

EVALUATION OF IRON DEFICIENCY ANEMIA AND ITS IMPACT ON GROWTH AND DEVELOPMENT IN PEDIATRIC POPULATION OF KHYBER PAKHTUNKHWA (KPK), PAKISTAN.

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ABSTRACT

Objectives: To determine the prevalence of iron deficiency anemia (IDA) among children aged 2-12 years in Khyber Pakhtunkhwa (KPK), Pakistan.

Methods: The study involved 100 children (2-12 years) of KPK in a cross-sectional study. Blood was analyzed both for hemoglobin and iron deficiency and physical development was analyzed by measuring height and weight. The standardized tests were used to measure cognitive performance. The SPSS was used to analyze the data through descriptive statistics, Chi-square and regression analysis.

Results: out of 100 patients 48% iron deficiency anemia (IDA) of children/children enrolled in the study, 30% mild anemia, 12% moderate anemia, and 6% severe anemia. The average age of the participants was 8.3295 or 8.3 years. The parameters of physical growth in children with IDA were significantly lower in comparison with their non-anemic counterparts. Particularly, the average height of anemic children was 110 cm +/- 7 cm and the mean weight was 19.5 kg +/- 3.5 kg, on the other hand, non-anemic children have an average height of 118 cm +/- 6 cm and an average weight of 22.4 kg +/- 4.2 kg ($p < 0.05$).

Conclusion: the prevalence of IDA in children in KPK is very high with serious adverse consequences on the physical and cognitive developments. These results demonstrate that the social and health-related factors of IDA, such as iron supplementation and dietary knowledge, should be used to enhance child health results in the area.

Keywords: Iron deficiency anemia, children, growth, development

Introduction

Iron deficiency anemia (IDA) is among the most common nutritional disorders in the world with children in the low- and middle-income countries being the most affected. This is a state that is caused by a lack in the amount of iron and as such, the production of hemoglobin is limited resulting in the body being unable to carry on oxygen effectively in the blood stream. Children are particularly susceptible because they have great demand of iron in the stages of rapid growth and development. IDA, besides being linked with physical health conditions (poor growth and slow development) is linked to serious cognitive and behavioral difficulties that can affect the educational results and future quality of life of a child [1,2]. The rates of IDA in children are so high in Pakistan, especially in rural regions where children have limited access to nutritious foods. The Khyber Pakhtunkhwa (KPK) is not an exception; this is situated in the north-western part of the country. There are a number of factors that affect the nutritional status of children in KPK and these factors include poverty, lack of education about proper diet, lack of medical care and

generally the use of cereal based diet, which is deficient in iron [3]. The province is typified with heterogeneous ethnicity and different levels of socioeconomic status that makes the evaluation of the IDA and its effects an imperative field of study on public health programs [4]. The effects of iron deficiency anemia on children include retarded growth, low birth weight, late motor and cognitive development as well as poor immune system. In extreme cases, untreated IDA can cause permanent impairment of the cognitive functions, which can have a great impact on the performance of a child in school. Iron is an essential constituent of hemoglobin, but it also plays a vital role in numerous enzymes that help the body to grow, metabolize as well as immune activity. Hence, timely diagnosis and treatment of IDA are the most important in order to avoid these negative outcomes [5,6]. Iron deficiency anemia has been a major issue of concern in KPK but little has been done as far as study is concerned to specifically determine the effect it has on the growth and development of children in this area. This study aims at assessing the prevalence of iron deficiency anemia in children in KPK, and the effects of iron deficiency on the physical development and cognitive ability of the children [7]. It is through this that the study will be valuable in terms of providing valuable data that will help in the formulation of more specific healthcare policies and intervention strategies to correct this problem in KPK [8]. In this study, a group of children in the urban and rural setting in KPK will be used to guarantee that the results reflect the various groups of people in the region. This study will offer evidence-based solution to iron deficiency among children because it will analyze the association of IDA with several developmental attending to the health of the children and help the world understand the effects of IDA to the health of children [9].

Materials and Methods

Study Design & Setting

This cross-sectional study conducted at department of children medicine Lady reading hospital Peshawar from June 2022 to Dec 2022 patients from both city and rural settings The patients between the age of 2-12 years of different districts in KPK.

Participants

100 children between 2-12 years old in the urban and rural regions of KPK, Pakistan. The children will be chosen in the local schools and community health centers. A consent form will be collected among the parents, and the children who will match the inclusion criteria will be registered. The participants will be tested through iron deficiency anemia screening through blood tests and physical examination.

Inclusion Criteria

The children aged between 2-12 years old, in both the urban and rural region of KPK, with informed consent between their parents.

Exclusion Criteria

Children with known chronic diseases, severe infections, or other problems with growth or cognitive functioning (e.g., neurological conditions, genetic syndromes).

Diagnostic and Management Strategy

Diagnosis Iron deficiency anemia Diagnosis will be made in patients with hemoglobin levels less than 11 g/dL and ferritin levels less than 12 ng/mL. They will be given iron supplementation (oral or intravenous) and nutritional counseling to boost iron consumption. The response to treatment will also be followed up to determine response to treatment.

Statistical Analysis

Analysis of the data will be performed with the help of SPSS version 26.0. Participant characteristics will be summarized using descriptive statistics such as mean, standard deviation, and %ages. The Chi-square test will determine the associations of IDA with growth/cognitive outcomes. To establish the relationship between IDA and developmental impairments, regression analysis will be done, and the **p-value** of less than 0.05 will be regarded as statistically significant.

Results

100 children with 45% of the sample having iron deficiency anemia (IDA). Of the individuals who had IDA, 18% were mildly anemic, 20% were moderately anemic and 7% were severely anemic. The Mean age was 8.3 +3.4 years. Table 1 demonstrates the prevalence and severity of anemia. Physical examination indicated that average height and weight of anemic children were much lower as compared to their non-anemic counterparts. In particular, the mean height of children with anemia was 110 -7 cm and that of children without anemia was 118 -6 cm ($p < 0.05$). On the same note, anemic children had a mean weight of 18.6 ± 3.5 kg as compared to non-anemic group whose mean weight was 22.3 ± 4.2 kg (p not less than 0.05). The comparison between the physical growth parameters of the anemic and non-anemic children was conducted using standard IQ tests in table 2. The findings revealed that the IQ scores of children with IDA were significantly lower than those of their non-anemic counterparts (mean: 85 ± 7 vs. 94 ± 6 respectively), p -value= < 0.01 . Moreover, there was also a decrease in attention and memory tests and the difference was statistically significant between the anemic children. The results of the cognitive test of the anemic and non-anemic children are presented in Table 3.

Table 1: Demographic Characteristics of Participants

Characteristic	Value (n = 100)
Mean Age (years)	8.2 ± 3.5
Gender: Male (%)	48 (48%)
Gender: Female (%)	52 (52%)
Urban Population (%)	40 (40%)
Rural Population (%)	60 (60%)

This is a table illustrating the severity of the iron deficiency anemia (IDA) among the 100 children that were part of the study. Forty-five percent of the children were found to have IDA, 18 percent mild anemia, 20 percent moderate anemia, and 7 percent severe anemia. The rest 55 percent of children were not found to have anemia.

Table 2: Prevalence of Iron Deficiency Anemia (IDA)

Severity of Anemia	Number of Children (n = 100)	%age (%)
Mild Anemia	30	30%
Moderate Anemia	12	12%
Severe Anemia	6	6%
No Anemia	52	52%

The comparison in this table is the physical growth parameters (height and weight) among the anemic and non-anemic children. Results indicate that there is a big difference in the height and weight of the two groups where the anemic children had lower means in their height (110 ± 7 cm) and their weight (18.6 ± 3.5 kg) than the non-anemic children whose mean height was 118 ± 6 cm and mean weight was 22.3 ± 4.2 kg. These were statistically significant ($p < 0.05$).

Table 3: Comparison of Physical Growth Parameters Between Anemic and Non-Anemic Children

Growth Parameter	Anemic Children (n = 48)	Non-Anemic Children (n = 52)	p-value
Mean Height (cm)	110 ± 7	118 ± 6	< 0.05
Mean Weight (kg)	19.5 ± 3.5	22.4 ± 4.2	< 0.05

This table illustrates the cognitive function scores of anemic and non-anemic children based on IQ, attention, and memory tests. The results indicate that children with IDA scored significantly lower on all cognitive tests compared to their non-anemic counterparts. Specifically, the mean IQ score for anemic children was 85 ± 7 , significantly lower than the non-anemic children's mean score of 94 ± 6 ($p < 0.01$). Similarly, attention and memory test scores were also significantly lower in the anemic group ($p < 0.05$ for both attention and memory tests).

Table 4: Cognitive Function Scores in Anemic and Non-Anemic Children

Cognitive Test	Anemic Children (n = 48)	Non-Anemic Children (n = 52)	p-value
Mean IQ Score	85 ± 7	95 ± 6	< 0.01
Attention Test Score	12.5 ± 3.2	15.1 ± 2.5	< 0.05
Memory Test Score	14.8 ± 4.1	17.3 ± 3.1	< 0.05

Table 4 presents cognitive test scores (IQ, attention, and memory) for both anemic and non-anemic children. It shows a significant difference in cognitive function, with anemic children scoring lower on all tests (p -value < 0.01 for IQ, p -value < 0.05 for attention and memory).

Discussion

The rate and effects of iron deficiency anemia (IDA) on physical development and cognitive development in children in Khyber Pakhtunkhwa (KPK), Pakistan. The results demonstrate that the prevalence of IDA (48%) is high and that it is strongly negatively correlated with both growth parameters and cognitive function which would be consistent with the results of the recent studies that IDA is a serious public health issue affecting child development in the world and in low- and middle-income countries [11,12]. Various recent studies support the negative effect of iron deficiency on child development. As an illustration, a meta-analysis of school age samples has established that iron deficiency and IDA have a negative relationship with cognitive outcomes such as attention and intelligence scores, and positively respond to iron supplementation, but still does not have a consistent effect on outcomes in the specific domains of memory [13]. These international results are the same as those of our study where anemic children got their lowest scores in cognitive measurements compared to their non anemic counterparts ($p < 0.01$). This congruence reinforces the argument that impaired iron homeostasis can undermine neurocognitive development in key developmental stages [14]. Similarly, the current studies point to the correlation of IDA and physical growth measures. According to systematic reviews, ID and IDA correlate with stunting and reduced anthropometric variables in a developing pediatric population, which supports the lower means of height and weight in an anemic group ($p < 0.05$). These results are probably an indication of the role of iron in hemoglobin production and development that mediates the action of endocrine hormones like IGF 1, whereby iron deficiency disrupts energy metabolism and somatic growth [15]. High prevalence of childhood anemia and developmental impairment is also evidenced in South Asia. In a multicenter review in Pakistan, the estimates of IDA prevalence were found to vary widely across different areas and the association of IDA with poor physical and cognitive outcomes in children including lower school performance [16]. Moreover, localized study in districts of KPK (e.g., Banu and Tank) also indicated high levels of anemia and related physiological growth and mental activity diminishments, which confirmed the

regional tendencies that could be compared with our results [17]. Nonetheless, there is the recent literature, which focuses on the heterogeneity of effect sizes and context-dependent results. Those methodological differences, age at assessment and length of deficiency influence measurable outcomes as a 2025 systematic review on early childhood iron deficiency found mixed statistical significance across domains of neurodevelopment. Furthermore, toward that, iron deficiency without anemia, the study has indicated that even subclinical levels of low iron status can have a small effect on cognitive and behavioral performance, so this may be the case beyond instances of clinical anemia. Our study corresponds with the general issue that clinical or subclinical iron deficiencies can negatively inform development [18]. The underlying mechanisms of these associations are probably the central functions of iron in the transport of oxygen, the formation of neurotransmitters, myelination, and energy metabolism of the growing brain and musculoskeletal systems. Lack of nutrition interferes with these mechanisms, especially in the accelerated developmental periods of early and middle childhood, leading to permanent cognitive and physical disabilities. though supplementation has been demonstrated to have some positive effects, the benefits depend on age and initial severity and the cognitive domains assessed. These findings support the significance of early screening and holistic nutritional interventions such as dietary diversification, fortification as well as target iron delivery programs especially in high burden areas such as KPK. [19,20] the findings our study are sufficient to confirm and extend the literature that has shown that iron deficiency anemia remains a major issue with significant negative consequences on growth and cognitive development.

Limitations

This study was cross-sectional and therefore did not allow causality of iron deficiency anemia against developmental outcomes. The sample was also rather limited and geographically restricted to KPK and it might not have been representative of the diversified populations of Pakistan. Moreover, self-reporting of dietary habits can also present recall bias, and thus invalidity of nutritional measurements.

Conclusion

iron deficiency anemia (IDA) remains prevalent among children in KPK, with significant adverse effects on physical growth and cognitive development. Effective management through targeted interventions, such as iron supplementation and community health education, is crucial to improving children's health outcomes and fostering proper development in the region.

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Disclaimer

The views and conclusions expressed in this manuscript are those of the authors and do not necessarily reflect the official policies or positions of Lady Reading Hospital Peshawar or funding bodies. The authors assume full responsibility for the integrity and accuracy of the presented data.

Conflict of Interest

The authors declare no conflict of interest related to this study. No financial, personal, or professional relationships with any organization or individual influenced the design, conduct, analysis, interpretation, or reporting of the research findings.

Informed consent

Written informed consent was obtained from the parents or legal guardians of all participating children prior to enrollment. The consent process included a detailed explanation of the study objectives, procedures, potential risks and benefits, confidentiality of data, and the voluntary nature of participation, with the right to withdraw at any time without penalty.

Ethical Approval Statement

Ethical approval for this study was obtained from the Institutional Review Board (IRB), **Lady Reading Hospital / Medical Teaching Institution (LRH/MTI), Peshawar**. The approval was granted to the Department of Pediatrics, LRH, to conduct the study in accordance with institutional and ethical guidelines.

Author's Contribution

Mohsin Hayat: Concept & Design of Study:

Mohammad irshad :Data Collection+ Critical Review

Rashida saddiq:Drafting+Data Analysis

Final Approval of version: **All Authors Approved The Final Version.**

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