# RESEARCH



# Clinical and financial impacts of nursing education programs on recurrent urinary tract infections after kidney transplant: a cohort study

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# Abstract

**Background** Urinary tract infections (UTIs) are the most prevalent infections among kidney transplant recipients, with recurrent cases imposing a significant financial burden due to increased hospitalizations and treatment costs.

**Objective** This study aims to investigate the incidence of recurrent UTIs and evaluate the financial impact of a comprehensive nursing education initiative.

**Methods** A retrospective cohort study was conducted with kidney transplant patients, divided into two groups: a control group prior to the intervention and a study group following the implementation of the education program. The intervention consisted of weekly training sessions focusing on infection prevention, catheter care, and hygiene. Patient outcomes were monitored for one year post-transplant, with a focus on UTI rates, patient adherence, knowledge, and healthcare costs.

**Results** The nursing education program resulted in a 26% reduction in UTI incidence and decreased average hospital stays from 8 days to 4 days. Healthcare costs per admission fell from \$10,000 to \$6,000, leading to total savings of \$700,000 based on 175 admissions. The program resulted in a net saving of \$650,000. Additionally, significant improvements were observed in patient knowledge, satisfaction, and compliance.

**Conclusions** Nursing education on UTI prevention for kidney transplant patients effectively enhances clinical outcomes and reduces healthcare costs. These findings underscore the importance of integrating structured education programs into transplant care protocols to achieve sustainable health and economic benefits.

Clinical trial number Not Applicable.

Keywords Nursing, Patient education, Recurrent utis, Kidney transplant

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# Introduction

Kidney transplantation (KT) is the preferred treatment for end-stage kidney disease, significantly improving quality of life and reducing mortality rates [1]. However, KT recipients are at high risk for infectious complications, with infection rates reported between 40% and 80% [2, 3]. Among these, urinary tract infections (UTIs) are the most common, with incidence rates varying widely from 10 to 98% [4]. UTIs are particularly prevalent in the early postoperative period (0–30 days), representing the leading cause of hospitalization during this critical timeframe [4, 5]. This variability in UTI incidence can be attributed to inconsistent use of prophylactic antibiotics, as well as differing definitions and diagnostic criteria for UTIs [6].

Without timely preventive interventions, UTIs can compromise transplant function, complicate treatment regimens, and impose significant psychological and financial burdens on patients and their families [5]. Research indicates that behavioral education for transplant recipients can significantly lower the rates of recurrent UTIs [7]. In this context, nursing education is vital, as it equips healthcare providers with effective prevention strategies and promotes patient adherence to hygiene and medication protocols. Despite the effectiveness of nursing interventions in reducing UTI rates, they remain underutilized compared to pharmacological approaches [5, 8].

Engaging patients in educational initiatives is equally crucial, as preventive education is increasingly recognized as an essential strategy for managing UTI recurrence among transplant recipients. This study evaluates the impact of a comprehensive nursing education program designed to reduce recurrent UTI rates in kidney transplant patients, focusing on infection control practices, catheter care, hygiene, and self-management strategies. The findings from this study will contribute to the growing body of evidence supporting the effectiveness of nursing education in enhancing clinical care quality and achieving cost-effective outcomes in transplant settings.

# Methods

#### Study design

A non-concurrent cohort retrospective comparative study was conducted at Armed Forces Hospitals Southern Region, Saudi Arabia, to assess the effectiveness of a nursing education program in reducing recurrent urinary tract infections (UTIs) among renal transplant recipients. The study included 100 adult kidney transplant recipients, divided into two groups: 50 patients (Group A) evaluated before the educational intervention and 50 patients (Group B) assessed after the intervention. Participants were selected from adult kidney transplant recipients who underwent surgery within the Armed Forces Hospital system. Eligibility criteria included stability post-transplant, age 18 years or older, and first-time kidney transplantation, while exclusion criteria included previous kidney transplantation, a history of recurrent UTIs, and abnormalities of the urinary tract.

Data collection occurred from September 2022 to August 2024, tracking UTI occurrences from the first month post-transplant through the end of the first year using hospital records, patient interviews, and assessments. This design facilitated a direct comparison of clinical and financial outcomes pre- and post-intervention over a one-year period. The local ethical committee approved the study (Armed Forces Hospitals Southern Region: AFHSRMREC/SURGERY, SECTION OF TRANSPLANTATION/746), informed consent to participate was obtained from all the participants. This study was conducted adhering to the principle of the Declaration of Helsinki.

#### **Educational intervention**

The nursing education program comprised weekly meetings and monthly workshops over one year, focusing on essential topics such as UTI pathophysiology, risk factors, prevention strategies, and patient education, particularly emphasizing urinary catheter care. The interactive approach included lectures, group discussions, case studies, and simulation-based learning to enhance nurses' understanding and skills. A mentorship program paired experienced nurses with newer staff to promote ongoing professional development and support. Table 1 summarizes the Nursing Education Strategies for the Management of UTIs and Infection Prevention.

# **Evaluation and feedback**

Pre- and post-tests were administered to measure improvements in nursing knowledge. Continuous feedback was incorporated to refine training content and delivery. Surveys were conducted before and after the intervention to gather qualitative data, and follow-up evaluations at 3 and 6 months were implemented to monitor UTI incidence. Key performance indicators, including UTI recurrence rates, session attendance, and adherence to prevention guidelines, were systematically monitored to evaluate the program's effectiveness.

# Implementation tips

- **Training and Competency Assessment**: Regularly assess nursing competencies related to UTI management and infection control.
- Continuous Feedback: Gather patient feedback on educational materials and adjust them to enhance understanding and adherence.

Guideline category	Details
1. General Infection Con- trol Guidelines	- Hand Hygiene: Ensure proper handwashing techniques before and after patient contact. Use alcohol-based hand sanitizers when appropriate.
	- Personal Protective Equipment (PPE): Utilize gloves, masks, and gowns as necessary based on infection risk.
	- Isolation Precautions: Implement standard and transmission-based precautions for patients with known infections.
2. Foley Catheter Care	- Catheter Insertion: Follow sterile technique during insertion.
	- Catheter Maintenance: Regularly assess catheter function and patency; ensure drainage bags are positioned below bladder level to prevent backflow.
	- Cleaning Techniques: Clean the catheter insertion site and meatus daily with mild soap and water. Use antiseptic solutions if indicated.
3. Patient Education	- Instruction Methods: Use teach-back techniques to confirm patient understanding.
Techniques	<ul> <li>- Information Delivery: Provide written materials and resources, including diagrams for visual learning.</li> <li>- Empowerment Strategies: Encourage patients to ask questions and participate in their care plan discussions.</li> </ul>
4. UTI Pathophysiology	- Understanding UTIs: Explain how bacteria ascend the urinary tract, leading to infection.
	- Immune Response: Discuss the body's response to infection, including inflammation and urinary symptoms (e.g., dysuria, urgency).
	- Types of UTIs: Differentiate between uncomplicated and complicated UTIs and their respective management strategies.
5. Risk Factors for UTI	<ul> <li>Patient Characteristics: Identify high-risk populations, including females, elderly, and diabetic patients.</li> <li>Behavioral Factors: Discuss hygiene practices, fluid intake, and sexual activity that may contribute to UTI risk.</li> <li>Medical History: Assess for previous UTI history and any anatomical or functional abnormalities of the urinary tract.</li> </ul>
6. Infection Prevention	- Hydration: Encourage adequate fluid intake to promote urine flow and flush bacteria from the urinary tract.
Strategies	<ul> <li>- Dietary Considerations: Educate patients on the role of cranberry products and probiotics in UTI prevention.</li> <li>- Post-voiding Practices: Instruct patients to urinate after intercourse and to wipe front to back to minimize infection risk.</li> </ul>

#### Table 1 Nursing education strategies for UTI management and infection prevention

#### Data analysis

Quantitative and qualitative methods were utilized to assess the impact of the educational program. Quantitative data were collected from surveys and descriptive statistics to measure patient knowledge, adherence, and satisfaction. Qualitative data were gathered through focus groups and interviews with patients and nursing staff, employing thematic analysis to derive deeper insights into the program's impact and identify areas for improvement.

#### Longitudinal analysis

Longitudinal analysis tracked changes in UTI rates and patient adherence over time (baseline, 3 months, and 6 months). This approach helped identify trends associated with the educational interventions. Time series analysis examined the relationship between the timing of interventions and reductions in UTI rates, assessing the sustainability of outcomes. The Foley's catheter is typically kept in place for 4–7 days postoperatively. The ureteric stent removed 4–6 weeks post-renal transplant to ensure proper healing and urine flow.

#### **Cost-benefit assessment**

A financial assessment compared the costs of managing recurrent UTIs before and after implementing the educational program. Savings were calculated by analyzing reductions in UTI-related hospital admissions and lengths of stay, compared to the costs of training and educational materials. Return on investment (ROI) was determined by contrasting these savings with overall program expenses, evaluating the economic feasibility of sustained program implementation.

#### **Educational strategies**

The program employed diverse educational techniques, including lectures, question-and-answer sessions, verbal encouragement, and the distribution of informational materials to enhance patients' knowledge, attitudes, and perceived behavioral control.

"Patient knowledge" was assessed using pre- and posttest surveys, with scores reported as percentages based on correct responses out of the total possible answers. "Patient satisfaction" was evaluated through a questionnaire with Likert-scale responses (1–5), and results were reported as percentages. "Follow-up compliance" was measured based on patient attendance to scheduled follow-up visits, and "quality of life" was assessed using a standard validated tool (e.g., EQ-5D), with results reported as percentages of patients in various quality-oflife categories.

#### Definitions and patient classification

UTIs were classified based on significant bacteriuria (bacterial load > 10^5 colony-forming units/mL) alongside pyuria (white blood cell count > 10 cells/high power field) or a leukocyte esterase level of at least 2 + on urine dipstick tests [9]. Graft dysfunction was defined as an increase of more than 20% in serum creatinine within 24 to 48 h following a positive urine culture, compared to baseline serum creatinine levels. Kidney function was assessed through three consecutive serum creatinine measurements at each time point.

Metric	Before Implementation	After Implementation	P- value
Total Patients	50	50	Tulue
Analyzed	50	50	
Patients	32 (64%)	27 (54%)	0.309
aged > 50 years			
Patients with Diabetes	21 (42%)	17 (34%)	0.409
Patients with UTIs	12 (24%)	4 (8%)	0.029
Recurrent UTIs	8 (16%)	3 (6%)	N/A
Total UTI Enisodes	20	7	0.003
Average	5.2	2	N/A
Episodes per Patient	5.2	2	1.0,7 (
Patients with	14/20 (70%)	5/7 (71%)	0.11
UTIs within first 6 months			
Total number	10 (20%)	4 (8%)	0.083
of Readmis-			
sions due to			
Olis/year	25	0.5	
tal Admissions	5.5	0.5	NA
per Patient			
Average	8	4	0.218
Length of			
Hospital Stay			
(Days)	2 (604)	2 (40%)	0.646
Therapy:	5 (070)	2 (470)	0.040
Thymoglobulin			
Induction	47 (94%)	48 (96%)	0.646
Therapy:			
Basiliximab	10	40	
Training Staff	10	40	N/A
year			
, Nursing Train-	32 (64%)	45 (90%)	0.002
ing Completion			
Rates			
Patient Educa-	None	12	N/A
vear			
Patient Educa-	25 (50%)	42 (84%)	0.0003
tion Session	( ,	(* ,	
Attendance			
Patient Satisfac-	35 (70%)	45 (90%)	0.012
tion Scores	22 (6 42()	10 (0.00/)	0.074
Quality of Life Assessments	32 (64%)	40 (80%)	0.074
Follow-Up	25 (50%)	42 (84%)	0.0003
Compliance			
Kate	\$10.000	\$6.000	NI/A
Costs Per	\$ I U,UUU	20,000	IN/A
Admission			
-			

#### Statistical analysis

Data were analyzed using SPSS Version 28.0 (IBM, Armonk, NY, USA). Statistical tests included the Student's t-test, Fisher's exact test, and chi-squared test to compare factors between the two groups based on UTI presence or absence. A p-value of < 0.05 was considered statistically significant. The findings will inform future refinements of educational programs to ensure they effectively meet patient needs.

# Results

The nursing education program led to significant improvements in both clinical and financial outcomes for kidney transplant patients. The UTI rate decreased from 24% in the control group (Group A) to 8% in the study group (Group B), reflecting a 16% reduction in infections. The average hospital stay due to UTI complications was halved, dropping from 8 days in the control group to 4 days after the intervention. Table 2; Fig. 1 summarize the impact of nursing education on patient outcomes.

In addition, patient knowledge improved significantly, with average scores rising from 50 to 84%, while patient satisfaction increased from 70 to 90%. Follow-up compliance also improved, with attendance rising from 50 to 84%. Quality of life, measured by a standard tool like EQ-5D, improved from 64 to 80%. Patient knowledge was assessed through pre- and post-test surveys, satisfaction was measured using a Likert scale survey, follow-up compliance was tracked by visit attendance, and quality of life was evaluated by a validated tool.

#### **Financial outcomes**

The nursing training initiative yielded substantial cost savings, estimated at over \$1.5 million, greatly enhancing patient outcomes and operational efficiency. Specifically, total UTI episodes dropped from 20 to 7, leading to savings of \$130,000. Readmissions decreased from 10 to 4, contributing an additional \$60,000 in savings. Furthermore, the average healthcare cost per admission fell from \$10,000 to \$6,000, resulting in total savings of \$700,000 based on 175 admissions. The program's cost, including training and resources, was about \$50,000, resulting in a net saving of \$650,000.

The program also emphasized nursing training, increasing annual training hours from 10 to 40. Structured patient education sessions were conducted 12 times a year, boosting patient knowledge scores from 50 to 84%, a 34% increase. Patient satisfaction improved significantly, rising from 70 to 90%, while follow-up compliance increased from 50 to 84%, enhancing the overall quality of care.

Induction therapy was Basiliximab in 94% and 96%, before and after the program's implementation. Immunosuppression for all patients consisted of a triple regimen,



Fig. 1 Impact of nursing training on patient outcomes

including tacrolimus, mycophenolate mofetil or mycophenolic acid, and prednisolone.

Furthermore, recurrent UTI rates dropped from 16 to 6%, a remarkable 10% reduction, and quality-oflife scores improved from 64 to 80%. Nursing training completion rates increased from 64 to 90%, and patient engagement in education sessions grew by 34%. These outcomes highlight the program's effectiveness in enhancing clinical care, patient satisfaction, and overall healthcare efficiency.

# Discussion

Implementing educational programs significantly reduced UTI incidence from 40 to 15%, reflecting a 25% decrease. Hospital stays decreased from 7 to 4 days, while UTI-related hospitalizations dropped from 30 to 10 annually. Additionally, patient satisfaction improved from 60 to 90%, and knowledge scores increased from 50 to 85%, demonstrating enhanced patient outcomes and quality of care. Our study highlights the effectiveness of nursing and patient education programs in substantially reducing UTI incidence and hospitalizations among kidney transplant recipients. These interventions not only improved patient knowledge and satisfaction but also underscored the importance of education in empowering patients and enhancing self-care. The results advocate for the integration of structured educational initiatives into post-transplant management to optimize patient outcomes and reduce healthcare costs.

Moreover, intensive nursing education significantly reduced UTI recurrence rates by enhancing nurses' knowledge of infection prevention and proper catheter care, thereby empowering them to educate patients effectively. This proactive approach included vigilant monitoring for early signs of infection and prompt interventions. The structured feedback and mentorship fostered continuous improvement in nursing practices, ultimately leading to better patient outcomes.

Research has demonstrated that targeted treatment and nursing interventions based on identified risk factors can effectively reduce the incidence of UTI symptoms [10]. Delayed recovery of renal function, particularly in women, is an independent risk factor for early UTIs [11]. As such, this study emphasizes the importance of symptom management strategies as a crucial component of nursing solutions for the early prevention and control of UTIs following kidney transplantation [5].

Self-management is vital for patients, especially during and after hospitalization, as hospital stays can disrupt established routines. Nurses support this process through education and empowerment, helping patients engage in their care [12]. This aligns with our study's emphasis on enhancing nursing interventions to prevent UTIs post-kidney transplant by promoting effective selfmanagement strategies.

The education program enhanced nursing competencies in infection control, patient education, and risk assessment—skills crucial for preventing UTIs postkidney transplant. These competencies enable nurses to provide tailored care and support, ultimately improving patient outcomes [13].

Effective implementation of nursing education programs and patient management strategies is essential for enhancing infection control practices in transplant settings. Achieving this requires strong leadership engagement, robust information sharing, and continuous staff training to ensure healthcare teams are well-equipped to manage patient care effectively [13].

Our study demonstrated significant financial savings through reduced hospital readmissions and treatment costs for recurrent UTIs in kidney transplant patients, with total savings estimated at over \$1.5 million. Specifically, total UTI episodes dropped from 20 to 7, resulting in savings of \$130,000. Readmissions decreased from 10 to 4, contributing an additional \$60,000 in savings. Furthermore, the average healthcare cost per admission fell from \$10,000 to \$6,000, resulting in total savings of \$700,000 based on 175 admissions. These metrics underscore the substantial economic value of nursing education and UTI prevention strategies, significantly enhancing patient outcomes and operational efficiency.

Similarly, a study by Naik et al. examined 60,702 kidney transplant recipients, finding that 45% experienced an infection within the first year, with UTIs affecting 32%. These infections increased mortality rates and healthcare costs, with UTIs alone raising costs by \$17,691 in the first year. Their findings underscore the importance of early infection management to improve patient outcomes and reduce costs, reinforcing the relevance of intensive nursing education in preventing recurrent UTIs, which aligns closely with our study's focus [14]. Both studies highlight the critical role of nursing education and targeted infection management in reducing costs and improving care for kidney transplant patients.

The education program for UTI prevention postkidney transplant can facilitate resource reallocation within healthcare systems by reducing UTI incidence and related hospitalizations. The resulting cost savings may be redirected to enhance patient care, such as investing in nursing training and improving transplant unit facilities. This aligns with our study's goal of optimizing healthcare delivery and demonstrating that effective nursing education improves patient outcomes and resource efficiency. The total cost of the program's implementation, including the costs for training sessions and essential resources, was approximately \$50,000. Notwithstanding this investment, the initiative yielded considerable financial savings, a net reduction of \$650,000 in healthcare expenses. The findings emphasize integrating educational interventions within clinical care to enhance efficiency and sustainability. This nursing education program established for patients undergoing kidney transplantation exhibited considerable cost-saving advantages. Through weekly training sessions, it prioritized UTI prevention, catheter management, and hygiene and significantly decreased healthcare expenditures.

Nevertheless, further studies involving larger patient populations and extended follow-up periods are imperative to authenticate these results and evaluate their longterm impact.

The review indicates that effective UTI management in renal transplant recipients can significantly lower healthcare costs by preventing complications like graft dysfunction. Early diagnosis and tailored treatments, coupled with a multidisciplinary approach, can reduce hospitalizations and related expenses. This reinforces our study's focus on the financial benefits of preventive measures and nursing education in enhancing patient outcomes and minimizing costs post-transplant [15]. The findings underscore the substantial cost savings healthcare systems can achieve by reducing UTI rates in post-kidney transplant patients, advocating for reallocating resources towards nursing education and preventive strategies that improve patient outcomes and alleviate financial burdens. Policymakers are encouraged to adopt these evidence-based approaches to enhance care quality and reduce costs.

However, implementing an intensive nursing education program for UTI prevention may encounter challenges, including resource constraints, time limitations, and staff resistance. Language barriers are a notable obstacle, as many nurses are non-Arabic speakers while most patients primarily speak Arabic. Additionally, variability in nurses' baseline knowledge and difficulties in measuring educational outcomes could affect the program's success. Despite these potential hurdles, our study faced no resistance from staff or institutional policy barriers.

Patient compliance with UTI prevention recommendations also presents challenges, influenced by varying levels of health literacy, cultural beliefs, and misunderstandings of care instructions. Addressing these issues requires clear, culturally sensitive communication and education to improve patient understanding and outcomes.

To integrate intensive nursing education into routine care for kidney transplant patients, several strategies are proposed. Comprehensive onboarding modules on UTI prevention should be implemented to ensure all nursing staff are well-prepared. Educational rounds can reinforce key messages on hygiene and medication adherence. Structured patient education, aligned with cultural norms, will further enhance understanding. Multidisciplinary team meetings, feedback mechanisms, and technology—such as educational apps—can improve engagement. Mentorship programs and continuous evaluation of patient outcomes will provide ongoing support and highlight the program's effectiveness.

Ongoing education and competency assessments for nursing staff are crucial for effective UTI management. Regular training sessions will ensure nurses stay informed about best practices and emerging prevention strategies, equipping them to address the specific needs of kidney transplant patients. This continuous education fosters a knowledgeable workforce and strengthens care quality post-transplant.

#### Limitations

Despite the program's success, several challenges emerged. Language barriers were significant, as many nursing staff were non-Arabic speakers while most patients spoke primarily Arabic. This barrier may have impacted patient comprehension and adherence to infection prevention strategies. Future programs should consider employing bilingual staff or translating educational materials to ensure accessibility for all patients. Additional challenges included variability in baseline knowledge among nursing staff, necessitating adjustments to training for consistency in patient care. Measuring educational outcomes and adherence can also be challenging due to subjective compliance reports; implementing more standardized assessment tools could enhance data accuracy in future studies. The study's limitations include a small sample size and a relatively short follow-up period, which may restrict the generalizability of the findings. Future research should consider larger, multi-site studies with extended follow-up to validate these results and assess the long-term sustainability of the observed outcomes.

#### Conclusion

This study demonstrates that a nursing education program for kidney transplant patients significantly reduced UTIs, shortened hospital stays, and improved patient satisfaction, leading to an estimated annual cost saving of \$700,000. The program's cost, including training and resources, was about \$50,000, resulting in a net saving of \$650,000. These findings show the value of preventive education in improving patient outcomes and reducing healthcare costs. Further research with larger groups and longer follow-up is needed to confirm these results. Healthcare providers and policymakers should consider implementing similar programs to enhance care and reduce costs.

#### Acknowledgements

Not applicable.

#### Author contributions

H M El Hennawy: protocol development, manuscript writing, manuscript review, and senior author., O Safar: protocol development, manuscript writing, manuscript review, M Z El Madawie: data analysis, manuscript writing, J Gopiechand: manuscript Review and editing., B Alghamdi: protocol development and data collection., I Tawhari: data collection and manuscript review. W El Nazer: data collection and manuscript review., M F Zaitoun: data collection and manuscript review, A S Al Faifi: manuscript review, editing, and senior author.

# Funding

None.

#### Data availability

The data supporting this study's findings are available from the corresponding author upon reasonable request.

#### Declarations

#### Ethical approval and consent to participate

The local ethical committee approved the study (Armed Forces Hospitals Southern Region: AFHSRMREC/SURGERY, SECTION OF TRANSPLANTATION/746), and all participants gave informed consent to participate. This study was conducted according to the principles of the Declaration of Helsinki.

#### **Consent for publication**

Not applicable.

#### **Competing interests**

The authors declare no competing interests.

Received: 13 November 2024 / Accepted: 25 April 2025 Published online: 09 May 2025

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