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Original Research Article

SERUM ZINC LEVELS IN ACUTE LOWER RESPIRATORY TRACT INFECTIONS IN CHILDREN AGED 5-12 YEARS: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Acute Lower Respiratory Tract Infections (ALRTI) remain a major cause of morbidity and mortality among children, particularly in low- and middle-income countries. Micronutrient deficiencies—especially zinc deficiency—are highly prevalent among children. This impairs immune function, increases the risk of infection, and worsens disease outcomes. The aim is to assess serum zinc levels in children aged 5–12 years diagnosed with acute lower respiratory tract infections. **Materials and Methods:** A hospital-based cross-sectional study was conducted over six months in the Department of Paediatrics at Aarupadai Veedu Medical College and Hospital, Puducherry. A total of 105 children aged 5–12 years diagnosed with ALRTI were enrolled. Demographic details, clinical history, anthropometry, dietary habits, deworming and immunization status were recorded. Disease severity was assessed using the Respiratory Severity Score (RSS). **Results:** The mean age was 8.18 ± 2.26 years, with male predominance (59%). The mean serum zinc level was 55.02 ± 13.82 µg/dL. Lower serum zinc levels were significantly associated with higher RSS scores ($p = 0.001$). Serum zinc showed a positive correlation with BMI ($r = 0.274$, $p = 0.005$) and a negative correlation with disease severity ($r = -0.458$, $p = 0.001$). Significant associations were also observed between serum zinc levels and BMI categories ($p = 0.03$) and dietary habits ($p = 0.002$). **Conclusion:** Serum zinc levels are significantly associated with ALRTI severity and undernutrition in children 5-12 years of age. Optimised nutritional status, adequate zinc intake and strengthened preventive measures may reduce disease severity and improve outcomes.

INTRODUCTION

Acute respiratory infections (ARI) are a leading health problem worldwide. An estimated 4 to 5 million children in developing countries die every year from ARIs. This mortality is concentrated in the South Asian countries of Bangladesh, India, Nepal and Indonesia, accounting for about 40%.[1] The high disease burden in these areas has been linked to a number of socio-environmental factors including poverty, malnutrition, poor housing conditions, exposure to indoor smoke, overcrowding, limited access to healthcare and lack of awareness. Lower Respiratory Tract Infection is any infection of the lung or below the level of the larynx. These include pneumonia, bronchitis and tuberculosis. Recurrent Respiratory Tract Infections (RRTI) are defined as "three or more episodes of acute infections in a 1 year period".[2]

Acute lower respiratory tract infections (ALRTIs) remain a major cause of morbidity and mortality in children worldwide, with a higher burden in low- and middle-income countries.[3] Recurrent ALRTIs are of special concern, as repeated episodes may impair lung function, weaken immunity, remodel airways and increase healthcare burden.

Zinc is an essential trace element that plays a role in immune regulation and protection against infections. The importance of nutritional status in susceptibility and clinical outcomes of infectious diseases has long been appreciated. Micronutrients, such as zinc, have been identified as essential elements with broad physiological and immunological functions. Antiviral properties have been shown to act directly, including interference with the ability of the virus to enter host cells and inhibition of intracellular replication.[4] E. Bhat et al in 2016 have reported that risk of infections increases in case of zinc deficiency while infections may deplete zinc stores that in turn increases susceptibility.[5]

Importantly, children with low serum zinc levels were found more prone not only to acute but also to recurrent ALRTIs, as inferior zinc status compromises immune competence and delays mucosal recovery. Repeated infections may aggravate zinc deficiency by impairing appetite, increasing loss of nutrients, and elevating metabolic demands, thereby creating a vicious cycle of disease and micronutrient depletion. In addition to susceptibility, serum zinc levels have also been significantly associated with severity of ALRTIs. Lower zinc levels are associated with more intense inflammatory responses and more respiratory distress and clinical course is chronic. Zinc deficiency may exacerbate the severity of ALRTIs through potentiation of oxidative stress, impairment of epithelial repair and reduced efficiency of pathogen clearance.

Zinc deficiency is common in children, especially in areas with poor diet and recurrent infections. This vicious cycle occurs when the infection causes the loss of appetite and a rise in metabolic demand that depletes zinc stores even further.[6] Low serum zinc levels in children may increase the risk of developing severe and prolonged respiratory infections, according to Khera et al,[7] Supplementation trials have shown a reduction in duration and severity of respiratory illness, but results are not entirely consistent across populations and age groups.

School children aged 5 to 12 years are a special group because they are growing rapidly, have high nutritional needs, and are frequently exposed to infectious agents in the community and school environment.[11] However, most research on zinc and respiratory infections has focused on children under five years of age, leaving a gap in understanding of their relationship in older children. Assessing zinc levels in this age group can provide important information for prevention and treatment strategies. The purpose of this study is to assess serum zinc levels in children aged 5 to 12 years with acute lower respiratory tract infection.

MATERIALS AND METHODS

This cross-sectional study was conducted in the Department of Paediatrics (OPD) at Aarupadai Veedu Medical College and Hospital, Puducherry. The objective of this study was to determine the association and correlation between serum zinc levels and acute Lower respiratory tract infections. The duration of study was conducted for a period of six months from July 2025 to December 2025 until the desired samples of subjects were obtained for the study. A total of 105 children aged 5–12 years of both genders, diagnosed with acute respiratory tract infections and exhibiting symptoms of lower respiratory tract infection (LRTI), were included using convenient sampling. Children below 5 years or above 12 years of age, critically ill children, those with loose stools, immunocompromised states, malabsorption or chronic illnesses, children who had received zinc supplementation in the preceding one month, and those whose parents did not consent were excluded and written informed consent from parents or guardians was obtained from all participants after explaining the study. The sample size of 105 was calculated based on a previous study by Islam et al. in 2018 on serum zinc levels among children with ARI, with a mean of 25.19, an absolute precision of 3%, a 5% level of significance, and 90% study power.[12] Demographic details, including age, gender, and socioeconomic status, along with detailed clinical history, anthropometric measurements, and general and systemic examination findings, were recorded. Based on clinical evaluation, children were diagnosed with acute upper or lower respiratory tract infections. For children with lower respiratory tract infections, disease severity was assessed using the Respiratory Severity Score (RSS), and they were categorized into mild (≤3) and severe (≥4) groups. Venous blood samples were collected in plain red-top tubes under aseptic precautions and sent to the Department of Biochemistry for the assessment of serum zinc levels using a photometric method on a fully automated Mindray BS 600M analyzer; the results were verified through quality control checks.

All clinical and laboratory data were systematically recorded and analyzed to assess the correlation between serum zinc levels and the severity of acute lower respiratory tract infection. To analyse the data SPSS (IBM SPSS Statistics for Windows, Version 26.0, Armonk, NY: IBM Corp. Released 2019) is used. The Normality tests, Kolmogorov-Smirnov and Shapiro-Wilks tests results revealed that the data follows normal distribution. Therefore, to analyse the data, parametric test was applied. Descriptive statistics determined the frequency, percentage, mean and standard deviation for the variables. Associations between categorical variables, including serum zinc interpretation with RSS score, dietary habits, and BMI interpretation, were assessed using the Chi-square test. Correlations between continuous variables such as BMI, serum zinc level, and RSS score were analyzed using Pearson's correlation coefficient. Significance level is fixed as 5% ($\alpha = 0.05$). P-value <0.05 was considered statistically significant.

Ethical Approval and Registration

Ethical permission was obtained with ethical approval number IHEC No: AV/IHEC/2024/083 from the institutional Human Ethics Committee of Aarupadai Veedu Medical College and Hospital in Kirumampakam, Puducherry.

Statistical Analysis

Serum zinc levels were estimated by the photometric method. Pearson's correlation coefficient (r) and chi-square test were performed using SPSS version 26.0, with significance set at $p<0.05$.

RESULTS

A total of 105 children aged 5–12 years with acute lower respiratory tract infection were included in the study. The majority belonged to the 5–7 years age group (41.9%), followed by 8–10 years (37.1%) and 11–12 years (21.0%), with a mean age of 8.18 ± 2.26 years. Males predominated the study population (59%), while females constituted 41%. The mean weight, height, and BMI were 23.87 ± 7.09 kg, 126.22 ± 12.47 cm, and 14.63 ± 2.13 kg/m², respectively. Based on BMI, 72.4% of children had normal nutritional status, 21.0% were underweight, and 6.6% were overweight. A history of three or more similar respiratory episodes in the preceding six months was noted in 41% of children. Regular deworming was reported in 66.7%, while 33.3% had no such history. Most children followed a non-vegetarian diet (69.5%), and 91.4% were immunized up to date. According to the Respiratory Severity Score, 79.0% had mild disease and 21.0% had severe disease. The mean serum zinc level was 55.02 ± 13.82 µg/dL. A statistically significant association was observed between serum zinc levels and disease severity, with lower zinc levels correlating with higher RSS scores ($p = 0.001$). Significant associations were also noted between serum zinc levels and dietary habits ($p = 0.002$) and BMI categories ($p = 0.03$). Serum zinc levels showed a positive correlation with BMI ($r = 0.274$, $p = 0.005$) and a significant negative correlation with RSS score ($r = -0.458$, $p = 0.001$), indicating that lower zinc levels were associated with poorer nutritional status and more severe respiratory illness.

Table 1: Mean and Standard Deviation of age, weight, Height BMI and serum Zinc level among the study participants

Variables	Mean	Standard Deviation	Minimum	Maximum
Age	8.18	2.261	5	12
Weight	23.87	7.094	14.0	40.0
Height	126.22	12.473	106	153
BMI	14.63	2.128	11.1607	20.1853
serum Zinc level	55.02	13.822	32	90

[Table 1] presents the descriptive statistics of the study participants. The mean age of the children was 8.18 ± 2.26 years, with ages ranging from 5 to 12 years. The mean weight was 23.87 ± 7.09 kg (range: 14–40 kg), while the mean height was 126.22 ± 12.47 cm (range: 106–153 cm). The average BMI was 14.63 ± 2.13 kg/m², with values ranging from 11.16 to 20.19 kg/m². The mean serum zinc level among the participants was 55.02 ± 13.82 µg/dL, with levels ranging from 32 to 90 µg/dL.

Table 2: Association between serum Zinc interpretation and RSS score among the study participants

Serum Zinc interpretation	RSS score		P value
	Mild	Severe	
Very low	8	9	0.001*
Low	63	13	
Normal	12	0	

[Table 2] shows the association between serum zinc status and RSS score. Among children with very low serum zinc levels, 8 had mild RSS scores and 9 had severe RSS scores. In the low zinc group, 63 children had mild RSS scores and 13 had severe RSS scores. All 12 children with normal serum zinc levels had mild RSS scores, while none had severe RSS scores. The association was found to be statistically significant ($p = 0.001$), indicating that lower serum zinc levels were associated with greater disease severity as reflected by higher RSS scores.

Table 3: Association between serum Zinc interpretation and BMI interpretation among the study participants

Serum Zinc interpretation	BMI interpretation			P value
	Underweight	Normal	Overweight	
Very low	7	8	2	0.03*
Low	15	56	5	
Normal	0	12	0	

[Table 3] depicts the relationship between serum zinc status and BMI categories. Among participants with very low serum zinc levels, 7 were underweight, 8 had normal BMI, and 2 were overweight. In the low zinc category, 15 children were underweight, 56 had normal BMI, and 5 were overweight. All 12 participants with normal serum zinc levels belonged to the normal BMI category. The association between serum zinc status and BMI classification was statistically significant ($p = 0.03$), suggesting a relationship between nutritional status and serum zinc levels.

Table 4: Correlation of serum Zinc level between BMI, RSS among the study participants

Correlations	BMI	serum Zinc level	P value
BMI	1	0.274**	0.005*
serum Zinc level	0.274**	1	

Table 4 demonstrates the correlation between serum zinc level and BMI. A positive correlation was observed between BMI and serum zinc levels (r = 0.274). This correlation was statistically significant (p = 0.005), indicating that children with higher BMI values tended to have higher serum zinc levels. However, the strength of the correlation was weak.

Table 5: Correlation between RSS score and serum Zinc level among the study participants

Correlations	RSS	serum Zinc level	P value
RSS score	1	-0.458**	0.001*
serum Zinc level	-0.458**	1	

[Table 5] presents the correlation between RSS score and serum zinc level. A moderate negative correlation was found between RSS score and serum zinc level (r = -0.458). This relationship was statistically significant (p = 0.001), indicating that higher RSS scores were associated with lower serum zinc levels. This finding suggests that zinc deficiency may be linked to increased severity of the condition assessed by the RSS score.

Table 6: Correlation between serum Zinc level and BMI interpretation among the study participants

Correlations	BMI	serum Zinc level	P value
serum Zinc level	1	0.234**	0.01*
BMI interpretation	0.234**	1	

[Table 6] shows the correlation between serum zinc levels and BMI interpretation categories. A positive correlation was observed between serum zinc levels and BMI interpretation (r = 0.234), which was statistically significant (p = 0.01). This finding indicates that children with better nutritional status, as reflected by BMI classification, tended to have higher serum zinc levels.

DISCUSSION

The children included in this study were aged between 5 and 12 years. The majority belonged to the 5–7 year age group (44 children, 41.9%), followed by the 8–10 year group (39 children, 37.1%) and the 11–12 year group (22 children, 21.0%). The mean age was 8.18 ± 2.26 years. Study findings indicate that younger school-going children are at a higher risk of ALRTI, likely due to developing immunity and increased exposure to others in school and community settings. Similar results were observed in a 2013 study by Shah et al., which found a higher risk of respiratory infections in children under 8 years of age.[13] In contrast, a 2013 study by Cardinale et al. reported a uniform distribution of respiratory infections across all age groups, suggesting that regional and environmental factors may influence age-related susceptibility.[14]

On the basis of gender, 59% of the people included in the study were men and 41% were women. This study found a higher number of men, which matches previous research by Islam and others in 2018. He had found that due to differences in immunity and respiratory anatomy, boys are more prone to respiratory infections.[12]

The mean weight, height, and BMI of the participants were 23.87 ± 7.09 kg, 126.22 ± 12.47 cm, and 14.63 ± 2.13 kg/m², respectively. Based on BMI, 72.4% of the children had a normal nutritional status, 21% were underweight, and 6.6% were overweight. A statistically significant association (P = 0.03) was found between serum zinc levels and BMI; underweight children were more likely to have very low zinc levels. This aligns with findings by Islam et al. (2018) and Gu et al. (2019), who reported that malnutrition increases the risk of infection and deficiencies in micronutrients, including zinc.[12-15] In contrast, Elmadfa et al. (2017) observed a weak association between nutritional status and zinc levels, suggesting that other factors, such as infection or dietary quality, also play a role.[16] Furthermore, a significant positive correlation (P = 0.005) was observed between BMI and serum zinc levels, indicating that children with better nutritional status had higher serum zinc levels.

Regarding dietary habits, 69.5% of the participants were non-vegetarian, while 30.5% were vegetarian. Children following a vegetarian diet were significantly more likely to have low zinc levels (P = 0.002). This finding aligns with a 2008 study by Gibson et al., which noted that vegetarian diets often contain lower levels of bioavailable zinc due to the presence of phytates—compounds that inhibit zinc absorption.[17] This highlights the impact of diet on zinc levels and, consequently, on immunity and susceptibility to ALRTI. In contrast, a 2025 study by Simon et al. found no significant difference in serum zinc levels between vegetarian and non-vegetarian children, suggesting that factors such as total nutrient intake and bioavailability can modulate the effect of diet type on zinc levels.[18]

Regarding clinical history, 41% of the children reported three or more episodes of similar respiratory issues in the preceding six months, indicating a prevalence of recurrent ALRTI. While 66.7% of participants reported undergoing regular deworming, 33.3% did not adhere to a regular deworming schedule. Irregular deworming can hinder the absorption of micronutrients, including zinc, thereby increasing the risk of infection. Al-Kholi et al. reported similar findings in 2024; they observed higher rates of recurrent respiratory infections and lower serum zinc levels in children with irregular deworming schedules, underscoring the role of parasite control in preventing infections.[19] In contrast, a 2013 study by Polman et al. found no significant association between the frequency of deworming and cases of respiratory infections, suggesting that factors such as hygiene, nutrition, and environmental exposure may also play a crucial role.[20]

In this study, the majority of children (91.4%) were vaccinated according to age-appropriate schedules, whereas 8.6% had incomplete or no vaccination. This high level of vaccination likely contributed to the predominance of mild respiratory cases (79%), as proper vaccination offers protection against severe respiratory pathogens and supports the protective role of zinc. Conway et al. (2011) reported similar findings, observing high vaccination coverage (>90%) among children, which was associated with fewer cases of severe respiratory infection.[21] In contrast, a 2025 study by Endalew et al. observed a lower vaccination rate (approximately 75%) in the same age group, highlighting disparities in vaccine coverage that could influence susceptibility to infection.[22]

The mean serum zinc level among participants was 55.02 ± 13.82 µg/dL. A significant association was found between serum zinc levels and RSS scores (P = 0.001). Children with very low zinc levels were more likely to develop severe respiratory illness (9 out of 17), whereas all children with normal zinc levels exhibited only mild symptoms. These results support an earlier study by Wong et al. (2025), which indicated that zinc deficiency increases both the incidence and severity of respiratory infections in children.[23] Conversely, Khera et al. (2020) found no significant association between zinc levels and clinical severity, suggesting that other factors may influence disease outcomes.[7]

Serum zinc levels also showed a significant association with BMI (P = 0.005) and BMI interpretation (P = 0.01). Children with better nutritional status were more likely to have adequate zinc levels, whereas underweight children were prone to deficiency. These findings align with a 2019 study by Escobedo-Monge et al., which emphasized the crucial role of nutrition in maintaining adequate zinc levels and reducing the severity of infections.[24]

CONCLUSION

This study highlights the significant role of serum zinc in children aged 5–12 years suffering from acute lower respiratory tract infections (ALRTI) and examines its associations with demographic, nutritional, dietary, and clinical factors. The findings indicate that younger children—particularly those aged 5–7 years—are more susceptible to ALRTI, with a slightly higher incidence observed in boys, a trend consistent with previous studies. Nutritional status, as assessed by BMI, is strongly linked to serum zinc levels; underweight children are at a higher risk of zinc deficiency and, consequently, more severe respiratory illness. Dietary habits also influence zinc status; vegetarian children are more likely to have lower zinc levels due to reduced bioavailability. Clinical factors such as recurrent respiratory issues and irregular deworming were associated with low zinc levels, suggesting that both micronutrient status and parasite control play a role in susceptibility to infection. The prevalence of mild respiratory cases among participants may be attributed to high vaccination coverage. Overall, the study demonstrates that adequate serum zinc levels, good nutritional status, proper diet, regular deworming, and vaccination collectively contribute to reducing disease severity and improving outcomes in children with ALRTI. These findings underscore the importance of nutritional interventions, zinc supplementation, and public health measures in the prevention and management of respiratory infections among school-aged children.

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