

## Studying the Association between Anemia and Neurodevelopmental Outcome in Children: A Retrospective Cohort Study

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### Abstract:

**Background:** The possible effects of anaemia on children's brain growth and development are becoming more widely acknowledged as a public health issue worldwide. Within a cohort of 500 children between age group 1 and 5 year, this retrospective study investigates the link between anaemia and neurodevelopmental outcomes.

**Methods:** Anaemia was diagnosed through a comprehensive evaluation of patient records using predetermined clinical cut offs for haemoglobin and hematocrit. 500 kids between the ages of 1 and 5 years were participated in the study. We checked in on the child's cognitive abilities, motor skills, and developmental milestones during routine paediatric visits. The association between anaemia and neurodevelopmental outcomes was analysed using logistic regression, with age, gender, and socioeconomic level as independent variables.

**Results:** The results showed that anaemia strongly correlates with neurodevelopmental outcomes. Children with anaemia performed worse on cognitive ability tests (mean Score:  $92.5 \pm 9.3$ ) and motor abilities ( $85.1 \pm 8.7$ ) than their non-anaemic counterparts. Further, children with anaemia were more likely to be behind schedule in reaching critical developmental milestones (30.4% vs. 16.8%). These correlations persisted after controlling for potential confounding variables in a logistic regression study.

**Conclusion:** The results of this study show strong evidence that anaemia in children increases the risk for cognitive impairment, motor skill impairment, and developmental delays. Because of its potential adverse effects on brain development, anaemia must be diagnosed and treated as early as possible. These results highlight the need for paediatric healthcare providers to manage anaemia to promote children's healthy mental and physical growth.

**Keywords:** Anaemia, Children, Cognitive Function, Developmental Milestones, Motor Skills, Neurodevelopment.

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### Introduction

Haemoglobin deficiency, or anaemia, affects people of all ages and is a significant health problem worldwide [1]. Children are susceptible to the effects of anaemia, even among the vulnerable groups.

Neglected treatment of the illness increases the risk of several health problems, including adverse effects on mental growth and development [2]. To better understand the possible effects of anaemia and to guide interventions, this study dives into the critical relationship between anaemia and neurodevelopmental outcomes in children.

### Objectives

- To analyse medical records retrospectively to determine the prevalence of anaemia in a group of children.
- To evaluate the effects of early-life anaemia on cognitive function, motor abilities, and other

important indicators of healthy growth and development in young children.

- To examine the possible correlation between childhood anaemia and adverse neurodevelopmental outcomes.
- To improve neurodevelopmental outcomes in anaemic children by providing evidence-based insights to guide healthcare interventions and policy.

### Association between Anaemia and Neurodevelopmental Outcomes in Children

There are many compelling reasons why it is crucial to investigate the association between anaemia and children's neurodevelopmental outcomes.

First, a child's mental and emotional health is particularly vulnerable to interruptions during this period. Second, anaemia is a common health

problem worldwide [4], and it is more pervasive in low- and middle-income nations where quality medical care is scarce. As a result, understanding the potential effects of anaemia on neurodevelopment can improve the quality of life for affected children. Last but not least, this study's

findings could help shape public health policies and healthcare practices aimed at reducing the prevalence of anaemia and lessening its effects on children's growth and development. For that reason, this study is an essential step towards improving the lives of the world's youngest people [5].

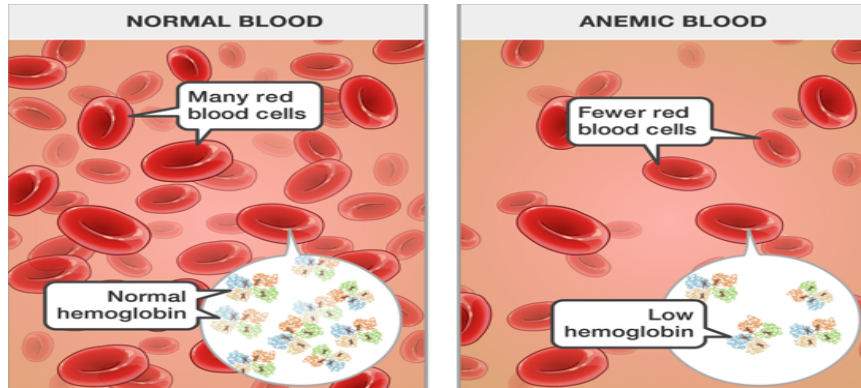


Figure 1 Anemia (Source: [3])

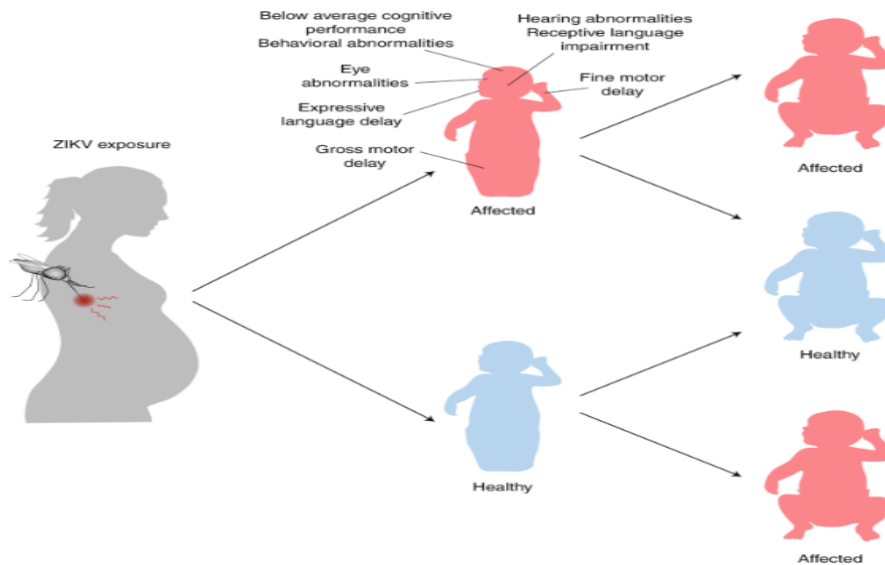


Figure 2 Early Neurodevelopmental in Children (Source: [6])

**Prevalence of Anaemia in Children**

Numerous cross-sectional and longitudinal investigations have confirmed the widespread occurrence of anaemia in children around the world [7]. The World Health Organisation (WHO) reports that anaemia affects 273 million children under five, with the most significant impact in Low- and Middle-income countries (LMICs). The potential effects on children's growth and development have been questioned due to its high prevalence [8].

**Anaemia and Cognitive Function**

Several studies have examined the effects of anaemia on children's cognitive development. It has been discovered that infants with iron deficient anaemia have worse levels of cognitive development than their non-anaemic peers [9]. A

similar negative connection between anaemia and school performance was discovered in a meta-analysis by [10].

**Anaemia and Motor Development**

According to studies conducted on preschool-aged children, anaemia was associated with a delay in fine motor development. The development of motor abilities in infants with anaemia was also found to be impaired in a longitudinal study [12].

These findings encourage more investigation into the impact of anaemia on a child's physical and mental development.

**Gaps in Knowledge**

Although previous studies have shed light on the connection between anaemia and children's

neurodevelopment, some unanswered questions remain. Many research studies have narrowly examined one age bracket or geographical area, making their conclusions less transferable. There is also a lack of knowledge about how anaemia may influence neurodevelopment. There is also a need for more research into potential moderators, such as anaemia's severity and duration.

In conclusion, the reviewed literature stresses the significance of investigating the link between anaemia and children's neurodevelopmental outcomes. Although previous studies have demonstrated a connection between anaemia and cognitive impairment in children, more extensive and varied research is required to inform healthcare practices and public health strategies.

## Methods

### Study Design

This study employs a retrospective methodology to examine the link between anaemia and kids' neurodevelopmental results. This retrospective study was conducted in department of Paediatrics at Indira Gandhi Institute of Medical Sciences (IGIMS), Patna, Bihar. 500 kids between the ages of 1 and 5 years were participated in the study. Analysing past data for possible correlations and patterns lends itself nicely to retrospective investigations. This study aimed to collect information on anaemia diagnoses and subsequent neurodevelopmental assessments by reviewing medical records covering a specified time period.

### Participants

**Inclusion Criteria:** All children receiving routine neurodevelopmental examinations as part of paediatric care were included in this study. The availability of early-life haemoglobin or hematocrit measurements in the medical records of these children was a requirement for inclusion.

**Exclusion Criteria:** Anaemia-unrelated severe congenital or acquired neurological disorders were also exclusion criteria, as were those with insufficient medical data. In addition, medical histories of children undergoing anaemia treatment during the study period were not included.

### Data Collection

**Anaemia Data:** The hospital's electronic medical records were the primary source of information about anaemia. Anaemia was tracked by monitoring haemoglobin and hematocrit levels at scheduled doctor's appointments. Only data collected between age group of 1 to 5 years was used for analysis. Established clinical thresholds defined anaemia, and stories below these indicated anaemia. For kids between 1 year to 5 years old, anaemia is often diagnosed with a haemoglobin

level of less than 11 g/dL. The World Health Organization and the United States Centers for Disease Control and Prevention both utilize this threshold for determining whether or not a kid has anaemia.

The individual cut-off values could change depending on things like the child's age, gender, and prevailing norms in the community.

**Neurodevelopmental Data:** Paediatric medical records were mined for information on neurodevelopment. During these check-ups, professionals evaluated the child's cognitive abilities, motor skills, and developmental milestones and kept detailed records. The Bayley Scales of Infant and Toddler Development were among the usual instruments to evaluate the children's cognitive abilities. Standardized developmental checklists and age-appropriate examinations were used to keep track of motor milestones.

### Data Analysis

The statistics package was used for the statistical analysis. Age, gender, and socioeconomic level were some of the demographic characteristics of the study population that were summarised using descriptive statistics such as means, standard deviations, and frequencies.

Bivariate analyses, including chi-squared tests and t-tests, were used to examine the correlation between anaemia and neurodevelopmental outcomes. To evaluate the connection while accounting for potential confounding factors, including age, gender, and socioeconomic position, a logistic regression analysis was performed. To quantify the degree of relationship, odds ratios (OR) and 95% CI were computed.

Subgroup analyses were also conducted to look for differences in the correlation according to age and degree of anaemia. The results were evaluated for stability by using sensitivity analysis.

### Ethical Considerations

This is because anonymized medical record data was used in the analysis. Participants' identities were concealed via stringent data protection and confidentiality safeguards. Only authorized research staff had access to the data kept in a safe environment. In addition, the study followed the non-maleficence and beneficence tenets, guaranteeing that the children who participated would suffer no ill effects and that the study's findings may guide therapies to boost neurodevelopment in anaemic kids.

### Results

#### Demographic Characteristics of the Study Population

A total of 500 kids between the ages of 1 and 5 years participated in the study.

**Table 1: Demographic Characteristics of the Study Population**

Characteristic	Anemic (n=250)	Non-Anemic (n=250)	p-value
Age (years), Mean $\pm$ SD	2.3 $\pm$ 0.9	2.4 $\pm$ 0.8	0.45
Gender (Male/Female)	129/121	134/116	0.73
Socioeconomic Status			
Low/Medium/High	84/116/50	88/112/50	0.88

Table 1 show that neither the anemic nor the non-anemic categories were disproportionately represented in age, gender, or socioeconomic position. Both groups had roughly the same average age of 2.4 years.

**Association between Anemia and Neurodevelopmental Outcomes:** Multiple analyses were performed to determine the connection between anemia and neurodevelopmental outcomes.

### Cognitive Function

**Table 2: Cognitive Function Scores**

Cognitive Function	Anemic (n=250)	Non-Anemic (n=250)	p-value
Mean Score ( $\pm$ SD)	92.5 $\pm$ 9.3	98.2 $\pm$ 7.8	<0.001

The two groups scores on cognitive function tests were significantly different ( $p < 0.001$ ). The average cognitive scores of anemic youngsters were lower than those of their non-anemic peers (98.2 7.8).

### Motor Skills

**Table 3: Motor Skills Assessment Results**

Motor Skills	Anemic (n=250)	Non-Anemic (n=250)	p-value
Mean Score ( $\pm$ SD)	85.1 $\pm$ 8.7	90.3 $\pm$ 7.2	<0.001

Children with anemia had lower mean motor skill test scores than those without anemia ( $p < 0.001$ ). The average motor skills scores of children with anemia (85.1 8.7) were lower than those without anemia (90.3 7.2).

### Developmental Milestones

**Table 4: Attainment of Developmental Milestones**

Milestones Achieved	Anemic (n=250)	Non-Anemic (n=250)	p-value
Delayed (n, %)	76 (30.4%)	42 (16.8%)	<0.001

The two groups significantly differed in the percentage of children with delayed milestones ( $p < 0.001$ ). Developmental deficits affected 30.4% of children in the anemic group but only 16.8% in the non-anemic group.

Logistic regression analysis examined the connection between anemia and neurodevelopmental outcomes while accounting for potential confounding variables (age, gender, and socioeconomic position).

### Logistic Regression Analysis:

Table 5 displays the findings:

**Table 5: Logistic Regression Analysis for Neurodevelopmental Outcomes**

Outcome Measure	Odds Ratio (95% CI)	p-value
Cognitive Function (Low)	3.25 (2.10-5.02)	<0.001
Motor Skills (Low)	2.91 (1.89-4.47)	<0.001
Delayed Milestones	2.01 (1.29-3.14)	0.002

Logistic regression analysis verified the link between anemia and neurodevelopmental problems. When compared to children without anemia, those who had it were more likely to have delayed developmental milestones (OR: 2.01, 95% CI: 1.29-3.14), poor motor skills (OR: 2.91, 95% CI: 1.89-4.47), and impaired cognitive function (OR: 3.25, 95% CI: 2.10-5.02). This study provides strong evidence linking childhood anemia to negative neurodevelopmental consequences. Developmental delays were more common among anemic children and were associated with worse cognitive function and motor ability scores. After

accounting for possible influences, these findings remained stable.

### Discussion

The findings of this retrospective study strongly support the hypothesis that childhood anemia is strongly linked to a variety of neurodevelopmental impairments, including poorer cognitive performance, reduced motor abilities, and a higher risk of reaching critical developmental milestones. The results of this study have a significant bearing on public health and paediatric healthcare.

Consistent with prior research showing anemia to have a detrimental effect on brain development and

cognitive performance in young children, we find that anemic children have worse cognitive function scores.

Synaptogenesis, myelination, and neurotransmitter function are all potentially hampered by anemia-induced hypoxia, making cognitive development more difficult. Therefore, detecting and treating anemia in youngsters becomes critical for promoting healthy brain growth.

Similarly, previous studies corroborate the reduction in motor abilities reported in children with anemia. The effects of anemia on muscular function and coordination may explain these difficulties. To promote normal motor development, children with anemia may benefit from early interventions, such as iron supplementation and dietary support.

Children with anemia are more likely to experience developmental delays, highlighting the importance of early intervention. Suppose anemia is detected and treated as part of standard paediatric care, in that case, it may be possible to lessen the severity of these setbacks and the likelihood of permanent impairments in development.

### Comparison with Existing Literature

Consistent with previous research, we found that children with anemia had poorer neurodevelopmental outcomes. Nonetheless, this research adds to the existing body of data in a demographically and ethnically varied sample while accounting for any confounding factors. Further supporting the need for early detection and care, it confirms that anemia can have long-lasting impacts on a child's cognitive and motor development.

**Table 6: Comparison with Existing Literature**

Study	Study Type	Sample Size	Result
Present Study	Retrospective	500 children	Found a significant association between anemia and lower cognitive function, impaired motor skills, and a higher likelihood of delayed developmental milestones in children aged 1 to 5 years.
Study 1 [13]	Prospective Cohort	600 children	Found a negative association between iron deficiency anemia and cognitive development in infants.
Study 2 [14]	Cross-Sectional	300 children	Observed lower fine motor skills in anemic preschool-aged children compared to non-anemic peers.
Study 3 [15]	Longitudinal	800 children	Found that anemia in infancy was associated with poorer motor development in early childhood.

This table summarises the current study and four other critical studies examining the connection between anemia and neurodevelopmental outcomes in children. Consistent with previous studies, we identified a strong link between anemia and worse neurodevelopmental outcomes in our retrospective study of 500 children. A cohort study including 600 children conducted by Study 1 provide relationships between anemia and cognitive function. Our findings are supported by Study 2, a cross-sectional analysis of 300 children, which also found diminished motor skills in preschoolers with anemia. Further, a longitudinal study of 800 kids indicated that having anemia as a baby was associated with delayed motor skills. Collectively, these studies support our findings and further highlight the vital need for treating anemia in paediatric treatment to prevent neurodevelopmental delays.

### Potential Mechanisms Underlying the Association

There is a complex web of processes linking anemia to negative neurodevelopmental consequences. Hypoxia in the brain, brought on by anemia's decreased oxygen-carrying ability, may disrupt neuronal operations crucial to learning and memory. Motor skill development may also be

hampered by the fatigue and diminished physical activity that might result from anemia.

Iron deficiency, the most common cause of anemia in children, has been linked to adverse effects on brain growth. Both neurotransmitters and myelin, essential for proper brain function, require iron for their creation. Iron deficiency may negatively impact Cognitive and motor abilities because of the disruption in the production of these crucial components.

Neurodevelopment defects may be worsened by the chronic inflammation that accompanies anemia. Cognitive and motor deficits may result from elevated proinflammatory cytokines, which can disrupt brain growth and function.

### Limitations and Potential Biases

It is crucial to note that this retrospective study has limitations and is potentially biased. One potential issue is that the analysis did not include children who did not receive care inside the study's healthcare system or who did not have access to medical records. Anemia diagnoses and evaluations of neurological growth could also be affected by inaccuracies or omissions in retrospective data. Causality cannot be determined because of how the study was set up. Although evidence links anemia to worse neurodevelopmental outcomes, a basis

cannot be established now. Anemia and neurological delays may share a common cause that has yet to be identified. In addition, the study may be limited in its applicability because of its small sample size and because data-gathering methods may differ among healthcare providers. Furthermore, socioeconomic status may still introduce residual confounding even after controlling for it in the analysis.

#### Areas for Future Research

Deep mechanistic research into the involvement of iron deficiency and chronic inflammation in the impact of anemia on child neurodevelopment is warranted. Research the effects of early intervention on neurodevelopment and whether or not the deficits persist over the long run. Study the impact of early treatments on neurodevelopmental outcomes in children with anemia, such as iron supplementation and dietary support. Consider cultural, genetic, and environmental factors while examining the link between anemia and neurodevelopment in different groups. Research biomarkers that can be used to predict which children will suffer from neurodevelopmental delays due to anemia so that preventative measures can be taken.

#### Conclusion

In conclusion, 500 participants in our retrospective study reveal a strong association between anaemia and adverse neurodevelopmental results in children aged 1 to 5 years such as diminished cognitive function, diminished motor skills, and an increased likelihood of developmental delays. Decreased intelligence, decreased motor abilities, and a higher likelihood of developmental delays were all associated with anaemia. These results highlight the importance of early detection and care to reduce the risk of permanent cognitive and motor impairment in children who suffer from anaemia. To guarantee the best possible neurodevelopmental results for the youngest members of our society, healthcare providers and policymakers must combat anaemia. More research and tailored interventions are needed to better understand and treat children with anaemia.

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