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RESEARCH ARTICLE

A CASE CONTROL STUDY OF HAEMOGLOBIN LEVEL IN CHILDREN AGED 2 YEARS TO 5 YEARS WITH A LOWER RESPIRATORY TRACT INFECTION IN A TERITIARY CARE CENTRE

Guddikiriti, Sm Prasad, Tanmayee Reddy and Nayana Kamath.

1. Department of Paediatrics Akash Institute of Medical Science and Research Centre Prasannahalli Road,Devanahalli, Bengaluru Rural–562110.

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Key words:-
Lower respiratory tract infection, haemoglobin, anemia, iron deficiency anemia, serum ferritin, children, case-control study.

Abstract

Background:Lower respiratory tract infection (LRTI) is one of the leading causes of morbidity and mortality among children under five years of age, particularly in developing countries. Anemia, especially iron deficiency anemia, impairs immune function and tissue oxygenatio n, thereby increasing susceptibility to respiratory infections.

Aim: To assess and compare haemoglobin levels in children aged 2–5 years with lower respiratory tract infection and in age-matched children without LRTI.

Materials and Methods:A hospital-based case-control study was conducted in the Department of Paediatrics, Akash Super Speciality Hospital, Devanahalli, Bengaluru, over 18 months (March 2024–September 2025). A total of 140 children aged 2–5 years were enrolled, including 70 cases with clinically diagnosed LRTI and 70 controls without LRTI. All participants underwent complete haemogram, peripheral smear examination, serum ferritin estimation, C-reactive protein (CRP) measurement, and chest radiography. Statistical analysis was performed using appropriate tests, and a p-value <0.05 was considered statistically significant.

Results:The mean haemoglobin level was significantly lower among cases (10.27 ± 1.65 g/dL) compared with controls (11.05 ± 1.91 g/dL) (p = 0.0107). Serum ferritin levels were also significantly lower in cases (13.19 ± 8.94 ng/mL) than controls (19.20 ± 7.31 ng/mL) (p < 0.0001). Mean CRP levels were significantly higher among cases (6.55 ± 11.39 mg/L) compared with controls (2.02 ± 4.17 mg/L) (p = 0.0021). Anemia, particularly moderate and severe anemia, was more common in children with LRTI. Significant associations were also observed between study group and age, sex, and peripheral smear findings.

Conclusion:Children aged 2–5 years with LRTI had significantly lower haemoglobin and serum ferritin levels than

Corresponding Author:- Guddikiriti
Address:-Department of Paediatrics Akash Institute of Medical Science and Research Centre Prasannahalli Road,Devanahalli, Bengaluru Rural–562110.

children without LRTI, suggesting that anemia, particularly iron deficiency anemia, is an important risk factor for lower respiratory tract infections. Early screening, prompt diagnosis, and appropriate treatment of anemia may help reduce the incidence and severity of LRTI in young children.

Introduction:-

Lower respiratory tract infections (LRTIs) remain one of the most important causes of morbidity and mortality among children under five years of age worldwide. They account for a substantial proportion of hospital admissions and childhood deaths, particularly in low- and middle-income countries where malnutrition, poor socioeconomic conditions, overcrowding, inadequate immunization, and limited access to healthcare continue to pose major public health challenges. According to the World Health Organization (WHO) [2] [1], pneumonia alone is responsible for approximately 14% of all deaths among children under five years of age, making it the single largest infectious cause of childhood mortality.

LRTIs comprise infections involving the respiratory tract below the level of the larynx and include pneumonia, bronchiolitis, bronchitis, and other infections affecting the bronchi, bronchioles, and lung parenchyma. Among these, pneumonia is the most severe and clinically significant disease. Children with LRTIs commonly present with fever, cough, tachypnea, chest indrawing, hypoxia, respiratory distress, and feeding difficulties. Delayed diagnosis and treatment may result in serious complications such as pleural effusion, empyema, respiratory failure, sepsis, and death.

India contributes significantly to the global burden of childhood pneumonia because of its large pediatric population and the high prevalence of multiple predisposing factors. Nutritional deficiencies, environmental pollution, indoor smoke exposure, incomplete immunization, low birth weight, prematurity, and recurrent infections increase the susceptibility of children to respiratory illnesses. Despite advances in vaccination, antimicrobial therapy, and intensive care services, LRTIs continue to remain an important cause of hospitalization among children aged below five years.

Anemia is another major public health problem affecting children worldwide. The World Health Organization defines anemia in children aged 6–59 months as a hemoglobin concentration below 11 g/dL. Iron deficiency anemia constitutes the commonest nutritional deficiency worldwide and accounts for nearly half of all cases of anemia. In India, the prevalence of anemia among children remains alarmingly high because of inadequate dietary iron intake, recurrent infections, parasitic infestations, poor socioeconomic status, and nutritional deficiencies.

Hemoglobin plays an essential role in oxygen transport and tissue oxygenation. Adequate hemoglobin concentration is necessary for maintaining normal cellular metabolism and optimal immune function. Iron is also required for the proliferation and maturation of immune cells, particularly lymphocytes, neutrophils, and macrophages. Iron deficiency impairs both innate and adaptive immunity, resulting in reduced bactericidal activity, altered cytokine production, and diminished cell-mediated immune responses. Consequently, anemic children are more susceptible to recurrent infections, especially lower respiratory tract infections.

Several studies have demonstrated an association between low hemoglobin levels and increased incidence and severity of respiratory infections. Reduced oxygen-carrying capacity caused by anemia may aggravate tissue hypoxia during pneumonia, thereby worsening respiratory distress and prolonging recovery. Iron deficiency has also been associated with impaired pulmonary defense mechanisms and increased susceptibility to bacterial and viral infections. However, published literature has shown variable results regarding the strength of this association,.

Serum ferritin serves as a reliable indicator of body iron stores and is useful in identifying iron deficiency before the development of severe anemia. Assessment of serum ferritin along with peripheral smear examination and complete blood count helps differentiate iron deficiency anemia from anemia due to inflammation or other hematological disorders. Evaluation of these parameters may therefore provide valuable insights into the contribution of iron deficiency to the occurrence of LRTIs.

Understanding the relationship between hemoglobin status and lower respiratory tract infections is important because anemia is a preventable and treatable condition. Early identification and correction of anemia through nutritional interventions, iron supplementation, health education, and appropriate public health measures may reduce

the incidence, severity, and complications of LRTIs, thereby improving child survival and reducing healthcare burden.

In view of the high prevalence of both anemia and lower respiratory tract infections among under-five children, the present hospital-based case-control study was undertaken to compare hemoglobin levels, serum ferritin levels, peripheral smear findings, CRP and Chesr X ray between children aged 2–5 years with lower respiratory tract infection and age-matched healthy controls. The study aims to evaluate whether anemia is associated with an increased risk of LRTI and to emphasize the importance of early diagnosis and management of anemia as a preventive strategy against childhood respiratory infections.

Materials and Methods:-

Study Design:-
A hospital-based case-control study.

Study Setting:-
The study was conducted in the Department of Paediatrics, Akash Super Speciality Hospital, Akash Institute of Medical Sciences and Research Centre, Devanahalli, Bengaluru Rural, Karnataka.

Study Duration:-
The study was conducted over a period of 18 months, from March 2024 to September 2025.

Study Population:-
Children aged 2–5 years attending the Department of Paediatrics were enrolled in the study.
Children with Hemoglobin level with LRTI taken as CASE
• Children with Hemoglobin level and other illness than LRTI taken as CONTROL
• Matching – Two groups of participants are matched as closely together as possible making it an equivalent group like age, sex, group frequency matching studies.
• For one case, one control has been studied.

Sample Size:-
A total of 140 children were included in the study:-
* Cases: 70
* Controls: 70

Inclusion Criteria:-
Case:-
- Children with Hemoglobin level with LRTI taken as CASE
- Clinically diagnosed with Lower Respiratory Tract Infection.
- * Parent/guardian willing to provide written informed consent.

Control:-
• Children with Hemoglobin level and other illness than LRTI taken as

Control:-
• Matching – Two groups of participants are matched as closely together as possible making it an equivalent group like age, sex, group frequency matching studies.
• For one case, one control has been studied.
- Parent/guardian willing to provide written informed consent.

Exclusion Criteria:-
* Children with congenital heart disease.
* Known hemoglobinopathies or inherited anemia.
* Chronic kidney disease or chronic liver disease.
* Malignancy.

* Primary or secondary immunodeficiency.
* Children receiving iron therapy or blood transfusion within the previous three months.
* Severe acute malnutrition.
* Refusal of consent.

Methodology:-

After obtaining approval from the Institutional Ethics Committee and written informed consent from the parents or legal guardians, eligible children fulfilling the inclusion criteria were enrolled consecutively. A detailed history including demographic profile, socioeconomic status, immunization status, nutritional history, breastfeeding practices, presenting complaints, duration of illness, and previous medical history was obtained. A thorough clinical examination was performed. Anthropometric measurements including weight and height were recorded. Vital parameters such as temperature, respiratory rate, pulse rate, oxygen saturation, and blood pressure were documented. Clinical signs of respiratory distress including tachypnea, chest indrawing, nasal flaring, grunting, and cyanosis were assessed according to WHO Acute Respiratory Infection guidelines. Children diagnosed with LRTI underwent appropriate investigations.

Investigations:-

The following investigations were performed in both cases and controls:-

* Complete Blood Count (CBC)
* Peripheral smear examination
* C-reactive protein (CRP)
* Serum ferritin estimation
* Chest X-ray

Anemia was classified according to the World Health Organization (WHO) [2] criteria for children aged 6–59 months:-

* Mild anemia: Hb 10.0–10.9 g/dL
* Moderate anemia: Hb 7.0–9.9 g/dL
* Severe anemia: Hb<7.0 g/dL

Iron deficiency anemia was diagnosed based on low hemoglobin levels along with reduced serum ferritin and supportive peripheral smear findings.

Outcome Measures:-

Primary Outcome:-

* Comparison of mean hemoglobin levels between children with LRTI and controls.

Secondary Outcomes:-

* Comparison of serum ferritin levels.
* Severity of anemia in both groups.
* Peripheral smear findings.
* Association between hemoglobin level and occurrence of LRTI.
* Association of CRP levels with LRTI.

Statistical Analysis:-

The collected data were entered into Microsoft Excel and analyzed using Statistical Package for Social Sciences (SPSS) software. Continuous variables were expressed as mean ± standard deviation (SD), whereas categorical variables were presented as frequencies and percentages. Comparisons between groups were performed using the Independent Student's t-test for continuous variables and Chi-square test or Fisher's Exact test for categorical variables, wherever appropriate. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations:-

• Institutional Ethics Committee (IEC), Akash Institute of Medical Sciences and Research Centre, approved the study before commencement (IEC Ref. No.: AIMSRC/IEC/21/2023-24 ; Approval Date: 29.02.2024).

* Written informed consent was obtained from the parents or legal guardians of all participants.
* Confidentiality of patient information was strictly maintained throughout the study.
* Participation was voluntary, and no child was denied standard medical care irrespective of study participation.

Statistical Analysis:-

Data collected from all study participants were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) software version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequency (n) and percentage (%). The normality of continuous variables was assessed before analysis. The Independent Student's t-test was used to compare the mean haemoglobin, serum ferritin, and CRP levels between cases and controls. The Chi-square test or Fisher's Exact test, wherever appropriate, was used to compare categorical variables such as age group, gender, severity of anemia, ARI classification, and peripheral smear findings. The association between haemoglobin levels and Lower Respiratory Tract Infection was assessed using appropriate statistical tests. Odds ratios (OR) with 95% confidence intervals (CI) were calculated wherever applicable to estimate the strength of association. A p-value of less than 0.05 was considered statistically significant.

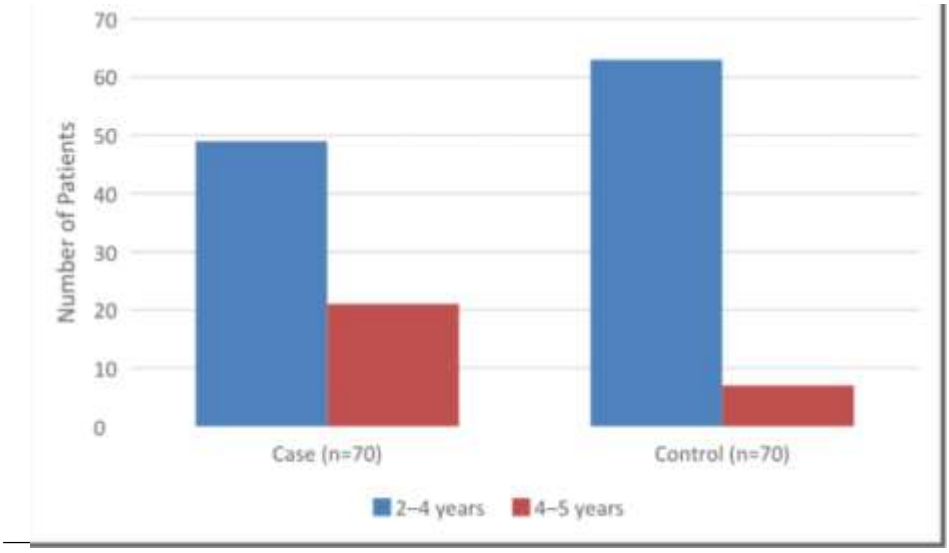
Results:-

A total of 140 children aged 2–5 years were included in the study. Of these, 70 were cases diagnosed with Lower Respiratory Tract Infection (LRTI) and 70 were controls without LRTI.

Association between Age Group and Study Group:-

Among the 70 children in the case group, 49 (70.0%) were aged 2–4 years and 21 (30.0%) were aged 4–5 years. In the control group, 63 (90.0%) children were aged 2–4 years, while 7 (10.0%) were aged 4–5 years. Children aged 2–4 years constituted the majority of LRTI cases. Age was significantly associated with LRTI, indicating that younger children were more frequently affected than those aged 4–5 years.

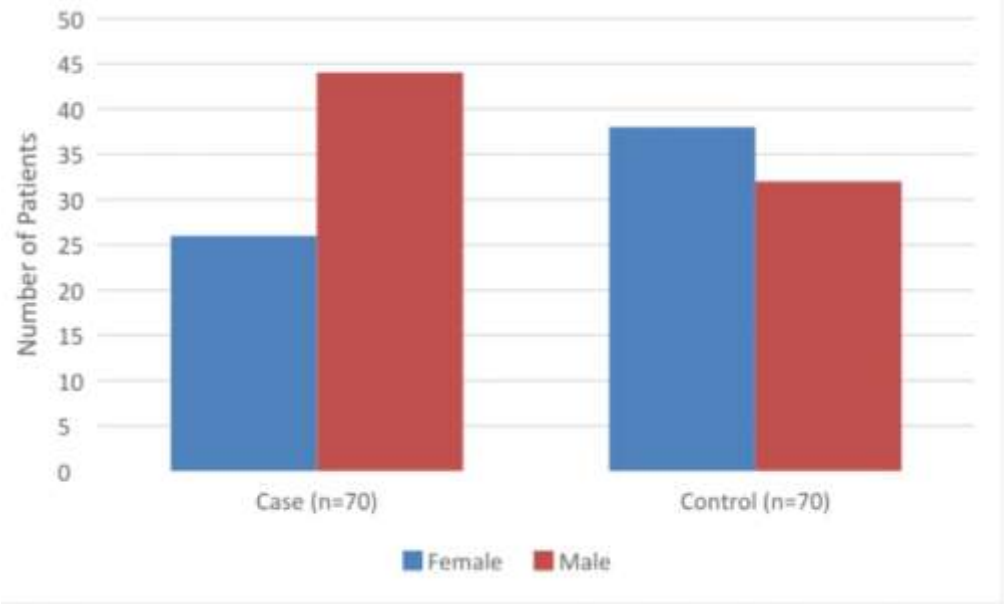
Age Group	Case (n=70)	Control (n=70)	Total (n=140)
2–4 years	49 (70.0%)	63 (90.0%)	112 (80.0%)
4–5 years	21 (30.0%)	7 (10.0%)	28 (20.0%)
Total	70 (100%)	70 (100%)	140 (100%)



Association between Sex and Study Group:-

Among the cases, 44 (62.9%) were males and 26 (37.1%) were females. In the control group, 32 (45.7%) were males and 38 (54.3%) were females. Male children were significantly more affected by lower respiratory tract infection than female children.

Sex	Case (n=70)	Control (n=70)	Total (n=140)
Female	26 (37.1%)	38 (54.3%)	64 (45.7%)
Male	44 (62.9%)	32 (45.7%)	76 (54.3%)
Total	70 (100%)	70 (100%)	140 (100%)



Association between Chest X-ray Findings and Study Group:-

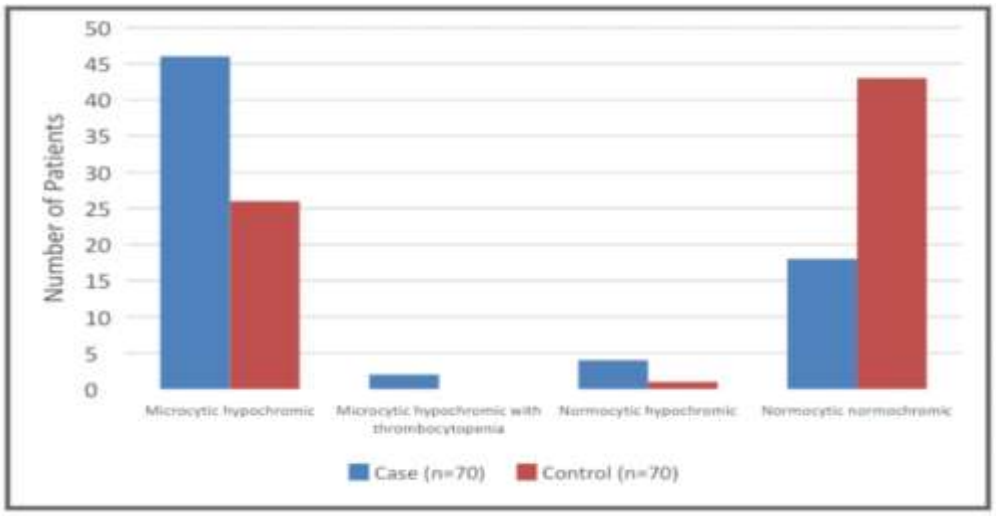
All 70 (100%) children in the case group had chest X-ray findings suggestive of lower respiratory tract infection, whereas all 70 (100%) children in the control group had normal chest X-rays. Abnormal chest X-ray findings were observed exclusively among cases, confirming the diagnosis of lower respiratory tract infection.

X-ray	Case (n=70)	Control (n=70)	Total (n=140)
LRTI	70 (100%)	0 (0%)	70 (50.0%)
Normal	0 (0%)	70 (100%)	70 (50.0%)
Total	70 (100%)	70 (100%)	140 (100%)

Association between Peripheral Smear Findings and Study Group:-

Among cases, 65.7% showed microcytic hypochromic anemia, while 25.7% had a normocytic normochromic smear. In contrast, 61.4% of controls had a normocytic normochromic smear, and only 37.1% had microcytic hypochromic anemia.Microcytic hypochromic anemia, suggestive of iron deficiency, was significantly more common among children with LRTI.

Peripheral Smear	Case (n=70)	Control (n=70)	Total (n=140)
Microcytic hypochromic	46 (65.7%)	26 (37.1%)	72 (51.4%)
Microcytic hypochromic with thrombocytopenia	2 (2.9%)	0 (0%)	2 (1.4%)
Normocytic hypochromic	4 (5.7%)	1 (1.4%)	5 (3.6%)
Normocytic normochromic	18 (25.7%)	43 (61.4%)	61 (43.6%)
Total	70 (100%)	70 (100%)	140 (100%)



Association between Diagnosis and Study Group:-
Interpretation:-
All children in the case group were diagnosed with lower respiratory tract infection, whereas controls had other diagnoses including acute febrile illness, dengue, enteric fever, tonsillitis, urinary tract infection, viral fever, and febrile seizures.

LRTI was present exclusively among cases, whereas controls represented children with non-respiratory illnesses.

Diagnosis	Case (n=70)	Control (n=70)	Total (n=140)
Other illness	0	70	70
LRTI	70	0	70
Total	70 (100%)	70 (100%)	140 (100%)

Association between ARI Criteria and Study Group:-
All 70 (100%) children in the case group fulfilled the WHO Acute Respiratory Infection (ARI) criteria, while none of the controls fulfilled these criteria.

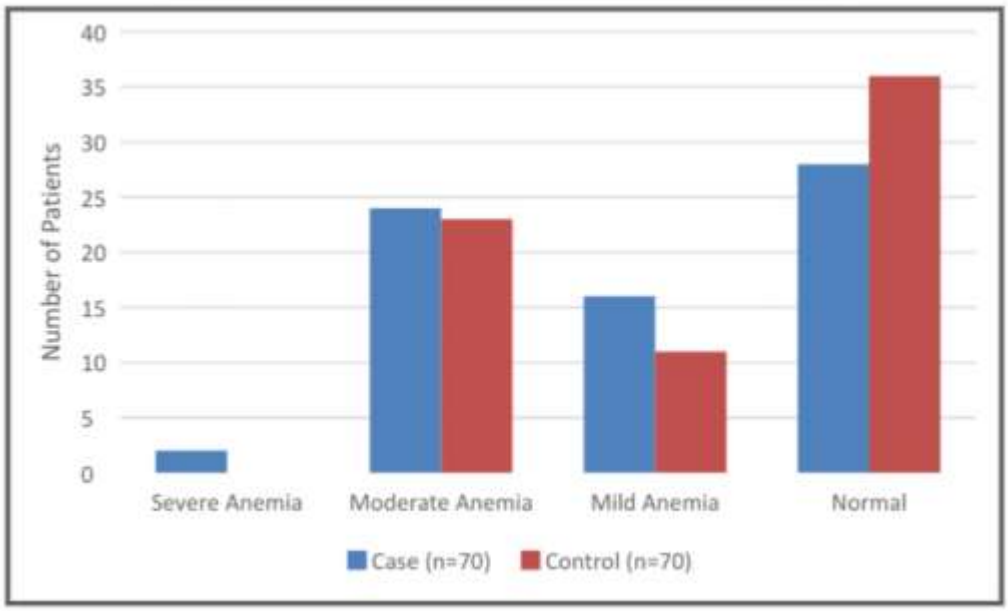
Fulfilment of ARI criteria was strongly associated with the presence of lower respiratory tract infection.

ARI Criteria	Case (n=70)	Control (n=70)	Total (n=140)
Present	70 (100%)	0 (0%)	70 (50.0%)
No	0 (0%)	70 (100%)	70 (50.0%)
Total	70 (100%)	70 (100%)	140 (100%)

Association between Hemoglobin Category and Study Group:-
Among cases, 2.9% had severe anemia, 34.3% had moderate anemia, 22.9% had mild anemia, and 40.0% had normal hemoglobin levels. Among controls, no child had severe anemia, while 51.4% had normal hemoglobin levels.

The distribution of anemia severity did not differ significantly between the two groups when analyzed categorically.

Hb Level Group	Case (n=70)	Control (n=70)	Total (n=140)
Severe Anemia	2 (2.9%)	0 (0.0%)	2 (1.4%)
Moderate Anemia	24 (34.3%)	23 (32.9%)	47 (33.6%)
Mild Anemia	16 (22.9%)	11 (15.7%)	27 (19.3%)
Normal	28 (40.0%)	36 (51.4%)	64 (45.7%)
Total	70 (100%)	70 (100%)	140 (100%)



Comparison of Mean Age

The mean age was 3.86 ± 0.93 years among cases and 3.21 ± 0.98 years among controls. Children with LRTI were significantly older within the 2–5-year age group compared to controls.

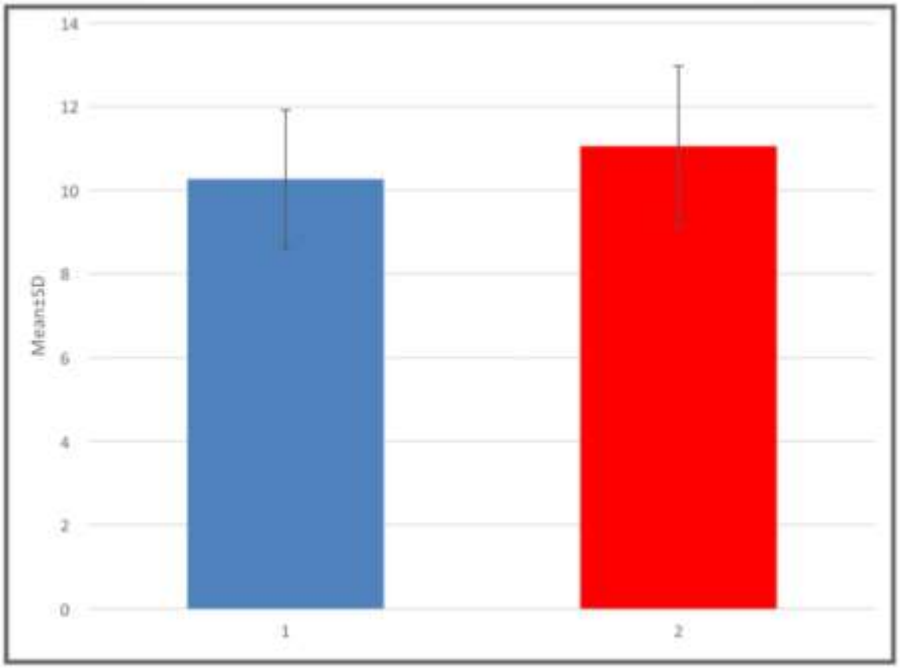
	Group	Number	Mean	SD	Minimum	Maximum	Median	p-value
Age	Case	70	3.8629	0.9291	2.0000	5.0000	4.0000	0.0001
Age	Control	70	3.2143	0.9764	2.0000	5.0000	3.0000	0.0001

Comparison of Mean Hemoglobin Level:-

The mean hemoglobin level among cases was 10.27 ± 1.65 g/dL, compared with 11.05 ± 1.91 g/dL among controls.

Children with LRTI had significantly lower hemoglobin levels than controls, suggesting an association between anemia and lower respiratory tract infection.

Group	Number	Mean	SD	Minimum	Maximum	Median	p-value	
Hb level	Case	70	10.2700	1.6477	5.9000	13.4000	10.0000	0.0107
Hb level	Control	70	11.0514	1.9146	7.7000	14.3000	11.7000	0.0107



Comparison of Mean CRP Level:-
Interpretation

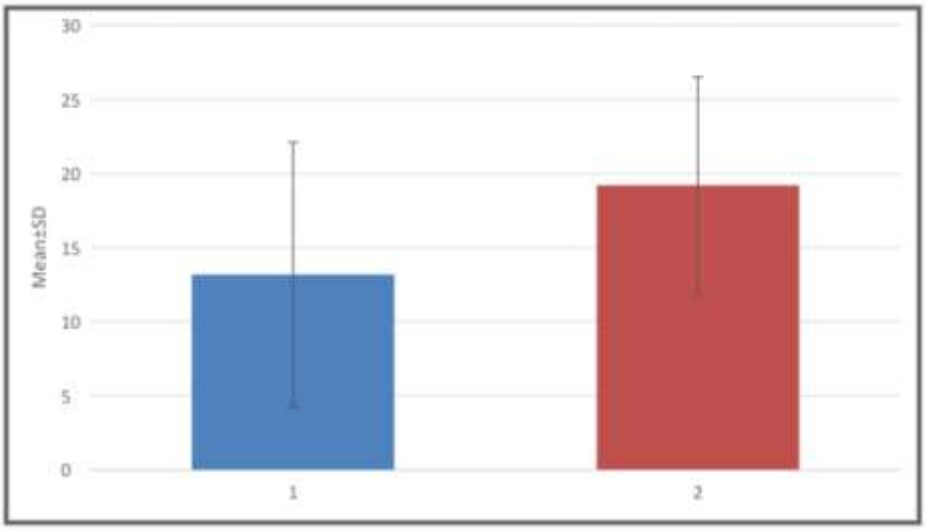
The mean CRP level was 6.55 ± 11.39 mg/L in cases and 2.02 ± 4.17 mg/L in controls.
Children with LRTI had significantly higher CRP levels, indicating greater inflammatory activity.

Group	Number	Mean	SD	Minimum	Maximum	Median	p-value	
CRP	Case	70	6.5519	11.3879	0.6000	79.1000	3.1900	0.0021
CRP	Control	70	2.0171	4.1662	0.6000	30.2000	1.2000	0.0021

Comparison of Mean Serum Ferritin Level:-
The mean serum ferritin level was 13.19 ± 8.94 ng/mL among cases compared with 19.20 ± 7.31 ng/mL among controls.

Lower serum ferritin levels among children with LRTI indicate reduced iron stores and support the role of iron deficiency anemia as a risk factor for lower respiratory tract infection.

	Group	Number	Mean	SD	Minimum	Maximum	Median	p-value
Serum Ferritin	Case	70	13.1857	8.9377	3.1000	55.0000	10.0000	<0.0001
Serum Ferritin	Control	70	19.2000	7.3101	8.0000	70.0000	18.0000	<0.0001



Distribution of Mean Crp Serum Feritin Level:-
Mean serum ferritin was significantly lower in cases than controls (13.19 ± 8.94 vs. 19.20 ± 7.31 ng/mL; $p < 0.0001$), indicating reduced iron stores in children with LRTI.

	Group	Number	Mean	SD	Minimum	Maximum	Median	p-value
CRP	Iron Deficiency	57	3.744	3.1679	0.6	17.09	2.8	0.8307
CRP	Low	50	4.5544	11.6139	0.8	79.1	1.4	0.8307
CRP	Normal	33	4.8091	10.702	0.6	55	1.6	0.8307

Discussion:-

Lower respiratory tract infection (LRTI) continues to be one of the leading causes of morbidity and mortality among children under five years of age, particularly in developing countries. Anemia, especially iron deficiency anemia, has been proposed as an important modifiable risk factor that predisposes children to respiratory infections by impairing immune function and reducing oxygen-carrying capacity. The present hospital-based case-control study was undertaken to evaluate the association between haemoglobin levels and lower respiratory tract infection in children aged 2–5 years. In the present study, the majority of children (80%) belonged to the 2–4-year age group. A statistically significant association was observed between age group and study group ($p = 0.003$). The mean age was significantly higher among cases (3.86 ± 0.93 years) than controls (3.21 ± 0.98 years) ($p = 0.0001$). Similar findings have been reported by Ramakrishnan et al. [6], Sharma et al. [9], and Malla et al. [10], who observed that preschool children constitute the age group most commonly affected by LRTI because of immature immunity, increased exposure to respiratory pathogens, and nutritional deficiencies.

Male children constituted 62.9% of the case group compared with 45.7% of controls, and the association between sex and LRTI was statistically significant ($p = 0.042$). This male predominance has also been reported in studies by Broor et al. [7], Sharma et al. [9], and Savitha et al. [8], suggesting that biological susceptibility, behavioral factors, and greater healthcare-seeking for male children may contribute to the observed difference. Chest radiography demonstrated findings suggestive of LRTI in all children in the case group, while all controls had normal chest radiographs ($p < 0.0001$). This confirms the accuracy of clinical diagnosis and supports the use of chest radiography as an important diagnostic tool in children with suspected LRTI. Peripheral smear examination showed that microcytic hypochromic anemia was the predominant hematological pattern among cases (65.7%), whereas normocytic normochromic morphology predominated among controls (61.4%). The association was highly significant ($p < 0.0001$). These findings indicate that iron deficiency anemia is the commonest type of anemia among children with LRTI and are comparable with observations reported by Hassan et al. [11] and Malla et al. [10]

Although anemia appeared to be more common among children with LRTI, comparison based on WHO anemia categories (severe, moderate, mild, and normal) did not demonstrate a statistically significant association ($p =$

0.267). This may be explained by the relatively high prevalence of anemia among Indian preschool children, resulting in substantial numbers of anemic children in both case and control groups. Nevertheless, assessment of continuous variables revealed significant differences in hemoglobin concentration between the groups. The mean hemoglobin level in the present study was 10.27 ± 1.65 g/dL among cases compared with 11.05 ± 1.91 g/dL among controls ($p = 0.0107$). This finding suggests that children with LRTI have significantly lower hemoglobin levels than children without LRTI. Similar observations have been reported by Ramakrishnan et al. [6], Sharma et al. [9], Malla et al. [10], and Hassan et al. [11], who concluded that anemia is an important risk factor for respiratory tract infections.

Serum ferritin, an indicator of body iron stores, was significantly lower among cases (13.19 ± 8.94 ng/mL) than controls (19.20 ± 7.31 ng/mL) ($p < 0.0001$). Reduced ferritin levels indicate depleted iron stores and support the presence of iron deficiency among children with LRTI. These findings are consistent with previous studies demonstrating that iron deficiency adversely affects both innate and adaptive immunity, thereby increasing susceptibility to respiratory infections. The mean CRP level was significantly higher among cases (6.55 ± 11.39 mg/L) than controls (2.02 ± 4.17 mg/L) ($p = 0.0021$), indicating increased systemic inflammatory activity in children with LRTI. However, no significant association was observed between CRP levels and iron status ($p = 0.8307$), suggesting that elevated inflammatory markers were primarily related to the acute infection rather than iron deficiency.

The findings of the present study emphasize the close relationship between nutritional status and childhood respiratory infections. Iron deficiency reduces lymphocyte proliferation, neutrophil function, and cytokine responses, thereby impairing host defense mechanisms. Reduced hemoglobin levels further compromise tissue oxygenation during pneumonia, potentially increasing disease severity and delaying recovery. The strengths of this study include its case-control design, inclusion of age-matched controls, assessment of serum ferritin along with hemoglobin estimation, and comprehensive hematological evaluation. However, the study has certain limitations. It was conducted at a single tertiary care center with a relatively small sample size, limiting the generalizability of the findings. Since serum ferritin is an acute-phase reactant, inflammatory states may influence its concentration despite the use of CRP for interpretation. Additionally, dietary iron intake, socioeconomic status, and micronutrient deficiencies other than iron were not evaluated.

Overall, the present study demonstrates that children with lower respiratory tract infection have significantly lower hemoglobin and serum ferritin levels compared with controls, suggesting that iron deficiency anemia is an important risk factor for LRTI in children aged 2–5 years. Early identification and treatment of anemia, along with nutritional interventions and preventive strategies, may help reduce the burden of lower respiratory tract infections in this vulnerable population. Ethics statement: The study was approved by the Institutional Ethics Committee, Written informed consent was obtained from parents or legal guardians before enrolment.

Funding: This research received no external funding. The study was self-funded by the principal investigator.

Conflict of Interest: The authors declare that there are no conflicts of interest.

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