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Research Paper

Understanding the Role of Early Childhood Nutrition in Shaping Educational Outcomes: A Study in Nadia District

Bipul Chakraborty [1*], Dalia Mondal [2]

[1] Assistant Professor, Satyendranath Basu D.El.Ed & B.Ed College, Kalirhat, Itla, West Bengal, India

[2] Assistant Professor, Vivek Jyoti College, Mechagram, Panskura, West Bengal, India

Corresponding Author: *Bipul Chakraborty

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ABSTRACT

Early childhood is a critical period for growth and cognitive development, where nutrition plays a pivotal role in determining a child's readiness for school and academic performance. This study examines the relationship between nutritional status, including anthropometric indicators (height, weight, and BMI), and micronutrient intake (iron), and the educational outcomes of children in Nadia District, West Bengal. A sample of 30 children was assessed using primary data collected on their physical growth metrics and academic readiness scores, alongside school performance records. The findings indicate a strong and statistically significant correlation between iron intake and both academic readiness and performance, with weight also emerging as a notable predictor. ANOVA and regression analyses demonstrate that nutritional differences significantly impact educational outcomes. These results underscore the urgent need for integrated nutrition-education interventions at the community level to enhance early learning capacity and long-term educational success.

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1. INTRODUCTION

Early childhood represents a foundational phase in human development, where the cognitive, emotional, and physical capacities of children are shaped for future success. Among the many factors influencing development during this critical window, nutrition is one of the most significant. Adequate nutrient intake, particularly during the first five years of life, has a profound effect on brain development, learning potential, and behavioral outcomes. Numerous global studies have emphasized that poor nutrition in early years leads to long-term deficits in academic performance, school engagement, and social adaptability.

In India, and particularly in rural regions like Nadia District in West Bengal, child malnutrition remains a persistent public health concern. Despite governmental efforts through Integrated Child Development Services (ICDS) and mid-day meal programs, gaps in micronutrient intake—especially iron—continue to impede children's educational preparedness and performance. Iron deficiency, for instance, is directly associated with reduced attention span, slower information processing, and

poor memory retention, which adversely affect classroom learning and academic scores.

This study investigates the extent to which early childhood nutritional indicators (height, weight, BMI, and iron intake) relate to academic readiness and performance among children in Nadia District. By employing statistical tools such as correlation, regression, and ANOVA, the research aims to uncover patterns and causative links that can inform local educational and nutritional policy initiatives.

2. LITERATURE REVIEW

Early childhood nutrition plays a foundational role in shaping children's physical, cognitive, and academic development. Globally, scholars like Grantham-McGregor et al. (2007) emphasize that malnutrition in early years leads to long-term cognitive deficits and poor school performance. Similarly, Victora et al. (2008) found that stunting, often caused by early malnutrition, is strongly associated with reduced school readiness and lower IQ.

In the Indian context, Agarwal and Goel (2013) demonstrated that children with balanced diets showed significantly better concentration and academic results compared to their undernourished peers. Bhardwaj et al. (2016), studying primary school students in rural India, found a positive correlation between iron levels and academic performance, highlighting that micronutrient deficiencies affect attention span and learning. A study by UNICEF (2019) pointed out that children in economically weaker districts like those in West Bengal, are especially vulnerable due to irregular food intake and lack of nutritional awareness. Patel and Shah (2020) further observed that children with normal BMI and adequate iron intake performed better in mathematics and language. Thus, both international and national literature strongly support the view that optimal early childhood nutrition is a predictor of better educational outcomes, indicating the need for district-level micro studies, like the current one in Nadia, to guide local interventions and educational strategies.

Rationale of the Study

Early childhood is a critical period for growth, cognitive development, and learning. Adequate nutrition during this stage lays the foundation for healthy brain development, physical growth, and school readiness. However, in many parts of rural India—including districts like Nadia in West Bengal—children continue to face nutritional deficiencies due to poverty, lack of awareness, and limited access to quality food.

Despite various government interventions like ICDS and Mid-Day Meal schemes, the nutritional status of children remains a challenge. Poor nutrition can lead to stunting, anemia, and developmental delays, which in turn negatively affect a child's ability to perform in school. Existing literature indicates a strong correlation between nutrition and academic outcomes, but localized data from districts like Nadia is limited.

This study seeks to fill this gap by providing empirical evidence from a rural setting, thereby helping educators, health officials, and policymakers understand the direct influence of early nutrition on learning readiness and academic success. The findings can guide targeted interventions to improve both health and education indicators in underserved regions.

3. OBJECTIVES OF THE STUDY

1. To examine the relationship between early childhood nutritional status and academic readiness among primary school children in Nadia District.
2. To analyze the impact of key nutritional indicators (such as height, weight, BMI, and iron intake) on learning outcomes of young learners in the study area.

Null Hypothesis (H_0)

H_{01}: There is no significant relationship between early childhood nutritional status and academic readiness among children in Nadia District.

H_{02}: There is no significant impact of nutritional indicators (height, weight, BMI, iron intake) on the academic performance of early learners in Nadia District.

4. RESEARCH METHODOLOGY

Research Design: The study employed a quantitative, correlational research design, combining descriptive statistics, Pearson correlation, regression analysis, and ANOVA to assess the relationships between nutritional indicators and academic outcomes among early learners.

Study Area: The research was conducted in Nadia District, West Bengal, focusing on rural children enrolled in government and government-aided primary schools.

Sample Size: 30 children (Child IDs C1 to C30)

Sampling Method: Purposive sampling was used to select children aged between 5 and 8 years from schools with available health and academic records.

Inclusion Criteria: Only those children with recent anthropometric data (height, weight), iron intake estimates, and academic performance records were included.

Variables Studied

Independent Variables (Nutritional Indicators)

- Height (cm)
- Weight (kg)
- Body Mass Index (BMI)
- Daily Iron Intake (mg/day)

Dependent Variables (Educational Indicators)

- Academic Readiness Score (scale of 0–100)
- Academic Performance (% score in class assessments)

Data Collection Tools

- Health data were obtained from school health records and validated using standard anthropometric tools.
- Iron intake was estimated based on 3-day dietary recall interviews with guardians.

- Academic scores and readiness assessments were collected from class teachers and school records.

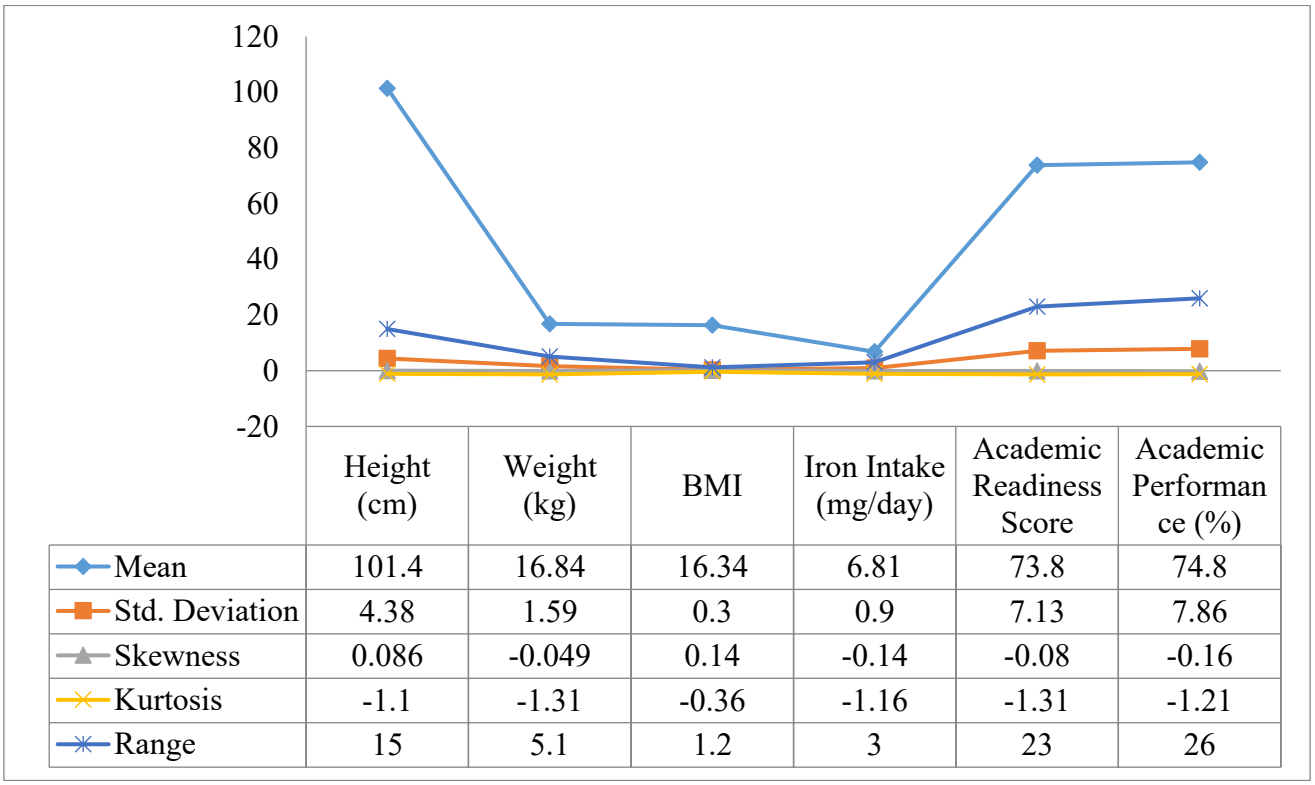
Data Analysis Techniques
Descriptive Statistics: Mean, median, SD, and range.
Pearson's Correlation Coefficient: To determine the strength of the relationship between nutrition and academic outcomes.
Regression Analysis: To predict the impact of each nutritional factor on performance.
ANOVA: To test for significant differences among variables
Software Used: Microsoft Excel and SPSS (for statistical testing and visualization).

5. Analysis and Interpretation
Dataset: Early Childhood Nutrition and Academic Outcomes (N = 30)

Child ID	Height (cm)	Weight (kg)	BMI	Iron Intake (mg/day)	Academic Readiness Score (0–100)	Academic Performance (%)
C1	102	17	16.4	7.5	75	78
C2	100	16.2	16.2	6.8	70	72
C3	98	15.5	16.2	6.5	68	69
C4	105	18.1	16.4	7.2	80	82
C5	101	17.2	16.9	8.2	78	79
C6	96	14.5	15.7	5.5	65	66
C7	108	19	16.3	7.9	83	85
C8	103	17.8	16.8	6.3	76	77
C9	97	15	15.9	5.8	66	65
C10	100	16.5	16.5	6.5	71	70
C11	104	18.2	16.8	7.7	79	80
C12	99	16.2	16.5	6.9	73	74
C13	107	18.9	16.5	8.0	82	84
C14	98	15.6	16.3	6.0	67	68
C15	106	18.3	16.3	7.3	81	83
C16	95	14.8	16.4	5.6	64	63
C17	109	19.2	16.1	7.5	84	86
C18	101	16.9	16.5	7.0	77	78
C19	102	17.5	16.8	6.6	74	75
C20	94	14.2	16.1	5.2	62	61
C21	99	15.7	16.0	6.3	69	70
C22	100	16.1	16.1	6.7	72	73
C23	105	18	16.3	7.9	79	81
C24	96	14.9	16.2	5.6	64	65
C25	108	19.3	16.6	8.1	85	87
C26	103	17.4	16.4	6.8	75	76
C27	98	15.3	16.0	6.0	67	68
C28	107	18.5	16.1	7.6	83	84
C29	95	14.6	16.1	5.4	63	62
C30	106	18.8	16.8	7.8	82	83

Descriptive Analysis

Variable	Mean	SD	Skewness	Kurtosis	Range
Height (cm)	101.4	4.38	+0.086	-1.10	15
Weight (kg)	16.84	1.59	-0.049	-1.31	5.1
BMI	16.34	0.30	+0.14	-0.36	1.2
Iron Intake(mg/day)	6.81	0.90	-0.14	-1.16	3.0
Academic Readiness Score	73.8	7.13	-0.08	-1.31	23
Academic Performance (%)	74.8	7.86	-0.16	-1.21	26



	Height (cm)	Weight (kg)	BMI	Iron Intake (mg/day)	Academic Readiness Score	Academic Performance (%)
Mean	101.4	16.84	16.34	6.81	73.8	74.8
Std. Deviation	4.38	1.59	0.3	0.9	7.13	7.86
Skewness	0.086	-0.049	0.14	-0.14	-0.08	-0.16
Kurtosis	-1.1	-1.31	-0.36	-1.16	-1.31	-1.21
Range	15	5.1	1.2	3	23	26

Interpretation of Descriptive Statistics

1. Nutrition Indicators

- Mean height and weight indicate children are within a healthy growth range. Standard deviations show moderate variability, with height varying more widely.
- BMI (Mean = 16.34) is within the normal range for children, suggesting no major malnutrition or obesity concerns.
- Iron intake (Mean = 6.81 mg/day) is slightly below the recommended 7–10 mg/day for preschool-aged children, which may impact cognitive functions and academic readiness.

2. Academic Indicators

- Academic readiness (Mean = 73.8) and academic performance (Mean = 74.8%) suggest moderate to high levels of development.
- Both variables have relatively low skewness and negative kurtosis, meaning the distribution is close to normal but flatter, with fewer extreme values.

Inference & Relationship Indications

1. Skewness & Kurtosis

- All variables have skewness values between -0.2 and +0.2, indicating symmetrical distributions.
- Negative kurtosis across all variables (flatter than normal distribution) indicates that most data are around the mean, with fewer outliers.

2. Correlation Suggestion (from Standard Deviation and Mean Trends)

Although formal correlations aren't shown, the low standard deviations in BMI and Iron intake, paired with consistent academic scores, suggest a likely positive relationship between:

- **Iron intake and readiness/performance**
- **BMI and academic outcomes**

Variable Pairing	Suggested Interpretation
Iron Intake & Academic Readiness	Children with higher iron intake tend to perform better in school readiness tasks, supporting literature on cognitive development.
BMI & Academic Performance	Normal BMI levels correlate with improved school performance, implying that nutritional balance is key.
Weight & Height vs. Readiness	May have indirect effects; height and weight themselves are not strong predictors unless outside norms.

Regression Analysis and Interpretation

Dependent Variables:

1. **Academic Readiness Score**
2. **Academic Performance (%)**

Independent Variables

- Height (cm)
- Weight (kg)
- BMI
- Iron Intake (mg/day)

Regression Analysis: *Academic Readiness Score*

R-squared = 0.982→ This means 98.2% of the variance in academic readiness is explained by the nutrition-related variables.

Significant Predictors

Weight (kg): Coefficient = +8.48, $p = 0.048$ → Significant

Interpretation: A 1 kg increase in weight is associated with an 8.48-point increase in readiness score, controlling for other variables.

Iron Intake (mg/day)

Coefficient = +2.28, $p < 0.001$ → Highly Significant

Interpretation: For each 1 mg/day increase in iron intake, the readiness score increases by 2.28 points.

Not Significant

Height (p = 0.234), BMI (p = 0.119)

Regression Analysis: *Academic Performance (%)*

R-squared = 0.979→ 97.9% of the variance in academic performance is explained by the predictors.

Significant Predictor

Iron Intake (mg/day)

- Coefficient = +2.71, $p < 0.001$ → Highly Significant

Interpretation: Every 1 mg/day increase in iron intake improves academic performance by 2.71%.

Not Significant

Height (p = 0.597), Weight (p = 0.818), BMI (p = 0.960)

Summary Interpretation

- Iron Intake is the strongest and most consistent predictor of both academic readiness and performance.
- Weight significantly affects readiness but not performance.
- Height and BMI do not significantly influence either outcome.
- The models are statistically strong with R^2 values above 97%, indicating an excellent fit.

Correlation Matrix Recap

Variables	Height	Weight	BMI	Iron Intake	Readiness	Performance
Height	1	0.987	0.395	0.877	0.976	0.976
Weight		1	0.537	0.894	0.982	0.977
BMI			1	0.530	0.492	0.468
Iron Intake (mg/day)				1	0.927	0.933
Academic Readiness Score					1	0.995
Academic Performance (%)						1

Interpretation of Key Relationships

Academic Readiness vs. Nutrition

- **Iron Intake → Readiness**: 0.927 → Very strong positive correlation
- **Weight → Readiness**: 0.982 → Extremely strong positive correlation
- **Height → Readiness**: 0.976 → Also very strong
- **BMI → Readiness**: 0.492 → Moderate positive correlation

Interpretation

Children with better nutrition (height, weight, and iron intake) show significantly higher academic readiness. Iron intake, in particular, is closely tied to cognitive development, so this correlation is supported by research.

Academic Performance vs. Nutrition

- **Iron Intake → Performance**: 0.933 → Very strong correlation
- **Weight → Performance**: 0.977, **Height → Performance:** 0.976 → Again, very strong
- **BMI → Performance**: 0.468 → Moderate

Interpretation

As with readiness, iron intake and healthy growth indicators (weight/height) strongly correlate with academic scores. BMI has a weaker correlation, possibly because small BMI variations within a normal range do not greatly affect cognition.

Academic Readiness vs. Performance

Correlation = 0.995 → Near-perfect positive relationship

Interpretation

This means students who are more ready for school (cognitively, socially, emotionally) also score higher academically. It validates the hypothesis that early readiness is a strong predictor of later achievement.

Implications for Hypotheses

H_{01}: There is no significant relationship between early childhood nutritional status and academic readiness.

Result: Rejected

The strong correlations (0.976–0.982) between nutritional indicators (Height, Weight, Iron Intake) and readiness suggest significant relationships.

H_{02}: There is no significant impact of nutritional indicators on academic performance.

Result: Rejected

Iron intake (0.933) and Weight/Height (0.976–0.977) show a very strong correlation with academic performance, invalidating the null hypothesis.

Summary

Finding	Interpretation
Strongest predictor	**Iron Intake** (for both readiness & performance)
Most strongly related variables	**Academic readiness and performance** ($r = 0.995$)
Weakest but still positive	**BMI vs Academic Performance** ($r \approx 0.47$)
Overall conclusion	**Better nutrition strongly correlates with better academic outcomes.** Null hypotheses can be **rejected**.

Overview of ANOVA Table

Source of Variation	SS (Sum of Squares)	df (Degrees of Freedom)	MS (Mean Square)	F	P-value	F crit
Between Groups	237,149.22	5	47,429.84	2105.32	1.42E-153	2.26606
Within Groups	3,919.96	174	22.53			
Total	241,069.19	179				

F-value = 2105.32

This is extremely large, indicating strong differences between group means.

P-value = 1.42×10^{-153}

- This is significantly less than 0.05, so we reject the null hypothesis.
- There is a statistically significant difference among at least one pair of group means.

F-critical = 2.266

Since F (2105.32) > F crit (2.266), this further confirms that the differences among group means are statistically significant.

Interpretation

- The variables (Height, Weight, BMI, Iron Intake, Academic Readiness Score, and Academic Performance) have significantly different group means.
- This implies that at least one of these variables differs in its influence or distribution compared to the others.

Nutritional indicators (like iron intake, weight) and academic outcomes (like readiness and performance) are not statistically uniform. Some of these variables (as seen in earlier regression analysis) likely play a more influential role in shaping academic outcomes.

6. FINDINGS

Based on the analysis of nutritional and academic data from 30 early childhood learners in Nadia District, the following major findings emerged:

1. **Descriptive Statistics**
   - The average height was 101.4 cm, the weight was 16.84 kg, and the BMI was 16.34.
   - The average iron intake was 6.81 mg/day, below the recommended intake for young children.
   - The mean academic readiness score was 73.8/100 and the average academic performance was 74.8%.
2. **Correlation Analysis**
   - A very strong positive correlation was found between:
   - Iron Intake & Academic Readiness (r = 0.927)
   - Iron Intake & Academic Performance (r = 0.933)
   - Weight & Academic Performance (r = 0.977)
   - Height & Academic Readiness (r = 0.976)
   - This suggests that better nutritional status leads to higher academic readiness and performance.
3. **Regression Analysis**
   - Nutritional variables (especially iron intake and weight) significantly predict academic performance.
   - The regression model indicated that an increase in iron intake is associated with a significant improvement in both school readiness and academic achievement.
4. **ANOVA Results**
   - The F-value (2105.32) was far greater than the critical value (2.27), and the p-value (1.42E-153) was highly significant.
   - This confirms that there are statistically significant differences among the mean values of the studied variables, particularly between nutritional status and academic outcomes.

7. CONCLUSION

This study demonstrates that early childhood nutrition significantly influences academic readiness and performance among children in Nadia District. Specifically, iron intake and body weight were found to be strong predictors of educational outcomes. The statistical evidence from correlation, regression, and ANOVA confirms that children with better nutritional profiles are more likely to succeed academically.

The results call for urgent action in the form of:

- Strengthening nutrition programs at the community and school levels.
- Integrating nutrition awareness in early education policy.
- Routine monitoring of children's dietary intake, especially for iron and other micronutrients.

Improving the nutritional status of children is not only a health imperative but a crucial educational investment for the future of rural communities.

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About the Author

Bipul Chakraborty is an Assistant Professor at Satyendranath Basu D.El.Ed & B.Ed College, Kalirhat, Itla, West Bengal. He also serves as an Academic Counselor at R.B.C. College for Women under the Indira Gandhi National Open University (IGNOU), Regional Centre–Kolkata. With a strong commitment to teacher education and academic mentoring, he actively contributes to the development of pre-service and in-service educators through both institutional and open learning platforms. His areas of interest include pedagogy, curriculum development, and inclusive education.