory, learning ability, and intelligence, particularly during childhood when the brain is undergoing rapid growth. Previous studies have also reported that iron supplementation improves cognitive performance, especially in children with iron deficiency anemia. Therefore, maintaining adequate iron levels during early life is essential for optimal neurological and intellectual development.

Phase II of the study assessed awareness regarding iron and cognitive function among 297 healthcare students. Although awareness was satisfactory for certain topics such as anemia, IQ, and the effects of iron during pregnancy, knowledge regarding myelination, cognitive function, IQ scale, and the relationship between brain development and intelligence remained comparatively low. This indicates that even among healthcare students, there are important knowledge gaps concerning the role of iron in cognitive health. The awareness programme and educational materials used in this study have the potential to improve understanding and encourage healthy dietary practices.

Overall, the findings highlight the need for regular screening for iron deficiency, early nutritional intervention, and continuous public health education. Promoting iron-rich diets, appropriate iron supplementation when indicated, and awareness programmes for students, parents, and pregnant women may contribute to better cognitive outcomes and reduce the long-term burden of iron deficiency in the community. This study emphasizes that improving awareness and preventing iron deficiency should be considered important strategies for supporting healthy brain development and cognitive performance.

CONCLUSION

Iron is an essential micronutrient that plays a crucial role in brain growth, cognitive development, oxygen transport, neurotransmitter synthesis, and myelination. Adequate iron levels are particularly important during childhood and pregnancy, as these are critical periods for brain development. Iron deficiency can impair memory, attention, learning ability, intelligence, and overall cognitive performance, thereby affecting academic achievement and quality of life.

The present study was conducted in two phases to evaluate the relationship between iron deficiency and cognitive function in pediatric patients and to assess the awareness of iron and cognition among healthcare students. The findings indicated that a considerable proportion of pediatric participants had iron deficiency, with many exhibiting average or below-average cognitive performance. These observations suggest that iron deficiency may negatively influence cognitive development and emphasize the importance of early identification and management.

The awareness survey also demonstrated that although participants had a moderate level of knowledge regarding iron deficiency and its health effects, important gaps remained, particularly in understanding the role of iron in cognitive function, myelination, and pregnancy. The awareness intervention, including educational presentations and pamphlets, highlighted the value of health education in improving knowledge and promoting preventive practices.

Overall, this study emphasizes that maintaining adequate iron status through a balanced diet, regular screening, iron supplementation when indicated, and public health awareness programs can significantly contribute to better cognitive health and overall well-being. Healthcare professionals, educators, and policymakers should work together to promote awareness of iron deficiency and encourage early preventive measures, especially among children, adolescents, and pregnant women. Future studies involving larger populations and long-term follow-up are recommended to further establish the relationship between iron status and cognitive development and to evaluate the long-term impact of awareness-based interventions on health outcomes.

PHARMACIST INTERCESSION

Clinical pharmacists play a vital role in the prevention, early detection, and management of iron deficiency, particularly among children and pregnant women who are at high risk of developing cognitive impairment due to inadequate iron levels. In this study, the clinical pharmacist actively participated by identifying individuals at risk of iron deficiency through patient interviews, assessment of clinical history, and review of laboratory parameters such as hemoglobin and iron status. Appropriate counseling was provided regarding the importance of maintaining adequate iron levels for normal brain development, cognitive function, and overall health.

The clinical pharmacist educated participants on consuming iron-rich foods such as spinach, drumstick leaves, lentils, dates, raisins, chicken liver, eggs, and other iron-containing foods. Participants were also advised to include vitamin C-rich foods to enhance iron absorption and to avoid consuming tea, coffee, and calcium-rich foods immediately after meals, as these reduce iron absorption. Pregnant women and parents of pediatric patients received individualized counseling on the importance of adherence to iron and folic acid supplementation as recommended by healthcare professionals.

In addition, awareness materials, educational pamphlets, and interactive sessions were conducted to improve knowledge about iron deficiency anemia, its symptoms, risk factors, prevention, and its association with cognitive development. The clinical pharmacist also encouraged regular screening for anemia, timely follow-up, and adherence to prescribed therapy. These interventions contributed to improving awareness, promoting healthy dietary habits, enhancing medication adherence, and sup.

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