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Original Research Article

Latent iron deficiency in Indian women and children: A descriptive analysis

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ABSTRACT

Background : Iron deficiency is a global health concern, particularly in developing countries like India. While overt iron deficiency anemia (IDA) is well-documented, Latent Iron Deficiency (LID), a precursor to IDA, remains under-recognized. This study aims to elucidate the proportion of the Indian population with latent iron deficiency and underscore the importance of early detection of this condition.

Materials and Methods: 344624 anonymized medical records available through a personal health record (PHR) application developed by Eka Care, a health information technology company, were analysed. The ethical handling of data ensured that no personally identifiable information (PII) was accessible or utilized during the research process.

Results: Children aged 5-15 years had a LID prevalence of 32.7% (95% CI:27.4%,37.9%) while women aged 15-49 years had a prevalence of 31.5% (95% CI:30.3%,32.6%). 9% (95% CI: 8.5%,9.5%) of men in the same age group had LID.

Conclusion : This study revealed a significant burden of latent iron deficiency among Indian women and children. By implementing targeted screening and intervention strategies, one can improve health outcomes and break the cycle of iron deficiency in these vulnerable populations.

Clinical Significance : LID poses a serious risk for developing iron deficiency anemia (IDA) during and after pregnancy. Iron deficiency can adversely affect maternal and fetal health.This burden of LID highlights the critical need for routine screening and early intervention to prevent these adverse outcomes.

1. Introduction

Iron deficiency is a global health concern, particularly in developing countries like India. While overt iron deficiency anemia (IDA) is well-documented, Latent Iron Deficiency (LID), a precursor to IDA, remains under-recognized. This study aims to elucidate the prevalence of LID in Indian women and children using data from personal health records (PHRs) and emphasize the importance of its early detection.Iron is an essential trace mineral that is integral to numerous physiological processes in the human body. Most of the body's iron is incorporated into heme, apart from which it is also present in iron sulphur proteins and as a cofactor for many enzymes. Some important functions of iron are highlighted here.

2. Functions of Iron in the Human Body

2.1. Oxygen transport

Iron plays a critical role in oxygen transport, primarily through its incorporation into hemoglobin. Iron in the protoporphyrin ring of the heme molecule allows binding and transport of oxygen from the lungs to tissues throughout the body. This oxygen delivery is essential for cellular respiration, energy production, and overall tissue function.

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Furthermore, iron is a key component of myoglobin, a protein in muscle cells that facilitates the storage and release of oxygen within muscles, thereby supporting sustained physical activity.[1]

2.2. Energy production and metabolism

Iron is integral to cellular metabolism and energy production. As part of iron sulphur proteins and a cofactor, iron is involved in several metabolic pathways, including citric acid cycle (Krebs cycle) and the electron transport chain responsible for generating adenosine triphosphate (ATP), the primary energy currency of the body. Adequate iron levels are hence essential for maintaining cellular energy metabolism and overall physiological function.[1]

2.3. Genetic expression

Heme can bind to various transcription factors and bring about a change in genetic expression of genes responsible for antioxidant response, circadian rhythm, cell proliferation and cell death.[1]

2.4. Immune function

Iron is vital for proper immune function. It supports the growth and proliferation of immune cells, particularly lymphocytes. Through transcription factors and enzymes participating in free radical metabolism, iron influences both innate and adaptive immune systems.[2] Iron deficiency can compromise immune function, increasing susceptibility to infections and impairing the body's ability to mount an effective immune response.

2.5. Cognitive function and brain development

Iron is also crucial for cognitive function and brain development. Iron is a cofactor for enzymes required for neurotransmitter synthesis and also plays a role in myelination, both of which are essential for proper brain function, learning, and memory. Iron deficiency during critical periods of brain development, such as infancy and childhood, can result in cognitive impairments and developmental delays.[3]

Etiology of iron deficiency can be broadly understood in terms of poor dietary intake, impaired iron absorption and increased iron loss.[4] Despite its crucial roles, a significant proportion of both the global and Indian populations suffers from iron deficiency.

2.6. Anemia and iron deficiency - The current scenario

Anemia, marked by a decrease in the blood's oxygen-carrying capacity, is clinically defined by hemoglobin levels below 13 g/dL in adult men and below 12 g/dL in non-pregnant women. According to the World Health Organization (WHO), iron deficiency anemia (IDA) is the most common nutritional deficiency globally, affecting about 30% of the world population. Even without anemia, iron deficiency (ID) alone impacts around 20% of people worldwide.[5–7]

In 2019, anemia affected 29.9% of women of reproductive age globally, which translates to approximately half a billion women. Among these, 29.6% of non-pregnant women and 36.5% of pregnant women had low hemoglobin levels. In India, the prevalence of anemia among women of reproductive age is particularly high, with 57% of non-pregnant women and 52% of pregnant women affected.[8]

3. *The Iron Depletion Spectrum*

Iron deficiency isn't a uniform condition but rather a spectrum, beginning with iron depletion where the body's iron demand surpasses its supply, resulting in depletion of its iron reserves. This depletion initially impacts bone marrow iron levels and myoglobin synthesis in the muscles. As iron-dependent proteins, crucial for cellular energy production, become insufficient, individuals experience symptoms such as fatigue, loss of motivation, reduced exercise tolerance, diminished work productivity, poor concentration, and low immunity. These symptoms often occur even while hemoglobin levels remain within normal ranges, allowing this latent stage to go unnoticed, only reflected by diminishing bone marrow, liver and reticuloendothelial iron stores. Iron depletion progresses on to iron deficient erythropoiesis, finally culminating in dropping hemoglobin levels heralding the onset of iron deficiency anemia (IDA).[9]

3.1. Significance of transferrin saturation and ferritin levels

Declining bone marrow iron levels precede anemia, a critical clue often not readily apparent. Transferrin saturation and serum ferritin levels are key markers that decrease during the later stages of iron depletion and latent deficiency. Low ferritin levels strongly indicate iron depletion. Serum ferritin levels of 50ug have been seen to be associated with near negligible bone marrow iron. However, their reliability diminishes in the presence of chronic diseases where levels can be elevated. In such cases, transferrin saturation serves as an important indicator of iron status. Monitoring these markers is crucial for detecting iron deficiency before significant drops in hemoglobin occur.[4,9–11]

Our study aims to elucidate the proportion of the Indian population with latent iron deficiency and underscore the importance of early detection of this condition. The analysis aimed to identify patterns and prevalence of latent iron deficiency in individuals who did not present with overt anemia.

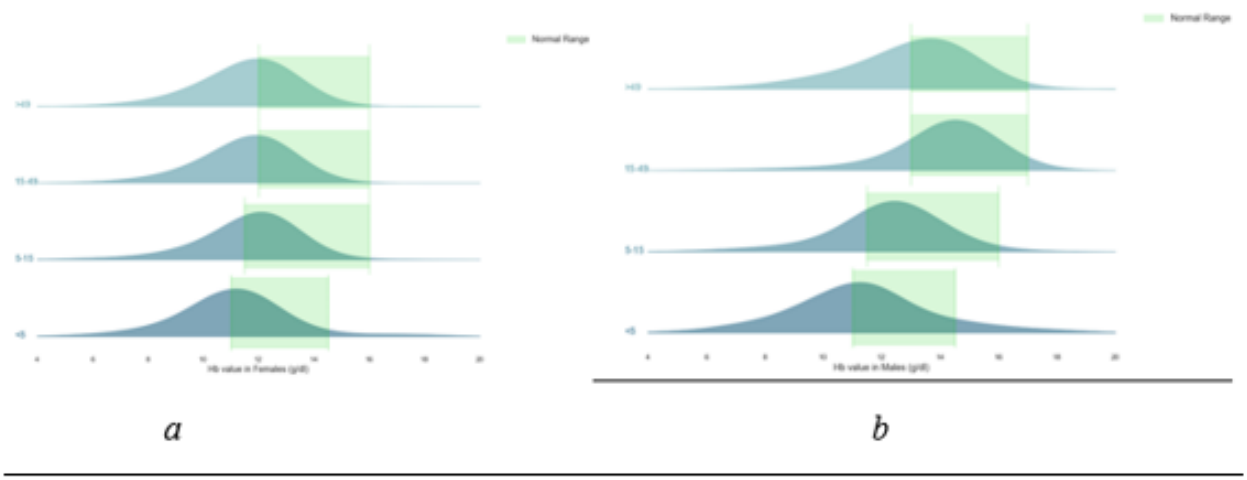

Figure 1: a: Hemoglobin distribution in females across all ages **b:** Hemoglobin distribution in males across all ages

4. Materials and Methods

4.1. Data collection

Data was sourced from anonymized medical records available through a personal health record (PHR) application developed by Eka Care, a health information technology company. The dataset included demographic information, hemoglobin levels and serum transferrin saturation levels. Data from 344624 medical records was analysed to calculate the age and gender based prevalence of anemia. Individuals with normal hemoglobin levels who had documented their transferrin saturation measurements were included in the analysis to study the prevalence of latent iron deficiency in the cohort. This study utilized a descriptive analysis approach to examine hemoglobin levels across various demographics within the Indian population. Furthermore, the distribution of transferrin saturation levels among men and women in the age group of 15-49 years and children in the age group 5-15 years was analysed.

4.2. Consent and privacy

The data used in this study were obtained from anonymized medical records, ensuring the privacy and confidentiality of all individuals involved.

The ethical handling of data ensured that no personally identifiable information (PII) was accessible or utilized during the research process. The anonymization process adhered to standard data protection protocols to safeguard user privacy and maintain the integrity of the research.

4.3. Statistical analysis

Descriptive statistics were used to analyse the prevalence of LID. Comparisons were made across different age groups and gender to identify patterns and significant differences.

5. Results

5.1. Prevalence of Anemia - Distribution across age and gender subgroups

A total of 344,624 medical records were reviewed to obtain hemoglobin levels across various age and gender subgroups. Hemoglobin values from 161,395 (47%) women and 183,229 (53%) men were analysed to determine the prevalence of anemia within the cohort.

5.2. Distribution of hemoglobin values among females

Women aged 15-49 years exhibited the highest prevalence of anemia at 52.6%, followed closely by women over 49 years at 51%. Among girls under 5 years, the prevalence was 41.6%, while those aged 5-15 years had a slightly lower prevalence of 35.3%.

5.3. Distribution of hemoglobin values among males

Men over 49 years had the highest prevalence of anemia at 41%, followed by 39.8% among those under 5 years. The prevalence in the 5-15 age group was slightly lower at 24.8%, while men aged 15-49 years had the lowest prevalence at 17.4%.

5.4. Prevalence of latent iron deficiency among women and children

A serum transferrin saturation below 16% was considered the cut-off for iron depletion, although some studies suggest a higher threshold of 20%.(9,10) We analysed data for women of reproductive age and children aged 5-15 years, as these groups are at higher risk of iron deficiency. Only individuals with normal hemoglobin levels were included in the analysis.

A total of 20,658 records were reviewed, including 306 children aged 5-15 years, 6,445 women, and 14,088 men aged 15-49 years.

Among the children aged 5-15 years, 100 out of 306 32.7% (95% CI:27.4%,37.9%) had normal hemoglobin levels with transferrin saturation levels below 16%. In the women aged 15-49 years, 2,029 out of 6,445 31.5% (95% CI:30.3%,32.6%). had transferrin saturation levels below 16% despite normal hemoglobin levels. This proportion was much lower in men of the same age group, at 9% (95% CI: 8.5%,9.5%).

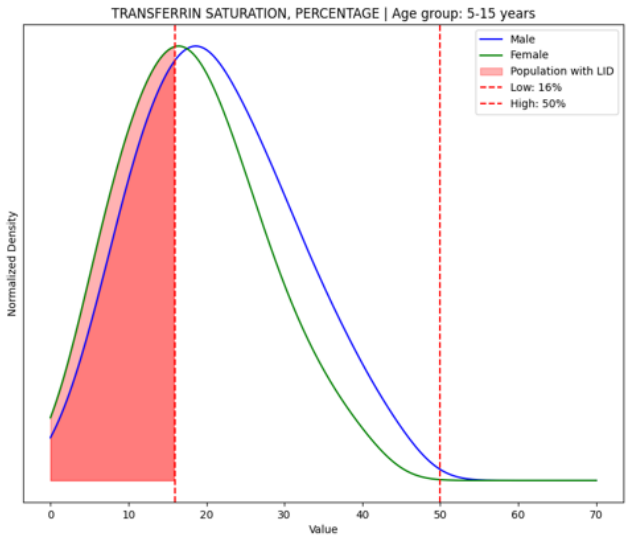

Figure 2: Distribution of transferrin saturation % among children in the 5-15 years age group with normal hemoglobin levels.

6. Discussion

6.1. Prevalence

Our analysis revealed that 31.5% of women aged 15-49 years and 32.7% of children aged 5-15 years exhibited transferrin saturation levels below 16%, despite having normal hemoglobin levels. These findings indicate a substantial burden of LID, which is often overlooked due to the absence of overt anemia. This silent deficiency can lead to significant health implications if not addressed promptly.

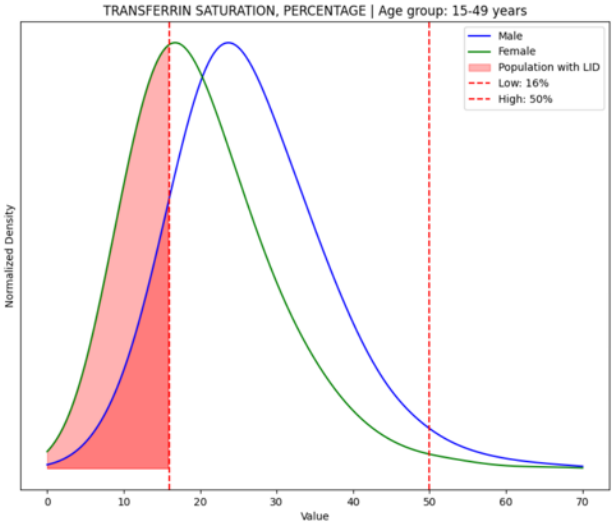

Figure 3: Distribution of transferrinsaturation % among men and women in the 15-49 years age group with normalhemoglobin levels.

6.2. Clinical implications - Risk factors and vulnerable populations

Heavy menstrual bleeding, pregnancy, childbirth and postpartum period are the major reasons behind LID in women of reproductive age.LID poses a serious risk for developing iron deficiency anemia (IDA) during and after pregnancy. Iron deficiency can adversely affect maternal health with increased risk of postpartum hemorrhage and preeclampsia and fetal health leading to pregnancy outcomes such as low birth weight, preterm delivery, small for gestational age, perinatal and neonatal mortality. The high prevalence of LID in this demographic highlights the critical need for routine screening and early intervention to prevent these adverse outcomes.[12] Among children, iron deficiency can impair cognitive and physical development, leading to long-term educational and health consequences. Children with LID are at a higher risk of progressing to IDA, which can exacerbate developmental delays and reduce overall quality of life.[13]

6.3. Comparison with other studies

A study on the prevalence of LID and IDA among women aged 12-21 years in the US, conducted by Weyand et al. reported an overall prevalence of iron deficiency prevalence of 38.6%.[14] Another study by Gupta et al revealed an LID prevalence of 10.4% among non pregnant women and 16.3% among pregnant women, with prevalence increasing with each trimester of pregnancy.[15] A study by Tang et al. in Canada reported 91.3% of pregnant women in the study to be LID.[16] Prevalence rates observed in our study are consistent with findings from other regions. The specific

focus on LID provides a unique perspective on the hidden burden of *LID* that might not be captured through traditional anemia screening alone. This emphasizes the importance of incorporating and interpreting serum ferritin and transferrin saturation measurements into routine health assessments, particularly in high-risk populations.

6.4. Limitations

Several limitations of this study must be acknowledged. First, the reliance on personal health records (PHRs) introduces potential selection bias which could result in an overestimation or underestimation of the true prevalence of LID in the general population. Additionally, the cross-sectional nature of the study limits the ability to track its progression and outcome over time

7. Recommendations

Despite these limitations, our findings highlight the need for routine screening for serum ferritin and transferrin saturation, alongside traditional hemoglobin measurements, in order to identify at-risk individuals before the onset of anemia.

8. Conclusion

In conclusion, this study reveals a significant burden of latent iron deficiency among Indian women and children. The early detection and management of LID are essential to prevent the progression to iron deficiency anemia and associated health complications. By implementing targeted screening and intervention strategies, we can improve health outcomes and break the cycle of iron deficiency in these vulnerable populations. Future research should focus on longitudinal studies and broader population samples to further elucidate the impact of LID and refine intervention approaches.

9. Source of Funding

None.

10. Conflict of Interest

None.

References

1. Dutt S, Hamza I, Bartnikas TB. Molecular Mechanisms of Iron and Heme Metabolism. *Annu Rev Nutr*. 2022;42(1):311–46.
2. Nairz M, Weiss G. Iron in infection and immunity. *Mol Aspects Med*. 2020;75:100864.
3. Wang M. 2016.
4. Goodnough LT, Nemeth E, Ganz T. Detection, evaluation, and management of iron-restricted erythropoiesis. *Blood*. 2010;116(23):4754–61.
5. Kassebaum NJ, Jasrasaria R, Naghavi M, Wulf SK, Johns N, Lozano R. 2014.
6. Anaemia. 2024. Available from: https://www.who.int/data/nutrition/nlis/info/anaemia.
7. 2024. Available from: https://www.who.int/data/gho/data/themes/topics/anaemia_in_women_and_children.
8. Mukt BA. 2024. Available from: https://anemiamuktbharat.info/.
9. Al-Naseem A, Sallam A, Choudhury S, Thachil J. Iron deficiency without anaemia: a diagnosis that matters. *Clin Med*. 2021;21(2):107–120.
10. Soppi ET. 2018.
11. Cappellini MD, Santini V, Braxs C, Shander A. Iron metabolism and iron deficiency anemia in women. *Fertil Steril*. 2022;118(4):607–621.
12. Petraglia F, Dolmans MM. Iron deficiency anemia: Impact on women's reproductive health. *Fertil Steril*. 2022;118(4):605–611.
13. Juul SE, Derman RJ, Auerbach M. Perinatal Iron Deficiency: Implications for Mothers and Infants. *Neonatology*. 2019;115(3):269–74.
14. Weyand AC, Chaitoff A, Freed GL, Sholzberg M, Choi SW, Mcgann PT. Prevalence of Iron Deficiency and Iron-Deficiency Anemia in US Females Aged 12-21 Years. *JAMA*. 2003;329(24):2191–2191.
15. Gupta PM, Hamner HC, Suchdev PS, Flores-Ayala R, Mei Z. Iron status of toddlers, nonpregnant females, and pregnant females in the United States. *Am J Clin Nutr*;2017:1640–1646.
16. Tang G, Lausman A, Abdulrehman J, Petrucci J, Nisenbaum R, Hicks LK. Prevalence of Iron Deficiency and Iron Deficiency Anemia during Pregnancy: A Single Centre Canadian Study. *Blood*. 2019;134(Supplement_1):3389–3389.

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