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Infection Patterns and Bacterial Profiles in Children with Nephrotic Syndrome at A Tertiary Care Centre In India

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Abstract

Background: Nephrotic syndrome (NS) is a common paediatric kidney disorder with increased susceptibility to infections due to immunosuppression and urinary loss of immunoglobulins. This study evaluates infection patterns and bacterial profiles in children with NS, comparing first episodes and relapses by age and gender.

Methods: A two-year prospective observational study was conducted at a tertiary care centre in India. Children aged 6 months to 12 years diagnosed with NS using ISKDC criteria were enrolled. Demographic, clinical, and laboratory data were recorded. Infections were diagnosed clinically and confirmed microbiologically or radiologically. Data analysis was done using SPSS v21.

Results: Seventy-one children were included (mean age 5.9 years; male: female ratio 1.6:1). First episodes accounted for 69%, predominantly in boys, while relapses were more common in girls. Urinary tract infection (UTI) was the most frequent infection (39.4%), followed by respiratory tract infections (38.0%), septicaemia (33.8%), and peritonitis (23.9%). UTIs were significantly more frequent during relapses (77.3%) than first episodes (22.4%), and in girls. *Klebsiella spp.* was the most common uropathogen (46.4%), followed by E. coli and *Staphylococcus aureus.* Children aged 1–5 years were most affected by UTIs.

Conclusion: Infections, particularly UTIs, are a major complication in paediatric NS, especially during relapses and in girls. The predominance of *Klebsiella spp.* underscores the need for empirical antibiotic policies based on local patterns. Early detection and preventive strategies are vital to reduce infection-related morbidity.

Keywords: urinary tract infection in children, urinary tract infection, steroid sensitive nephrotic syndrome, nephrotic syndrome, paediatric infections, klebsiella species.

Introduction

Nephrotic syndrome (NS) is a common paediatric renal disorder characterised by oedema, proteinuria, hypoalbuminaemia, and hyperlipidaemia, predominantly affecting children aged 1 to 6 years.[1] The aetiology is often idiopathic, with minimal change nephrotic syndrome (MCNS) and focal segmental glomerulosclerosis (FSGS) being the most frequently encountered histopathological types.[2] Infectious complications are notable, with a prevalence ranging from 21.56% to 39.8%, often associated with low serum albumin and concurrent haematuria.[3–4] Common infections include pneumonia, urinary tract infections (UTIs), and peritonitis, which contribute to prolonged hospitalisation.[4] Corticosteroids remain the mainstay of therapy; however, steroid resistance necessitates the use of additional immunosuppressive agents in selected cases.[5] A thorough understanding of the demographic and clinical profile of children with NS is essential for optimising management and reducing morbidity.[1 4]

Children with NS are predisposed to infections due to a combination of factors including immunosuppression, urinary loss of immunoglobulins, and oedema-related skin breakdown. The loss of serum proteins, particularly immunoglobulins, weakens the immune defence, increasing susceptibility to UTIs, septicaemia, and respiratory infections.[6] Oedema may further cause skin breakdown, providing a portal of entry for pathogens.[7] Infection patterns in NS vary regionally, with bacterial infections being more prevalent in resource-limited settings. Notably, *Klebsiella spp.* is frequently isolated, particularly in settings of poor sanitation and hospital-acquired infections.[8] These findings underscore the need for region-specific studies to assess the prevalence and types of infections, particularly UTIs, to refine clinical management strategies.[9]

Materials and Methods

This prospective observational study was conducted over a two-year period in the Department of Paediatrics at a tertiary care teaching hospital in India. The study aimed to evaluate the demographic profile, infection patterns, and clinical outcomes in children with nephrotic syndrome.

Inclusion Criteria: Children aged 6 months to 12 years diagnosed with nephrotic syndrome based on the International Study of Kidney Disease in Children (ISKDC) criteria were enrolled. These criteria included oedema, nephrotic-range proteinuria (urinary spot protein-to-creatinine ratio > 2), hypoalbuminaemia (serum albumin < 2.5 g/dL), and hyperlipidaemia (serum cholesterol > 200 mg/dL).[10] Both inpatients and outpatients were included after obtaining written informed consent.

Exclusion Criteria: Children aged <6 months or >12 years, those with nephrotic syndrome secondary to systemic diseases (e.g. lupus nephritis, post-infectious glomerulonephritis), congenital nephrotic syndrome, or oedema from other causes (severe acute malnutrition, congestive cardiac failure, hepatic failure) were excluded. Patients with recent antibiotic use were also excluded to minimise bias.

Participants were grouped as first-episode or relapse nephrotic syndrome. Data were collected using a structured proforma detailing demographic profile, clinical features, and history. All children underwent serum albumin, cholesterol, and urinary protein-to-creatinine ratio testing. Infection workup included complete blood count, C-reactive protein (CRP), blood culture, and urine culture and sensitivity.

Diagnostic Criteria for Infections: Urinary tract infection (UTI) was defined as ≥5 leukocytes/mm³ in a centrifuged urine sample plus ≥10^5 colony-forming units (CFU/mL)

growth of a single uropathogen in urine culture. Septicaemia was identified by a positive blood culture in the presence of systemic clinical symptoms. Peritonitis was diagnosed based on clinical signs such as abdominal pain or tenderness, supported by relevant laboratory evidence (e.g. elevated white cell count, raised C-reactive protein). Respiratory infections were clinically suspected and confirmed using chest radiographs in the presence of respiratory symptoms.

Outcome Measures: The primary outcome was to determine the prevalence and types of infections in children with nephrotic syndrome. Secondary outcomes included identifying causative organisms, comparing infection rates in first episode versus relapse, and evaluating infection distribution by age and gender.

Statistical analysis was performed using SPSS version 21 and Microsoft Excel. Categorical data were expressed as frequencies (N) and percentages (%), while continuous variables were presented as mean ± standard deviation (SD). The Chi-square test was used for categorical comparisons, and the paired t-test was applied to continuous variables. A p-value <0.05 was considered statistically significant. Additional stratified analyses were conducted by age and gender.

The study was approved by the Institutional Ethics Committee (Approval No: 2023/82) and adhered to the principles of the Declaration of Helsinki. Written informed consent was obtained from the guardians of all participants.

AI tools, including ChatGPT (Open AI, accessed July 2025), were used to assist with language clarity and formatting during manuscript preparation. These tools supported only editorial aspects and were not involved in data analysis or result interpretation. All content was carefully reviewed and approved by the authors, who take full responsibility for the final version.

Results

A total of 71 children with nephrotic syndrome (NS), aged between 6 months and 12 years, were enrolled in the study. The mean age of the study population was 5.9 ± 3.02 years. Boys had a mean age of 5.57 ± 2.94 years, while girls had a mean age of 6.58 ± 3.10 years. The overall male-to-female ratio was 1.6:1, indicating a predominance of boys. Among the first-episode NS group (n = 49), 35 (71.4%) were boys and 14 (28.6%) were girls, reflecting a strong male predominance. In contrast, the relapse group (n = 22) included 9 (40.9%) boys and 13 (59.1%) girls, showing a relative predominance of girls among relapsing cases. Children aged 1–5 years constituted the largest age group in the cohort, accounting for 37 cases (52.1%), including 26 (53.1%) from the first-episode group and 11 (50.0%) from the relapse group. The 5–10 years group comprised 27 cases (38.0%), while 7 children (9.9%) were over 10 years of age. No statistically significant differences in age or gender distribution were found between the groups ($p > 0.05$, Chi-square test). These findings are summarised in Table Infectious complications were frequently observed in the study cohort. Urinary tract infections (UTIs) were the most common, reported in 28 children (39.4%). This was followed by acute respiratory infections (ARIs) in 27 children (38.0%), of which 22 (81.5%) were upper respiratory tract infections (URTIs) and 5 (18.5%) were pneumonia. Septicaemia occurred in 24 children (33.8%), while peritonitis was identified in 17 children (23.9%), with a higher prevalence in boys (64.7%). Other infections included acute gastroenteritis (13 cases; 18.3%), scabies (5 cases; 7.0%), tuberculosis (2 cases; 2.8%), and abscess formation (1 case; 1.4%). When stratified by NS status, UTIs were significantly more frequent during relapses, with 17 cases (77.3%) in the relapse group compared to 11 (22.4%) in the first-

episode group. Septicaemia and ARIs also showed higher prevalence in children with relapsing NS. These infection patterns are summarised in Table 2.

Out of the 28 urinary tract infection (UTI) cases identified, 11 (39.2%) occurred during the first episode of nephrotic syndrome (NS), while 17 (60.8%) occurred during relapses, reinforcing the observation that infection risk is higher in relapsing NS. Age stratification revealed that UTIs were most prevalent in the 1–5 years age group (12 cases; 42.9%), followed by 5–10 years (11 cases; 39.3%), and >10 years (5 cases; 17.9%). The age-wise breakdown by NS status is summarised in Table 3.

The microbiological analysis of urinary tract infections (UTIs) in children with nephrotic syndrome (NS) revealed a predominance of *Klebsiella spp.*, isolated in 13 of 28 cases (46.4%). *Escherichia coli* (E. coli) was the second most frequent organism, identified in 7 cases (25.0%). Staphylococcus aureus accounted for 5 cases (17.9%), while *Pseudomonas spp.* and *Proteus spp.* were isolated in 2 (7.1%) and 1 (3.6%) cases, respectively, as detailed in Table 4.

The distribution of infections by gender reveals notable differences. Urinary tract infections (UTIs) were more prevalent in girls (15 cases; 55.6%) compared to boys (13 cases; 29.5%). Conversely, peritonitis and septicaemia were more commonly observed in boys, with 11 cases (25.0%) and 10 cases (22.7%), respectively. Respiratory tract infections were relatively evenly distributed across genders, with 16 boys (36.4%) and 11 girls (40.7%) affected. These findings are summarised in Table 5.

This study identified a significant incidence of urinary tract infections (UTIs) among children with nephrotic syndrome (NS), with *Klebsiella spp.* as the most frequently isolated pathogen, followed by *Escherichia coli* and *Staphylococcus aureus*. The age group most affected was 1–5 years, with a higher proportion of UTIs observed in first-episode NS and relapse cases. Peritonitis and septicaemia were observed more commonly in boys, while respiratory infections occurred across both genders. The microbiological profile indicated an emerging role for *Klebsiella spp*. as a predominant uropathogen.

Discussion

Our study highlights the significant burden of infections in children with nephrotic syndrome (NS), with urinary tract infections (UTIs) emerging as the most frequently observed. Notably, Klebsiella spp. was the most common uropathogen, followed by Escherichia coli (E. coli) and Staphylococcus aureus. Evidence from global studies supports these findings. In resource-limited settings, Klebsiella spp. often dominates. For instance, a study from Bangladesh found Klebsiella spp. to be a notable uropathogen, though E. coli remained the most common, accounting for 70% of UTI cases.[11] Similarly, a study from India reported E. coli as the predominant isolate, followed by Klebsiella spp., a pattern reflecting improved hygiene in better-resourced settings.[12] Conversely, research from Ethiopia and Bangladesh, specifically in children with NS, identified Klebsiella spp. as a significant hospital-acquired pathogen, particularly in settings with weaker infection control practices.[13] This regional variation underscores the influence of environmental and healthcare factors on pathogen distribution and infection risk.

The predominance of Klebsiella spp. in our cohort is concerning, particularly given its well-documented association with antimicrobial resistance (AMR). While our study did not assess AMR patterns, this finding highlights the urgent need for antibiotic stewardship and early screening for drug-resistant organisms in children with NS. Multiple studies have shown that multidrug-resistant (MDR) Klebsiella strains exhibit resistance to

several antibiotic classes, including carbapenems, and are associated with increased morbidity and mortality in hospitalised children.[14–16] Alarmingly, the emergence of hypervirulent MDR strains—which combine resistance mechanisms with enhanced virulence factors—has further complicated clinical management, especially as these strains show resistance to last-resort agents like polymyxins and tigecycline.[17] To address this, active surveillance and molecular monitoring of MDR strains are essential for guiding targeted infection control strategies and preventing intra-hospital transmission.[18 19] Furthermore, the integration of antimicrobial stewardship programmes and routine early screening protocols in paediatric units is crucial for curbing the incidence of MDR Klebsiella infections in high-risk hospitalised children.[20]

Our results also revealed that girls experienced a higher frequency of NS relapses compared to boys (60% vs 40%). This contrasts with several earlier studies that have reported higher relapse rates in boys. While this discrepancy may be attributed to sample variation, it also raises questions about the role of hormonal and immunological factors, as well as sociocultural practices, such as hygiene-related behaviours. Emerging evidence suggests that oestrogens play a significant role in modulating immune responses, which could influence infection susceptibility and relapse patterns, particularly among females. Oestrogens are known to enhance humoral immunity, potentially leading to more robust antibody-mediated responses, but may also contribute to a greater predisposition to autoimmune conditions.[21 22] In infectious contexts, oestrogens have been shown to alter inflammatory responses. These observations highlight the need for further research into gender-specific immune mechanisms in NS.

The predominance of urinary tract infections (UTIs) in children aged 1–5 years represents a critical period of vulnerability, particularly in those diagnosed with nephrotic syndrome (NS), as supported by multiple studies. This age group consistently exhibits high UTI prevalence, often presenting with nonspecific symptoms such as fever and dysuria, which can complicate timely diagnosis.[23–26] Reported prevalence rates vary across studies, with one noting a 6.5% UTI rate among children with acute febrile illness,[24] and another reporting rates as high as 18.8% in febrile children under five years of age.[27] Notably, our study observed that while the first-episode NS group showed a higher proportion of UTI cases in the 1–5 year age range (54.5%), the relapse group also demonstrated a significant burden (35.3%) in the same age bracket. In summary, the 1–5 years age group constitutes a critical window for UTI susceptibility in children with NS.

The observed association between peritonitis and male gender (64.7% of peritonitis cases in males) aligns with previous reports indicating that males are more prone to this complication due to factors such as anatomical differences and delayed symptom recognition, which can increase the risk of conditions like appendicitis.[28] Thus, the higher incidence of peritonitis in males may be attributed to a combination of biological, environmental, and behavioural factors, highlighting the need for targeted interventions to address these disparities.

Septicaemia is notably prevalent among children with nephrotic syndrome (NS), particularly during relapse periods when immune suppression is intensified due to corticosteroid therapy. The risk of infections in children with NS is exacerbated by frequent relapses associated with steroid-sensitive nephrotic syndrome (SSNS), with a significant association between upper respiratory tract infections and relapses.[29] Implementing systematic

quality improvement measures in the recognition and treatment of infections, alongside personalised immunomodulation strategies, is essential for improving outcomes in children with NS during relapse-prone periods. Our findings underscore the importance of preventive measures to reduce infection risks in children with NS.

This study has some limitations. As it was conducted at a single centre, the findings may not fully reflect infection trends in other regions. We did not assess antimicrobial resistance patterns, particularly for Klebsiella spp., which may have limited our ability to guide empirical treatment. Additionally, the exclusion of viral triggers and immune markers restricted insights into the broader aetiology of nephrotic syndrome relapses.

Future studies should consider multi-centre designs to improve generalisability and explore resistance trends in common pathogens. Including viral screening and immunological assessments could enhance understanding of relapse triggers and infection susceptibility, helping to guide more targeted prevention and treatment strategies in children with nephrotic syndrome.

Figures and Tables

Table 1: Demographic Characteristics of the Study Population

Characteristic	First Episode NS (n = 49)	Relapse NS (n = 22)	Total (n = 71)
Sex Distribution			
Boys	35 (71.4%)	9 (40.9%)	44 (62.0%)
Girls	14 (28.6%)	13 (59.1%)	27 (38.0%)
Age Group			
1–5 years	26 (53.1%)	11 (50.0%)	37 (52.1%)
5–10 years	18 (36.7%)	9 (40.9%)	27 (38.0%)
>10 years	5 (10.2%)	2 (9.1%)	7 (9.9%)
Mean Age (Years)	–	–	5.9 ± 3.02
Boys	–	–	5.57 ± 2.94
Girls	–	–	6.58 ± 3.10

Footnote: Data are presented as number of children (N) with percentages (%) in parentheses. Continuous variables are expressed as mean ± standard deviation. No statistically significant differences were found between groups for age or sex distribution ($p > 0.05$, Chi-square test).

Abbreviations: NS = Nephrotic Syndrome; SD = Standard Deviation.

Table 2: Spectrum of Infections in Children with First-Episode and Relapse Nephrotic Syndrome

Type of Infection	First Episode NS (n = 49)	Relapse NS (n = 22)	Total (n = 71)	Percentage (%)
Urinary Tract Infection	11 (22.4%)	17 (77.3%)	28	39.4%
Septicaemia	12 (24.5%)	12 (54.5%)	24	33.8%
Acute Respiratory Infection	15 (30.6%)	12 (54.5%)	27	38.0%
Upper Respiratory Tract Infection	12 (24.5%)	10 (45.5%)	22	31.0%

Pneumonia	3 (6.1%)	2 (9.1%)	5	7.0%
Peritonitis	11 (22.4%)	6 (27.3%)	17	23.9%
Acute Gastroenteritis	8 (16.3%)	5 (22.7%)	13	18.3%
Scabies	3 (6.1%)	2 (9.1%)	5	7.0%
Tuberculosis	1 (2.0%)	1 (4.5%)	2	2.8%
Abscess	1 (2.0%)	0 (0.0%)	1	1.4%

Footnote: Data are expressed as number of cases (N) with corresponding percentages (%) in parentheses. Multiple infections could co-exist in the same child.

Abbreviation: NS = Nephrotic Syndrome.

Table 3: Age Distribution of UTI Cases in First-Episode and Relapse Nephrotic Syndrome

Age Group (Years)	First Episode NS (n = 49)	Relapse NS (n = 22)	Total (n = 28)	Percentage (%)
1–5 years	6 (54.5%)	6 (35.3%)	12	42.9%
5–10 years	4 (36.4%)	7 (41.2%)	11	39.3%
>10 years	1 (9.1%)	4 (23.5%)	5	17.9%

Footnote: Data are expressed as number of UTI cases (N) per age group and NS status, with row-wise percentages (%) indicating the relative burden within each category.

Abbreviations: NS = Nephrotic Syndrome; UTI = Urinary Tract Infection.

Table 4: Distribution of Bacterial Isolates in UTI Cases among Children with Nephrotic Syndrome

Organism	Total Cases (n = 28)	Percentage (%)
Klebsiella spp.	13	46.4%
Escherichia coli	7	25.0%
Staphylococcus aureus	5	17.9%
Pseudomonas spp.	2	7.1%
Proteus spp.	1	3.6%

Footnote: Data are expressed as number of UTI cases (N) per bacterial species isolated, with row-wise percentages (%) indicating the relative frequency of each pathogen among all UTI cases.

Abbreviations: NS = Nephrotic Syndrome; UTI = Urinary Tract Infection.

Table 5: Distribution of Infections by Gender in Children with NS

Infection Type	Boys (n = 44)	Girls (n = 27)	Total (n = 71)	Percentage (%)
Urinary Tract Infection	13 (29.5%)	15 (55.6%)	28	39.4%
Peritonitis	11 (25.0%)	6 (22.2%)	17	23.9%
Septicaemia	10 (22.7%)	14 (51.9%)	24	33.8%
Respiratory Infection	16 (36.4%)	11 (40.7%)	27	38.0%

Footnote: Data are expressed as number of infection cases (N) by type and gender, with row-wise percentages indicating the distribution of each infection type among boys and girls.

Abbreviations: NS = Nephrotic Syndrome; UTI = Urinary Tract Infection.

Conclusions

This study outlines the clinical profile of nephrotic syndrome (NS) in 82 children aged 6 months to 12 years, with the first episode predominating (61%) and a higher frequency of relapses in females. The 1–5 years age group made up 58.5% of cases. Infections were observed in 47.6%, with urinary tract infections (61.5%) being the most common, followed by respiratory infections (28.2%) and peritonitis (7.6%). *Klebsiella spp.* was the most frequent uropathogen (33.3%), and infection rates were higher in males and children >5 years. These findings emphasise the need for early infection screening and age- and gender-specific management strategies to improve clinical outcomes in NS.

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