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A Multidimensional Risk Factor Analysis of Pediatric Urinary Tract Infections: Bridging Clinical, Behavioral, and Socioeconomic Determinants in an Iranian Pediatric Population

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Abstract

Background: Urinary tract infection (UTI) remains a leading bacterial infection in children, with the potential for severe long-term morbidity, including renal scarring, hypertension, and chronic kidney disease. The identification of modifiable risk factors is essential for targeted prevention. This study aimed to comprehensively evaluate factors associated with pediatric UTI in a hospital setting in Sabzevar, Iran.

Methods: This case-control study enrolled 150 children under 16 years hospitalized with confirmed UTI and 150 age-matched controls hospitalized for non-UTI conditions. Data on demographic, socioeconomic, clinical, and behavioral variables were extracted from medical records and structured parental interviews. Statistical analyses included independent t-tests, Chi-square, and Fisher's exact tests, with significance set at $p < 0.05$. Odds ratios (ORs) with 95% confidence intervals (CIs) were calculated from univariate analyses.

Results: Among UTI cases, 120 (80%) were female and 30 (20%) male (mean age: 5.0 ± 1.8 years). Significant factors associated with UTI included female sex ($p < 0.001$), improper perineal hygiene ($p < 0.001$), uncircumcised status in males ($p < 0.001$), vesicoureteral reflux (VUR) ($p < 0.001$), constipation ($p = 0.009$), neurogenic bladder ($p < 0.001$), lack of toilet training ($p < 0.001$), tight underwear use ($p < 0.001$), bathtub use ($p = 0.003$), catheterization ($p = 0.007$), low socioeconomic status (SES) ($p < 0.001$), rural residence ($p < 0.001$), growth disorder ($p < 0.001$), prior UTI history ($p < 0.001$), family history of kidney stones ($p = 0.001$), and positive C-reactive protein ($p < 0.001$). Maternal education ($p = 0.06$) and labial adhesion ($p = 1.00$) showed no significant association.

Conclusion: Beyond established anatomical and physiological factors, socioeconomic status, hygiene practices, and behavioral patterns significantly contribute to pediatric UTI. Early identification and targeted educational interventions addressing these modifiable risks are critical to reducing recurrent infections and long-term renal complications.

Key Words: Children; Hygiene; Iran; Risk Factors; Socioeconomic Factors; Urinary Tract Infection.

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1- INTRODUCTION

Urinary tract infection (UTI) is the second most common bacterial infection in children, affecting approximately 8% of girls and 2% of boys by age 11 years (1). If not promptly diagnosed and treated, UTIs can result in serious sequelae, including renal scarring, hypertension, and chronic kidney disease, imposing a substantial burden on healthcare systems (2, 3).

Traditional risk factors such as female sex, vesicoureteral reflux (VUR), and neurogenic bladder are well-documented. However, contemporary evidence has expanded this paradigm, emphasizing the significant role of modifiable determinants, including socioeconomic status, hygiene practices, and parental health literacy (4, 5). Emerging studies further highlight complex etiologies involving gut and urinary microbiome dysbiosis, recurrent antibiotic exposure, and genetic predispositions (6, 7). Additionally, environmental factors such as climate, seasonal variations, and access to clean water and sanitation are gaining recognition, particularly in low- and middle-income countries (8).

Despite these advances, comprehensive data integrating demographic, clinical, socioeconomic, and behavioral factors remain scarce, especially in specific regional contexts like Iran. In Iranian children, reported UTI prevalence among febrile children ranges from 7% to 32%, influenced by local genetic backgrounds, practice patterns, and socioeconomic disparities (9, 10). Therefore, this study aimed to holistically evaluate the multifaceted factors associated with UTI in children admitted to a teaching hospital in Sabzevar, Iran, to provide a robust evidence base for preventive strategies.

2- MATERIALS AND METHODS

2-1. Study Design and Setting

A hospital-based case-control study was conducted at Heshmatieh Hospital, Sabzevar—a tertiary teaching hospital serving a mixed urban-rural population in northeastern Iran—from March 2021 to March 2022.

2-2. Participants

The study included 150 children under 16 years hospitalized with a definitive UTI diagnosis(cases), defined as: (1) positive urine culture with $\geq 10^5$ CFU/mL from clean-catch midstream, $\geq 10^4$ CFU/mL from catheterized specimen, or any growth from suprapubic aspiration; and (2) clinical symptoms consistent with UTI. Exclusion criteria were incomplete medical records and contaminated samples.

A control group of 150 age-matched children (± 12 months) hospitalized for non-UTI conditions was enrolled for comparison. Control conditions included: respiratory tract infections (n=52, 34.7%), gastrointestinal infections (n=38, 25.3%), skin and soft tissue infections (n=28, 18.7%), minor surgical conditions (n=18, 12.0%), and other non-infectious conditions (n=14, 9.3%). Controls were selected from the same hospital during the same study period and were frequency-matched by age group (0–12 months, 1–5 years, 6–10 years, and 11–15 years). Children with any history of UTI, known urological abnormalities, or immunodeficiency were excluded from the control group.

2-3. Data Collection

Data were collected using a researcher-developed checklist via medical record review and telephone interviews with parents (conducted within 2 weeks of discharge to minimize recall bias). The checklist encompassed demographic (age, sex, residence), socioeconomic (family income, maternal education, home ownership), clinical and behavioral (UTI history, family history of kidney stones, constipation, toilet training, perineal hygiene, circumcision, tight underwear, bathtub use), medical and anatomical (growth disorder, neurogenic bladder, VUR, labial adhesion), and laboratory/imaging variables (urinalysis, CRP, renal ultrasound). All behavioral and hygiene-related information was collected using standardized questions with predefined response categories to minimize interviewer variability.

Socioeconomic status (SES) was categorized as good, moderate, or poor using a composite index based on the following variables: residence (urban/rural), home ownership (owned/rented/other), monthly family income (categorized as <10 million IRR, 10–20 million IRR, >20 million IRR), and healthcare access (presence of health insurance and regular access to primary care). Each component was assigned a score (0–3), and the total composite score was calculated (range: 0–12). SES categories were defined as: good (score 9–12), moderate (score 5–8), and poor (score 0–4). The scoring system and categorization criteria were developed based on previously validated approaches used in Iranian population health studies.

2-4. Ethical Considerations

The study received approval from the Ethics Committee of Sabzevar University of Medical Sciences (IR.MEDSAB.REC.1401.69). Written informed consent was obtained from all parents.

2-5. Statistical Analysis

Data were analyzed using SPSS version 16. Continuous variables were compared using independent t-tests, and categorical variables using Chi-square or Fisher’s exact tests, with $p < 0.05$ considered significant. Crude odds ratios (ORs) and 95% confidence intervals (CIs) were calculated from 2×2 contingency tables for each risk factor individually. No multivariable logistic regression analysis was performed; therefore, the reported ORs represent univariate (unadjusted) associations. The sample size was calculated based on an expected prevalence of key risk factors (e.g., female sex) of approximately 65% in cases and 50% in controls, with 80% power and $\alpha = 0.05$, yielding a minimum of 142 participants per group.

2-6. Data Management and Missing Data

Complete data were available for all 150 cases and 150 controls for the primary study variables. No missing data were encountered for the variables included in the final analysis, as incomplete medical records were an exclusion criterion and telephone interviews achieved 100% completion for enrolled participants.

3- RESULTS

3-1. Demographic Characteristics

A total of 150 children with confirmed UTI were enrolled (mean age: 5.0 ± 1.8 years; range: 1 month to 15 years). The female-to-male ratio was 4:1 (120 girls, 30 boys). The mean age of controls was 5.1 ± 1.7 years, with no significant difference between groups ($p = 0.62$).

3-2. Significant Associated Factors

Detailed findings are presented in Tables 1–4 and summarized below.

3-3. Previous UTI and Family History

Prior UTI was reported in 38 patients (25.3%) vs. 10 controls (6.7%) ($p < 0.001$, OR: 4.75, 95% CI: 2.26–9.99). Family history of kidney stones was noted in 44 (29.3%) vs. 15 (10.0%) controls ($p = 0.001$, OR: 3.73, 95% CI: 1.96–7.08).

3-4. Non-Significant Factors

Maternal education (p = 0.06), labial adhesion (p = 1.00), and *Enterobius vermicularis* infection (p = 0.34) were not significantly associated.

Table-1. Demographic and socioeconomic factors associated with pediatric UTI.

Variable	Category	UTI Group (n=150) n (%)	Control Group (n=150) n (%)	P-value	Odds Ratio (95% CI)*
Sex	Female	120 (80.0)	90 (60.0)	<0.001	2.67 (1.56–4.55)
	Male	30 (20.0)	60 (40.0)		Reference
Residence	Urban	103 (68.5)	128 (85.3)	<0.001	0.37 (0.21–0.66)
	Rural	47 (31.5)	22 (14.7)		Reference
Socioeconomic Status	Good	12 (8.0)	45 (30.0)	<0.001	Reference
	Moderate	116 (77.3)	89 (59.3)		3.35 (1.67–6.71)
	Poor	22 (14.7)	16 (10.7)		6.42 (2.62–15.76)
Maternal Education	Below Diploma	55 (36.7)	48 (32.0)	0.06	1.23 (0.77–1.96)
	Diploma/Associate	59 (39.3)	82 (54.7)		0.77 (0.48–1.24)
	Bachelor’s & Higher	8 (5.3)	20 (13.3)		Reference
Growth Disorder	Present	28 (18.7)	10 (6.7)	<0.001	3.20 (1.49–6.86)
	Absent	122 (81.3)	140 (93.3)		Reference

*Crude (unadjusted) odds ratios from univariate analysis.

Table-2. Anatomical and clinical risk factors for pediatric UTI.

Risk Factor	Category	UTI Group (n=150) n (%)	Control Group (n=150) n (%)	P-value	Odds Ratio (95% CI)*
Vesicoureteral Reflux	Present	17 (11.3)	2 (1.3)	<0.001	9.57 (2.17–42.28)
	Absent	133 (88.7)	148 (98.7)		Reference
Constipation	Present	24 (16.0)	9 (6.0)	0.009	2.98 (1.34–6.62)
	Absent	126 (84.0)	141 (94.0)		Reference
Neurogenic Bladder	Present	4 (2.7)	0 (0.0)	<0.001	8.96 (0.48–167.5)**
	Absent	146 (97.3)	150 (100.0)		Reference
Catheterization	Present	8 (5.3)	1 (0.7)	0.007	8.22 (1.01–66.76)
	Absent	142 (94.7)	149 (99.3)		Reference

*Crude (unadjusted) odds ratios from univariate analysis.
**CI extremely wide due to zero events in control group; interpret with caution.

Table-3. Behavioral and hygiene-related risk factors for pediatric UTI.

Risk Factor	Category	UTI Group (n=150) n (%)	Control Group (n=150) n (%)	P-value	Odds Ratio (95% CI)*
Uncircumcised Males†	Present	24 (16.0)	7 (4.7)	0.029	4.44 (1.17–16.90)
	Circumcised	6 (4.0)	53 (35.3)		Reference
Lack of Toilet Training	Present	28 (18.7)	6 (4.0)	<0.001	5.42 (2.18–13.49)
	Absent	122 (81.3)	144 (96.0)		Reference
Tight Underwear Use	Present	24 (16.0)	7 (4.7)	<0.001	3.97 (1.65–9.57)
	Absent	126 (84.0)	143 (95.3)		Reference
Bathtub Use	Present	27 (18.0)	12 (8.0)	0.003	2.55 (1.23–5.27)
	Absent	123 (82.0)	138 (92.0)		Reference
Improper Wiping (Girls)	Present	34 (22.7)	9 (6.0)	<0.001	4.58 (2.12–9.90)
	Absent	86 (57.3)	81 (54.0)		Reference

*Crude (unadjusted) odds ratios from univariate analysis.
†Among boys: 24/30 (80%) uncircumcised in UTI group vs. 7/60 (11.7%) in controls.

Table-4. Clinical presentation and laboratory findings in UTI group.

Variable	Category/Value	UTI Group (n=150)
Clinical Symptoms	Fever Irritability Dysuria Frequency	89 (59.3%) 41 (27.3%) 39 (26.0%) 33 (22.0%)
Laboratory Findings	Pyuria Bacteriuria CRP Positive	111 (74.0%) 116 (77.3%) 73 (48.7%)
Mean Laboratory Values	Hemoglobin (g/dL) WBC (cells/mm³) ESR (mm/hr)	11.4 ± 2.2 11.242 ± 4.222 32 ± 12
Imaging Findings	Normal Renal Ultrasound Hydronephrosis Normal VCUG Abnormal VCUG	118 (78.7%) 14 (9.3%) 118 (78.7%) 23 (15.3%)

4- DISCUSSION

This comprehensive analysis delineates a complex interplay of demographic, anatomical, socioeconomic, and behavioral determinants associated with pediatric UTI in an Iranian population. Our findings extend beyond traditional models, highlighting modifiable factors with substantial implications for prevention and clinical management. The observed associations should be interpreted as correlational rather than causal, given the case-control design and the lack of multivariable adjustment.

4-1. Demographic and Anatomical Factors

The striking female predominance (4:1 ratio) aligns with global epidemiology, attributable to anatomical differences shorter urethra and proximity to the perianal region (11). VUR exhibited the strongest association (OR: 9.57), consistent with its established role as a major predisposing factor for pyelonephritis and renal scarring (12, 13). Neurogenic bladder, though less prevalent, significantly increased risk, likely due to incomplete bladder emptying and elevated intravesical pressure (14). These findings are consistent with a large meta-analysis by Renko et al.(4), which identified VUR as one of the strongest predictors of recurrent UTI in children, and with the systematic review by Tullus (12) demonstrating that VUR increases the risk of renal scarring by approximately 3-fold.

4-2. Behavioral and Hygiene-Related Factors

Strong associations were identified between modifiable behavioral factors and UTI risk. Improper perineal hygiene (wiping back-to-front in girls) (OR: 4.58) and lack of toilet training (OR: 5.42) were highly significant, reflecting fecal bacterial introduction to the urethra and urinary stasis (15, 16). Uncircumcised male status (OR: 4.44) is a well-documented risk factor, as circumcision reduces bacterial colonization in the preputial space (17). Tight underwear and bathtub use were also significant, as they create a warm, moist environment conducive to bacterial growth (18). These findings are consistent with studies from other Middle Eastern settings (18) and with the meta-analysis by Renko et al. (4), which reported that circumcision significantly reduces UTI risk in boys (pooled OR: 0.13, 95% CI: 0.08–0.20). These factors represent cost-effective targets for public health education.

4-3. Gastrointestinal and Nutritional Factors

Constipation (OR: 2.98) was significantly associated with UTI, consistent with the established link between bowel dysfunction and urinary infections. Constipation causes mechanical bladder compression, impairing emptying and increasing post-void residual volume, a bacterial reservoir (19). This finding aligns with the study by Loening-Baucke (16), which demonstrated that treatment of chronic constipation significantly reduced UTI recurrence in children. The significant association with growth disorder (OR: 3.20) suggests a possible bidirectional relationship: malnutrition compromises immune function, while chronic infection can impair growth through inflammation and malabsorption (20, 21). However, due to the cross-sectional nature of this analysis, temporality cannot be established, and further longitudinal studies are needed to explore this relationship.

4-4. Socioeconomic Factors

A powerful, graded association was observed between lower SES and increased UTI risk (OR for poor SES: 6.42). This likely operates through multiple pathways, including limited healthcare access, crowded living conditions, inadequate sanitation, lower health literacy, and financial barriers to preventive practices (4, 22). The magnitude of this association in our cohort is notably larger than that reported in some Western populations (4, 23), which may reflect more pronounced socioeconomic disparities in healthcare access and health literacy in the Iranian context. Renko et al.(4) reported a pooled OR of approximately 1.5–2.0 for low socioeconomic status and UTI risk in their meta-analysis, suggesting that the SES-UTI association may be stronger in lower- and middle-income settings. Rural residence (OR: 2.67) similarly reflects reduced service access and environmental factors such as water quality (8).

4-5. Maternal Education and Clinical Findings

Interestingly, maternal education was not significantly associated ($p = 0.06$), which is consistent with findings from some studies (23) but contrasts with others (5). This finding may be explained by the possibility that formal education does not fully capture health literacy, or that structural factors like poverty may overshadow its effect in this context. Additionally, the relatively small sample size may have limited our ability to detect a small effect. Clinical findings, including high fever prevalence (59.3%), underscore the diagnostic challenge in young children, supporting current guidelines recommending UTI consideration in any febrile child without an obvious source (24). Moderate CRP positivity (48.7%) suggests a predominance of lower tract infections in this cohort.

4-6. Comparison with Previous Studies and Implications

Our findings align with meta-analyses confirming the roles of sex and VUR (12, 13), while providing novel insights into the strength of socioeconomic gradients in this region (4, 22). A direct comparison with regional studies from the Middle East and South Asia reveals consistent patterns: a study from Saudi Arabia (18) similarly identified female sex, constipation, and poor hygiene as major risk factors, while a study from Pakistan reported comparable ORs for low SES and rural residence. However, our study adds to the literature by providing a more comprehensive assessment spanning clinical, behavioral, and socioeconomic domains in a single Iranian cohort. These results advocate for a holistic, integrated approach to pediatric UTI prevention. Clinicians should incorporate socioeconomic and behavioral screening into routine assessments. Public health initiatives must extend beyond clinical settings to include community-based education on proper hygiene, constipation management, and toilet training. Critically, interventions must address structural determinants such as poverty and healthcare access to achieve equitable outcomes.

4-7. Strengths and Limitations

Several strengths of this study should be acknowledged. First, the comprehensive assessment spanning demographic, anatomical, socioeconomic, and behavioral domains provides a holistic view of pediatric UTI risk factors. Second, the inclusion of a well-defined control group with age matching strengthens the validity of comparisons. Third, the use of a standardized data collection instrument and the high response rate for parental interviews enhance data completeness.

Several limitations should also be considered. First, the single-center design may limit generalizability to other regions of Iran and other countries with different demographic and healthcare contexts. Second, the reliance on medical records and parental recall may introduce information bias, particularly for behavioral and hygiene-related variables, which are subject to social desirability bias and recall inaccuracies. While interviews were conducted within 2 weeks of discharge to minimize recall bias, this remains a limitation inherent to retrospective data collection. Third, the absence of multivariable analysis means that the reported odds ratios are unadjusted for potential confounding factors, and the associations may be influenced by interactions between variables. Fourth, the case-control design precludes the establishment of causal relationships, and the findings should be interpreted as associations rather than causal effects. Fifth, the inability to conduct imaging studies in all controls limited comparative analyses for some variables. Sixth, the composite SES index may not capture all dimensions of poverty, such as food insecurity or housing quality. Seventh, the wide confidence intervals for some estimates (e.g., neurogenic bladder) reflect limited statistical precision.

4-8. Future Research Directions

Future multicenter, prospective cohort studies using standardized, objective measurements are warranted to confirm these associations and establish temporal relationships. Investigations incorporating the urinary microbiome and its interaction with socioeconomic and behavioral factors are promising. Intervention studies evaluating targeted educational programs, particularly in low-resource settings, are urgently needed to translate these findings into practice. Additionally, research examining the health literacy pathways linking formal education, SES, and health behaviors could inform more nuanced public health strategies.

5- CONCLUSION

Pediatric UTI is influenced by a complex interplay of demographic, anatomical, socioeconomic, and behavioral factors. This study demonstrates that beyond established risks (female sex, VUR), modifiable factors—hygiene practices, toilet training, constipation, and socioeconomic status play crucial roles. Prevention strategies should integrate community-based education, improved healthcare access, early identification of anatomical abnormalities, and a multidisciplinary approach addressing the full spectrum of risk factors for optimal outcomes.

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7- FUNDING

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8- CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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