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Association of Iron Deficiency Anemia with Acute Bronchiolitis in Different Age Groups

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Abstract

Background: *Acute bronchiolitis is a leading cause of hospitalization in infants and young children, and iron-deficiency anemia (IDA) may exacerbate disease severity by impairing immune function and oxygen delivery.*

Aim of the study: *To investigate the association between IDA and the occurrence and clinical severity of acute bronchiolitis in children aged 1–24 months.*

Methods: *A hospital-based cross-sectional analytical study was conducted on 180 children admitted with acute bronchiolitis. Participants were categorized into IDA Present (n=68) and IDA Absent (n=112) groups. Clinical severity, laboratory parameters, and outcomes, including oxygen therapy, ICU admission, and mechanical ventilation, were analyzed. Logistic regression identified predictors of severe bronchiolitis.*

Result: *IDA prevalence was 37.78%. Children with IDA had significantly lower hemoglobin, MCV, ferritin, and oxygen saturation, and higher respiratory rates, prolonged oxygen therapy, longer hospital stay, and increased ICU and ventilator requirements ($p<0.01$). IDA and malnutrition were independent predictors of severe bronchiolitis (adjusted OR 3.15 and 2.41, respectively).*

Conclusion: *IDA is significantly associated with increased severity of acute bronchiolitis in children. Early screening and correction of iron deficiency, alongside supportive care, may improve clinical outcomes and reduce morbidity.*

Keywords: *Acute bronchiolitis, iron-deficiency anemia, infants, malnutrition, disease severity, Bangladesh*

I. INTRODUCTION

Acute bronchiolitis is defined as a viral lower respiratory tract infection affecting the small airways, such as bronchioles, primarily in infants and young children under 2 years of age, characterized by cough, wheezing, tachypnea, and signs of respiratory distress, such as nasal flaring, chest retractions, and hypoxia [1,2]. Iron-deficiency anemia (IDA) is the most prevalent micronutrient deficiency worldwide, affecting approximately 43% of children under 5 years, with the highest rates observed in LMICs [3,4]. Respiratory syncytial virus (RSV), responsible for over 50% of cases, is the most common causative agent of acute bronchiolitis, which is a leading cause of hospitalization among infants and young children in Bangladesh, with admissions peaking during the winter months [3,5]. IDA occurs when iron stores are insufficient to meet physiologic needs, leading to decreased hemoglobin synthesis and impaired oxygen delivery [3,4]. Beyond its hematologic role, iron is essential for optimal immune function; deficiency impairs neutrophil and lymphocyte activity, reduces cytokine production, and compromises mucosal immunity, increasing susceptibility to infections, including respiratory illnesses [6,7]. In the context of acute bronchiolitis, IDA may contribute to more severe disease presentations. Children with iron deficiency are at higher risk of prolonged hospitalization, increased need for supplemental oxygen, and greater likelihood of requiring intensive care support due to respiratory compromise [8,9]. Observational studies in similar low- and middle-income country settings suggest that IDA is associated with more frequent lower respiratory tract infections and may exacerbate the inflammatory response to viral pathogens, including respiratory syncytial virus (RSV), the primary cause of bronchiolitis [3,10]. Management of IDA in children primarily focuses on replenishing iron stores, correcting hemoglobin levels, and addressing underlying causes of deficiency [6]. Oral iron supplementation remains the first-line therapy, typically administered as ferrous sulfate, ferrous gluconate, or ferrous fumarate, with dosing based on elemental iron and age [11]. In Bangladesh, national guidelines recommend daily oral iron for children identified with moderate to severe anemia, alongside dietary counseling to improve intake of iron-rich foods such as meat, legumes, and fortified cereals [12]. In severe or refractory cases, parenteral iron or blood transfusions may be required, particularly when anemia is associated with hypoxia or

hemodynamic instability [6,11]. Preventive strategies, including iron-fortified foods, micronutrient powders, and public health campaigns, are also emphasized in Bangladesh to reduce the high prevalence of pediatric IDA [10,12]. Integrated management is crucial when IDA and bronchiolitis coexist. Anemic children with bronchiolitis may experience more severe hypoxia and prolonged illness; correcting iron deficiency can improve oxygen delivery, support immune function, and potentially reduce morbidity. [3,8,11]. Early identification of at-risk children through screening programs and prompt iron supplementation, alongside evidence-based supportive care for bronchiolitis, can improve clinical outcomes and reduce hospitalization duration [8,10]. Therefore, this study aimed to investigate the association between iron-deficiency anemia (IDA) and the occurrence and severity of acute bronchiolitis among infants and young children in Bangladesh.

II. METHODOLOGY & MATERIALS

This hospital-based cross-sectional analytical study was conducted in the Department of Paediatrics, Shaheed Monsur Ali Medical College and Hospital, Dhaka, Bangladesh, from January 2021 to December 2021. A total of 180 children aged between 1 and 24 months who were admitted with a clinical diagnosis of acute bronchiolitis were enrolled in the study. Acute bronchiolitis was diagnosed based on the presence of rhinorrhea, cough, wheezing, and respiratory distress following a viral prodrome, as per the American Academy of Pediatrics (AAP) guidelines.

Children were categorized into two groups based on hematological and biochemical parameters:

- IDA Present group (n = 68)
- IDA Absent group (n = 112)

Inclusion Criteria

- Children aged 1–24 months admitted with acute bronchiolitis.
- Availability of complete blood count, serum ferritin, and serum iron studies within 24 hours of admission.
- Informed written consent obtained from parents or legal guardians.

Exclusion Criteria

- Children with congenital heart disease, chronic lung disease, renal or hepatic disorders.
- Known hematological disorders other than iron deficiency (e.g., thalassemia, hemolytic anemia).
- Recent blood transfusion (within the past 3 months).
- Severe malnutrition (weight-for-height Z-score < -3 SD).
- Children on iron supplementation or chronic medication affecting iron metabolism.

Data Collection Procedure

Data were prospectively collected using a structured case record form. After obtaining informed written consent from parents or guardians, detailed demographic and clinical information was recorded, including age, sex, birth weight, nutritional status, and feeding history. Anthropometric measurements such as weight and length were taken, and weight-for-age Z-scores (WAZ) were calculated according to World Health Organization (WHO) growth standards. Clinical data relevant to acute bronchiolitis, such as respiratory rate, oxygen saturation at admission, duration of oxygen therapy, and total hospital stay, were meticulously documented. The need for intensive care unit (ICU) admission and mechanical ventilation was also recorded to assess the severity and outcomes. All data were collected within 24 hours of hospital admission to ensure accuracy and standardization.

Assessment of Iron Status

Venous blood samples were obtained at admission before treatment initiation. Complete blood count (CBC) was analyzed using an automated hematology analyzer to measure hemoglobin concentration, mean corpuscular volume (MCV), and other red cell indices. Serum ferritin, serum iron, and total iron-binding capacity (TIBC) were estimated using standard enzymatic colorimetric methods. Transferrin saturation was calculated from serum iron and TIBC. Iron deficiency anemia was defined according to World Health Organization (WHO) criteria as hemoglobin <11 g/dL, MCV <70 fL, and serum ferritin <12 ng/mL in the absence of infection or inflammation. Children with anemia but normal ferritin levels were excluded from the IDA group to prevent misclassification. All laboratory analyses were performed in the central biochemistry laboratory under strict internal quality control procedures.

Severity Assessment of Acute Bronchiolitis

The clinical severity of acute bronchiolitis was graded at admission using a composite scoring system that included respiratory rate, oxygen saturation (SpO_2), degree of chest retraction, feeding difficulty, and the need

for supplemental oxygen or mechanical ventilation. Mild bronchiolitis was defined as SpO_2 ≥94%, mild tachypnea, and no feeding difficulty; moderate bronchiolitis was defined as SpO_2 between 90% and 93% with moderate retractions or intermittent desaturation; and severe bronchiolitis was defined as SpO_2 <90%, marked respiratory distress, or the need for ventilatory support. Continuous monitoring of vital parameters was maintained throughout hospitalization, and the highest severity grade observed during the clinical course was used for analysis.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Quantitative variables were expressed as mean ± standard deviation (SD) or median (interquartile range, IQR) based on data distribution, while categorical variables were presented as frequencies and percentages. Comparisons between groups were made using the independent t-test or Mann–Whitney U test for continuous variables, and the Chi-square test or Fisher's exact test for categorical variables. Binary logistic regression analysis was performed to identify independent predictors of severe bronchiolitis after adjusting for age, nutritional status, sex, and birth weight. A p-value <0.05 was considered statistically significant.

Ethical Considerations

Ethical clearance was obtained from the Institutional Ethics Committee prior to study initiation. Parental informed consent was obtained before data collection. All patient data were anonymized and confidentiality strictly maintained according to the Declaration of Helsinki guidelines.

III. RESULT

Among children with acute bronchiolitis, 68 (37.78%) had iron deficiency anemia (IDA) and 112 (62.22%) did not (Figure 1). The mean age was 11.50 ± 5.00 months in the IDA group and 12.40 ± 5.30 months in the non-IDA group, with no significant difference (p = 0.21). Age group distribution was similar between groups (p = 0.33). Males were comparable in both groups (61.76% vs 58.90%; p = 0.69). The mean weight-for-age Z-score was significantly lower among children with IDA compared with those without IDA (−1.51 ± 0.65 vs −1.15 ± 0.58; p = 0.002). Exclusive breastfeeding (55.88% vs 66.07%; p = 0.17) and low birth weight (26.47% vs 19.64%; p = 0.25) were not significantly associated with IDA (Table 1). Mean hemoglobin was markedly lower in the IDA group (9.10 ± 0.70 g/dL) than in the non-IDA group (11.80 ± 0.90 g/dL; p < 0.001). Similarly, mean corpuscular volume was reduced among IDA children (68.90 ± 4.50 fL vs 79.80 ± 5.10 fL; p < 0.001). Median serum ferritin levels were substantially lower in the IDA group [10.10 (7.60–13.80) ng/mL] compared with non-IDA children [34.50 (28.20–43.00) ng/mL] (p < 0.001). Serum iron was also decreased in IDA (39.20 ± 9.00 µg/dL vs 73.00 ± 11.00 µg/dL; p < 0.001), while total iron binding capacity was significantly higher (400.00 ± 38.00 µg/dL vs 320.00 ± 42.00 µg/dL; p < 0.001). Consequently, transferrin saturation was much lower in IDA children (9.80 ± 3.10%) than in those without IDA (22.80 ± 4.20%; p < 0.001) (Table 2). The mean respiratory rate was higher in the IDA group (64.20 ± 8.50 breaths/min) than in the non-IDA group (59.10 ± 7.40 breaths/min; p < 0.001). Oxygen saturation at admission was significantly lower among IDA children (88.70 ± 3.60%) compared with non-IDA children (91.80 ± 3.10%; p < 0.001). The median duration of oxygen therapy was longer in the IDA group [4 (3–6) days] versus [2 (1–3) days] in non-IDA patients (p < 0.001). Likewise, mean hospital stay was prolonged in children with IDA (5.90 ± 1.90 days) compared to those without IDA (4.00 ± 1.30 days; p < 0.001). Severe outcomes were also more frequent in the IDA group, with higher ICU admission (25.00% vs 6.25%; p < 0.001) and greater need for mechanical ventilation (11.76% vs 1.94%; p = 0.006) (Table 3). Severity of bronchiolitis varied across age groups, with younger children showing higher proportions of severe disease. In the 1–6-month group, 32.73% had severe bronchiolitis compared with 26.15% in 7–12 months and 25.00% in 13–24 months, with significant distribution in the first two age groups (p = 0.03 and p = 0.04, respectively) (Table 4). When severity was analyzed by IDA status, children with IDA had fewer mild cases (20.59% vs 41.07%) but higher moderate (47.06% vs 41.07%) and severe disease (32.35% vs 17.86%). Compared with mild disease, IDA was associated with increased odds of moderate bronchiolitis (OR 2.18, 95% CI: 1.05–4.55; p = 0.04) and severe bronchiolitis (OR 3.30, 95% CI: 1.46–7.45; p = 0.004) (Table 5). On multivariate logistic regression, IDA remained an independent predictor of severe bronchiolitis (adjusted OR 3.15, 95% CI: 1.32–7.50; p = 0.009), along with malnutrition (adjusted OR 2.41, 95% CI: 1.01–5.74; p = 0.048), while age <6 months, male sex, and low birth weight were not statistically significant (Table 6).

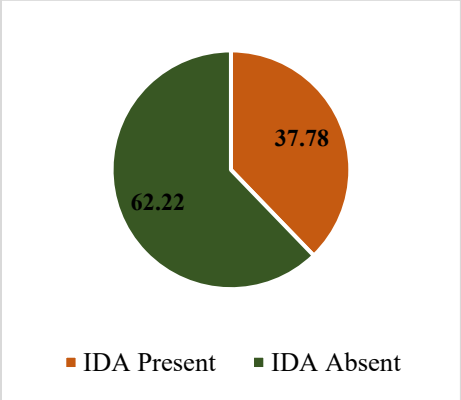

Figure 1: Distribution of study participants according to the presence of iron deficiency anemia (IDA).

Table 1: Baseline demographic and anthropometric characteristics of study population (N = 180)

Variables	Total (N=180)	IDA Present (n=68)	IDA Absent (n=112)	p-value
Age (months)				
1–6	55 (30.56)	22 (32.35)	33 (29.46)	0.331
7–12	65 (36.11)	26 (38.24)	39 (34.82)	
13–24	60 (33.33)	20 (29.41)	40 (35.71)	
Mean ± SD	12.1 ± 5.2	11.5 ± 5.0	12.4 ± 5.3	0.214
Gender				
Male	108 (60.00)	42 (61.76)	66 (58.9)	0.692
Female	72 (40.00)	26 (38.24)	46 (41.07)	
Weight-for-age Z-score				
Mean ± SD	-1.28 ± 0.63	-1.51 ± 0.65	-1.15 ± 0.58	0.002*
Exclusive breastfeeding (<6 months)	112 (62.22)	38 (55.88)	74 (66.07)	0.174
Low birth weight (<2.5 kg)	40 (22.22)	18 (26.47)	22 (19.64)	0.253

Table 2: Laboratory profiles among children with and without IDA

Parameter	IDA Present (n=68) Mean ± SD	IDA Absent (n=112) Mean ± SD	p-value
Hemoglobin (g/dL)	9.1 ± 0.7	11.8 ± 0.9	<0.001*
Mean Corpuscular Volume (fL)	68.9 ± 4.5	79.8 ± 5.1	<0.001*
Serum Ferritin (ng/mL), median (IQR)	10.1 (7.6–13.8)	34.5 (28.2–43.0)	<0.001*
Serum Iron (µg/dL)	39.2 ± 9.0	73.0 ± 11.0	<0.001*
Total Iron Binding Capacity (µg/dL)	400 ± 38	320 ± 42	<0.001*
Transferrin Saturation (%)	9.8 ± 3.1	22.8 ± 4.2	<0.001*

Table 3: Clinical severity of acute bronchiolitis in relation to IDA

Clinical Parameters	IDA Present (n=68)	IDA Absent (n=112)	p-value
Respiratory rate (breaths/min), mean ± SD	64.2 ± 8.5	59.1 ± 7.4	<0.001*
Oxygen saturation (%) at admission, mean ± SD	88.7 ± 3.6	91.8 ± 3.1	<0.001*
Duration of oxygen therapy (days), median (IQR)	4 (3–6)	2 (1–3)	<0.001*
Length of hospital stay (days), mean ± SD	5.9 ± 1.9	4.0 ± 1.3	<0.001*
ICU admission, n (%)	17 (25.00)	7 (6.25)	<0.001*
Mechanical ventilation required, n (%)	8 (11.76)	2 (1.94)	0.006*

Table 4: Distribution of bronchiolitis severity across pediatric age groups by IDA status

Age Group (months)	Mild, n (%)	Moderate, n (%)	Severe, n (%)	p-value
1–6 (n=55)	12 (21.82)	25 (45.45)	18 (32.73)	0.026*
7–12 (n=65)	20 (30.77)	28 (43.08)	17 (26.15)	0.041*
13–24 (n=60)	25 (41.67)	20 (33.33)	15 (25.00)	0.064

Table 5: Association between IDA and severity of bronchiolitis among the study population

Severity	IDA Present (n=68)	IDA Absent (n=112)	OR (95% CI)	p-value
Mild	14 (20.59)	46 (41.07)	Reference	—
Moderate	32 (47.06)	46 (41.07)	2.18 (1.05–4.55)	0.036*
Severe	22 (32.35)	20 (17.86)	3.30 (1.46–7.45)	0.004*

Table 6: Multivariate logistic regression for predictors of severe bronchiolitis

Variable	Adjusted OR (95% CI)	p-value
IDA (Yes vs. No)	3.15 (1.32–7.50)	0.009*
Age <6 months	2.05 (0.88–4.78)	0.099
Malnutrition (WAZ < -2 SD)	2.41 (1.01–5.74)	0.048*
Male sex	1.20 (0.56–2.58)	0.636
Low birth weight	1.48 (0.61–3.57)	0.383

IV. DISCUSSION

Acute bronchiolitis remains one of the most common lower respiratory tract infections in children, and its severity may be influenced by underlying nutritional deficiencies, including iron deficiency anemia, across different age groups [8]. In the present study, 37.78% of children with acute bronchiolitis had iron deficiency anemia (IDA), while 62.22% were non-anemic. This prevalence aligns with prior studies demonstrating that a substantial proportion of children with respiratory infections also exhibit iron deficiency, particularly in developing countries where nutritional deficiencies are common [13]. Baseline demographic analysis revealed no significant differences between IDA and non-IDA groups in terms of age, gender, exclusive breastfeeding, or low birth weight. However, weight-for-age Z-scores were significantly lower among children with IDA (mean -1.51 ± 0.65 vs -1.15 ± 0.58, p=0.002), reflecting the known association between iron deficiency and impaired growth. This finding is consistent with earlier studies showing that iron deficiency often coexists with mild-to-moderate malnutrition, contributing to increased vulnerability to infections [14]. Laboratory assessments confirmed that children with IDA had significantly lower hemoglobin, mean corpuscular volume, serum ferritin, serum iron, and transferrin saturation, along with elevated total iron-binding capacity (all $p<0.001$). These parameters are in line with classical hematological criteria for iron deficiency and mirror previous observations in pediatric populations with acute lower respiratory tract infections [15]. Regarding clinical severity, children with IDA demonstrated higher respiratory rates, lower oxygen saturation at admission, longer durations of oxygen therapy, extended hospital stays, higher ICU admission rates, and increased need for mechanical ventilation (all $p<0.01$). These findings support the concept that iron deficiency compromises host immune defenses, particularly affecting cellular immunity and oxygen transport, thereby exacerbating respiratory illness severity [16]. Age-stratified analysis showed that infants aged 1–6 months with IDA had a significantly higher proportion of moderate-to-severe bronchiolitis (p=0.026), while the 7–12 month group also exhibited a similar pattern (p=0.041). Although the 13–24 month group showed a trend toward increased severity in the IDA group, it was not statistically significant (p=0.064). These results suggest that the impact of iron deficiency on disease severity is most pronounced in younger infants, consistent with earlier pediatric studies [17]. There is a significant association between IDA and bronchiolitis severity. Children with IDA were more likely to develop moderate (OR 2.18; 95% CI 1.05–4.55, p=0.036) or severe bronchiolitis (OR 3.30; 95% CI 1.46–7.45, p=0.004) compared to non-anemic peers. This observation supports the hypothesis that iron deficiency increases susceptibility to more severe respiratory infections [16]. Finally, multivariate logistic regression identified IDA (adjusted OR 3.15; 95% CI 1.32–7.50, p=0.009) and malnutrition (WAZ < -2 SD; adjusted OR 2.41; 95% CI 1.01–5.74, p=0.048) as independent predictors of severe bronchiolitis, whereas age <6 months, male sex, and low birth weight were not statistically significant. These results underscore the critical role of nutritional status, particularly iron sufficiency, in determining the clinical course of bronchiolitis, corroborating previous findings that iron-deficient children are at higher risk of complicated respiratory illnesses [18].

Limitations of the study: This study was conducted at a single tertiary care center, which may limit the generalizability of findings to broader populations. The cross-sectional design precludes causal inference between iron-deficiency anemia (IDA) and bronchiolitis severity. Seasonal variation and viral etiology were not fully accounted for, potentially influencing disease severity. Additionally, nutritional factors beyond iron status, such as vitamin deficiencies, were not assessed. Finally, long-term outcomes post-discharge were not evaluated, limiting insight into the sustained impact of IDA on respiratory health.

V. CONCLUSION

This study demonstrates a significant association between iron-deficiency anemia (IDA) and both the occurrence and severity of acute bronchiolitis in children aged 1–24 months. Children with IDA exhibited lower oxygen saturation, higher respiratory rates, prolonged oxygen therapy, increased ICU admissions, and greater

need for mechanical ventilation compared to non-anemic peers. Multivariate analysis identified IDA as an independent predictor of severe bronchiolitis, alongside malnutrition. These findings highlight the critical role of iron in immune competence and respiratory resilience, emphasizing the need for early screening and management of IDA in pediatric populations to reduce morbidity and optimize clinical outcomes in acute bronchiolitis.

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