Section: Pediatrics

Original Research Article

IRON DEFICIENCY, NUTRITIONAL STATUS, AND ENVIRONMENTAL RISK FACTORS ASSOCIATED WITH RECURRENT BACTERIAL SKIN AND SOFT-TISSUE INFECTIONS IN CHILDREN: A CASE-CONTROL STUDY

M. Gopi Kiran[1], Deepthi Rayi[2], Silpa Ponnada[3], Lakshmi Kumari Villa[4]

[1]*Associate Professor, Department of Pediatrics, MNR Medical College and Hospital, Sangareddy, Telangana, India.*
[2]*Assistant Professor, Department of Pediatrics, MNR Medical College and Hospital, Sangareddy, Telangana, India.*
[3]*Assistant Professor, Department of DVL, MNR Medical College and Hospital, Sangareddy, Telangana, India.*
[4]*Consultant Dermatologist, Dr Lakshmi Skin and Hair Clinic, Miyapur, Hyderabad, Telangana, India.*

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Corresponding Author:
Dr. M. Gopi Kiran,
Associate Professor, Department of Pediatrics, MNR Medical College and Hospital, Sangareddy, Telangana, India.
Email: medurigopikiran@gmail.com

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ABSTRACT

Background: Recurrent bacterial skin and soft-tissue infections (SSTIs) in children may be influenced by nutritional deficiencies, socioeconomic circumstances, host susceptibility, and environmental exposures. Understanding these factors may help identify potential targets for prevention. This study was designed to evaluate the association between iron deficiency, nutritional status, and environmental risk factors among children with recurrent bacterial SSTIs attending a tertiary care hospital.

Materials and Methods: This prospective case-control study consists of 380 children, comprising 190 children with recurrent SSTIs and 190 controls. Sociodemographic characteristics, clinical features, nutritional indicators, household exposures, and laboratory parameters were considered. Laboratory assessments included haemoglobin, mean corpuscular volume, serum ferritin, and C-reactive protein. Multivariable logistic regression was used to examine factors associated with recurrent infection. Receiver operating characteristic (ROC) analysis and calibration assessment were also performed as exploratory statistical procedures.

Results: The iron deficiency was observed in 52.6% of cases and 37.9% of controls. Poor dietary diversity was more frequent among cases (50.0%) than controls (37.4%). Lower socioeconomic status and previous antibiotic exposure were associated with recurrent infection in the adjusted model. Serum ferritin concentrations did not differ significantly between groups (P>0.05). The exploratory prediction model demonstrated modest discrimination, with an area under the receiver operating characteristic curve of 0.662.

Conclusion: Iron deficiency, poor dietary diversity, lower socioeconomic status, and previous antibiotic exposure are associated with recurrent bacterial skin and soft-tissue infections in children. Nutritional assessment and targeted preventive strategies may help identify modifiable risk factors.

Keywords: Children, recurrent infection, skin and soft tissue infections, iron deficiency, nutritional status.

INTRODUCTION

Recurrent bacterial skin and soft-tissue infections (SSTIs) are an important clinical concern in children because repeated episodes may cause pain, scarring, school absenteeism, antibiotic exposure, and increased healthcare utilization. Common presentations include impetigo, folliculitis, furuncles, abscesses, and cellulitis. Staphylococcus aureus, including methicillin-resistant strains, is a major pathogen implicated in community-associated SSTIs.[1,2] Recurrence may occur despite appropriate treatment because of persistent colonization, repeated exposure to infected household contacts, and

environmental contamination.[2-4] Recent evidence also highlights the continuing challenge of preventing recurrent infections and the need for individualized prevention strategies.[5]

The development of recurrent SSTIs is multifactorial. Host characteristics, skin-barrier disruption, previous infections, bacterial colonization, and household hygiene practices may influence susceptibility and transmission.[2,3,5] Crowded living conditions, sharing personal items, and inadequate access to hygiene facilities may facilitate the circulation of pathogenic organisms. Household-based studies have demonstrated that infections can cluster among family members, emphasizing the importance of assessing environmental and interpersonal exposures alongside individual clinical factors.[3,4]

Nutritional status may represent another relevant component of host susceptibility. Iron is essential for cellular metabolism and normal immune function; however, the relationship between iron deficiency and recurrent bacterial SSTIs in children remains insufficiently characterized. Iron deficiency, anemia, and broader nutritional inadequacy should be evaluated as distinct but potentially overlapping conditions. Assessment also requires careful interpretation of serum ferritin because inflammation can elevate ferritin concentrations and obscure depleted iron stores. The World Health Organization (WHO) recommends considering inflammatory markers when ferritin is used to assess iron status in populations affected by infection or inflammation.[6]

Despite evidence concerning bacterial colonization and household transmission, the combined associations of iron status, nutritional indicators, socioeconomic circumstances, and environmental exposures with recurrent pediatric SSTIs require further investigation. A structured evaluation of these factors may help identify potentially modifiable associations and guide future prospective research. Therefore, this study designed to evaluate the association of iron deficiency and nutritional status with recurrent bacterial SSTIs among children attending a tertiary care Centre.

MATERIALS AND METHODS

The present hospital-based case-control study was conducted in Department of Pediatrics at MNR Medical College and Hospital, Sangareddy from June 2025 to August 2026. A total of 380 participants, including 190 cases and 190 age and gender matched controls were recruited. Cases were defined as children with recurrent bacterial SSTIs, operationally defined as at least two distinct episodes within the preceding 12 months, including the current episode, with documented or clinically verifiable resolution between episodes. Controls were defined as children presenting with a first or isolated bacterial SSTI who did not meet the recurrence criteria. The written informed consent was obtained from parents or legal guardians and study protocol was approved by the institutional ethics committee

Inclusion Criteria: Children aged 0-17 years with clinically diagnosed bacterial SSTIs. Eligible cases met the predefined recurrence criteria, whereas controls had no qualifying history of recurrent infection.

Exclusion Criteria: Children with major immunosuppression, suspected primary immunodeficiency requiring a separate diagnostic evaluation, insufficient information to establish infection status, skin barrier disorders, and nutritional abnormalities.

A structured data collection proforma was developed to record demographic, clinical, nutritional, hematological, and environmental variables. Demographic variables and clinical variables included infection type, anatomical site, previous episodes, antibiotic exposure, treatment history, relevant comorbidities, and skin barrier disorders such as atopic dermatitis and scabies were recorded.

Nutritional assessment included body mass index (BMI), age-appropriate growth indicators, dietary diversity, and reported consumption of iron rich foods and growth measurements were interpreted using appropriate WHO growth standards according to age were collected. Environmental variables included household crowding, water and sanitation access, availability of handwashing facilities, sharing of personal items, household history of similar infections, skin trauma, and wound care practices was recorded.

The laboratory variables included haemoglobin concentration, complete blood count indices, serum ferritin, and C-reactive protein (CRP). Iron deficiency and anemia were treated as separate outcomes, with age-appropriate diagnostic thresholds specified before analysis. Serum ferritin was interpreted in the context of inflammation because it may increase during acute infection.

Statistical Analysis

The collected data was extracted to Microsoft Excel sheet and analysed using SPSS v.26.0. Continuous variables were to be summarized as means and standard deviations and categorical variables were to be expressed as frequencies and percentages. Group comparisons were specified using the independent samples t-test for continuous variables and the chi-square test for categorical variables. Binary logistic regression was planned to evaluate the association between recurrent SSTIs and iron deficiency, nutritional indicators, and environmental exposures. Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) were specified as the principal measures of association. A $p<0.05$ was defined as statistically significant outcome.

RESULTS

Table 1: Sociodemographic characteristics of study participants

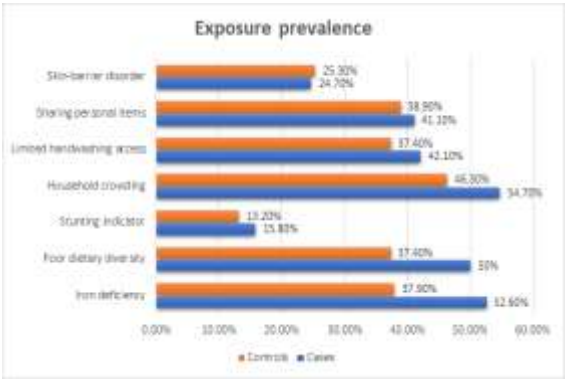
Demographic variable	Cases (n=190) Frequency (%)	Controls (n=190) Frequency (%)	p-value
Age (In years)			
<2	11 (5.8%)	13 (6.8%)	0.630
2-5	71 (37.4%)	59 (31.1%)	
6-11	74 (38.9%)	80 (42.1%)	
12-17	34 (17.9%)	38 (20.0%)	
Gender			
Male	103 (54.2%)	96 (50.5%)	0.538
Female	87 (45.8%)	94 (49.5%)	
Socioeconomic status			
Lower socioeconomic status	113 (59.5%)	77 (40.5%)	0.001
Lifestyle factors			
Stunting indicator	30 (15.8%)	25 (13.2%)	0.560
Poor dietary diversity	95 (50.0%)	71 (37.4%)	0.017
Household crowding	104 (54.7%)	88 (46.3%)	0.124
Limited handwashing access	80 (42.1%)	71 (37.4%)	0.402
Sharing personal items	78 (41.1%)	74 (38.9%)	0.753
Skin-barrier disorder	47 (24.7%)	48 (25.3%)	1.000
Prior antibiotic exposure	108 (56.8%)	77 (40.5%)	0.002
Dietary parameters			
Stunting indicator	30 (15.8%)	25 (13.2%)	0.560
Poor dietary diversity	95 (50.0%)	71 (37.4%)	0.017

Table 2: Laboratory parameters of study participants

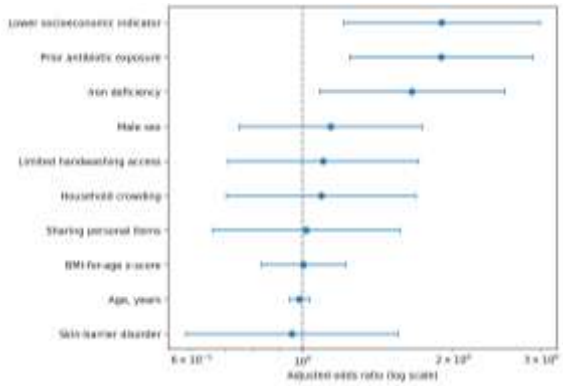
Laboratory parameter	Cases Mean±SD	Controls Mean±SD	p-value
Hemoglobin (g/dL)	11.38±1.00	11.50±0.94	0.146
Mean corpuscular volume (fL)	77.22±6.46	78.55±6.75	0.038
Serum ferritin (ng/mL)	40.71±30.02	43.39±26.24	0.096
C-reactive protein (mg/L)	3.29±3.29	2.06±1.64	0.001
Iron deficiency	100 (52.6%)	72 (37.9%)	0.005
Anemia	100 (52.6%)	91 (47.9%)	0.412
Iron deficiency anemia	70 (36.8%)	51 (26.8%)	0.047

Table 3: Clinical parameters of study participants

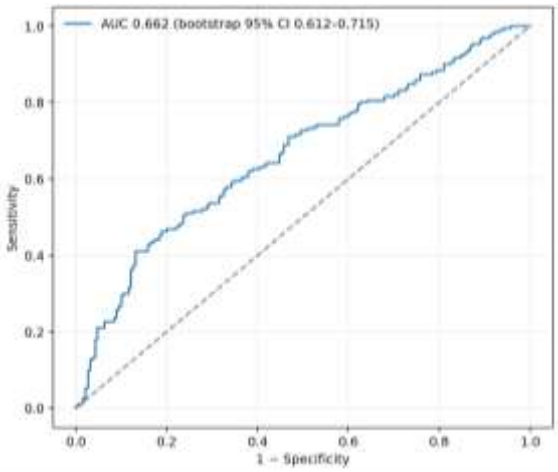
Parameter	Cases Frequency (%)	Controls Frequency (%)	p-value
Type of skin infection			
Abscess or furuncle	64 (33.7%)	70 (36.8%)	0.722
Cellulitis	48 (25.3%)	40 (21.1%)	
Folliculitis	25 (13.2%)	29 (15.3%)	
Impetigo	53 (27.9%)	51 (26.8%)	
Culture performed	76 (40.0%)	85 (44.7%)	0.406
Culture findings			
Culture +Ve	60 (78.9%)	57 (67.1%)	0.130
Culture -Ve	16 (21.1%)	28 (32.9%)	
Hospitalized during present episode	44 (23.2%)	45 (23.7%)	1.000



Graph 1: Exposure prevalence among study participants



Graph 2: Adjusted odds ratios and 95% confidence intervals associations with recurrent SSTI



Graph 3: Apparent ROC curve

DISCUSSION

Recurrent bacterial skin and soft-tissue infections (SSTIs) in children are clinically important because repeated episodes may reflect persistent bacterial colonization, household transmission, impaired skin-barrier function, or host-related susceptibility. Staphylococcus aureus is a major cause of these infections, and recurrence is a recognized challenge in pediatric practice.[7-9] The present case-control study explored associations between recurrent SSTIs, iron deficiency, nutritional status, socioeconomic circumstances, and environmental exposures.

In present study, iron deficiency was more frequent among children with recurrent SSTIs than among controls (52.6% Vs 37.9%). In the multivariable model, iron deficiency remained associated with recurrent infection (aOR 1.66, 95% CI 1.08-2.54). Iron has important roles in cellular metabolism and immune function, while micronutrient deficiencies can affect epithelial integrity, inflammatory regulation, and host defence.[10] Nevertheless, evidence specifically establishing iron deficiency as an independent cause of recurrent pediatric bacterial SSTIs remains limited.

Mean serum ferritin was numerically lower in the recurrent-infection group than in controls, but the difference was not statistically significant (32.34 Vs 37.51 ng/mL for the medians; p>0.096). In contrast, C-reactive protein was higher in cases in the present study. This distinction is clinically important because ferritin is an acute-phase reactant and may rise during infection, potentially masking depleted iron stores. The WHO recommends interpreting ferritin alongside inflammatory markers and applying appropriate age specific criteria.[6] Future studies should define iron deficiency prospectively, distinguish iron deficiency from anemia, and consider reassessment after acute inflammation has resolved.

Nutritional findings were mixed. Poor dietary diversity was more common among cases than controls (50.0% Vs 37.4%), whereas BMI for age z-score and the prevalence of stunting did not differ significantly (p>0.05). These measures capture different aspects of nutritional status: anthropometry reflects growth and body composition, while dietary diversity provides information about the range of foods consumed. Several studies support biologically plausible interactions between nutrition, infection, and immune function, but associations vary according to the nutrient, population, and infectious outcome studied.[10] Accordingly, dietary diversity warrants further assessment using validated age-appropriate tools and adjustment for socioeconomic circumstances.

In present study, lower socioeconomic status was associated with recurrent SSTI (aOR 1.90, 95% CI 1.21-2.98). Household crowding, limited handwashing access, and sharing personal items were also common, although their adjusted associations were not statistically significant (p>0.05). These findings should not be interpreted as evidence that such exposures are unimportant. Several studies on S. aureus transmission demonstrated that households and contaminated shared environments can contribute to bacterial acquisition and reinfection.[8,9,11-14] Socioeconomic disadvantage may influence several interrelated exposures, including access to hygiene facilities, timely treatment, household density, and nutrition. Larger studies with direct assessment of household contacts and bacterial colonization may clarify these relationships.

Prior antibiotic exposure was associated with recurrent infection in the illustrative model (aOR 1.89, 95% CI 1.24-2.89). This association may reflect confounding by indication; children with more severe or frequent infections are more likely to receive antibiotics. The finding does not establish that antibiotics cause recurrence. Clinical management should emphasize appropriate treatment, culture and susceptibility testing when indicated, wound care, hygiene education, and consideration of decolonization strategies for selected patients with recurrent staphylococcal infections.[2,7,12]

CONCLUSION

The findings showed a potential association of iron deficiency, poor dietary diversity, socioeconomic disadvantage, and previous antibiotic exposure with recurrent bacterial skin and soft-tissue infections in children. Iron deficiency, lower socioeconomic status, and prior antibiotic exposure remained associated with recurrence in the adjusted analysis. These findings emphasize the importance of comprehensive nutritional assessment, appropriate laboratory evaluation, and consideration of household and environmental factors when managing affected children.

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