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Dr. Meera S Panicker[1*], Dr. Suraj BR[2], Dr. Satvir Singh[3], Rajender Kumar[4], Dr. M. Sivaraman[5], Ms Monika Kashyap[6], Mousumi Deori[7]

[1*]*Assistant Professor, Department of Kaumarbhritya (Pedeatrics), Bharati Vidyapeeth Deemed to be University College of Ayurveda Pune ORCID ID: 0009-0000-4716-1010 meera.panicker@bharatividyapeeth.edu*

[2]*Consultant Nephrologist, Department of Nephrology, Rajiv Gandhi University of Health Sciences MBBS,MD(gen med), Dr NB Nephrology ORCID ID: 0000-0002-3010-7066, soorajbannur9@gmail.com*

[3]*Assistant Professor, Department of Pediatrics, Mahatma Gandhi Medical College & Hospital, Jaipur MD Pediatrics ORCID ID: 0009-0008-6703-2425, satvirgoldy@gmail.com*

[4]*Dean, Department of Health Allied Sciences, Gku University, Talwandi Sabo, ORCID ID: 0009-0005-2243-0751 Rajenderkumar171655@gku.ac.in*

[5]*Medical Superintendent, Vinayaka Missions Medical College, Salem, Tamil Nadu, India. 0000-0002-0175-0263 ms@vmmckkl.edu.in*

[6]*Associate Professor, Department of Nursing, The Assam Royal Global University https://orcid.org/0009-0007-7658-9543 kalitamonika24@gmail.com*

[7]*Associate Professor, Priyamvada Birla Institute of Nursing, Kolkata, West Bengal. ORCID ID: 0009-0005-5799-4928, mousumi8.8deori@gmail.com*

Improving Pediatric Renal Health: Clinical Public Health Strategies and Nephrology-Focused Nursing Interventions for Long-Term Outcomes

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ABSTRACT

Pediatric kidney diseases present a significant clinical and societal health burden in terms of frequent morbidity, impaired function and threat of enduring morbidity. This study compared integrated clinical public health approaches and nephrology-oriented nursing care to the outcome of pediatric renal disease. A descriptive observational study involved children aged 0-18 years old with chronic kidney disease (CKD), acute kidney injury (AKI), and nephrotic syndrome. Outcome patterns and predictors of renal improvement were studied using descriptive statistics, comparative statistics, and regression modelling. This cohort involved 120 children (mean age of 9.4 years, 32% AKI, 48% CKD, 20% nephrotic syndrome). Mean estimated glomerular filtration rate (eGFR) rose to 45% at 6 months and 52% at 12 months; baseline eGFR 38mL/min/m^2. The adherence rate also improved to 84% versus 62% and the quality of life improved to 71/100 compared to 48/100. The episodes of AKI reduced from 32% to 14%, infections from 41% to 19%, hypertension from 36% to 22%, nephrotic-syndrome-relapse from 28% to 12%, and the hospitalisation rate from 1.8 to 0.9 per patient-year. The regression analysis revealed that the following factors were significant predictors of renal improvement: nursing intensity ($\beta = 0.41$, $p < 0.01$), early screening participation ($\beta = 0.36$, $p < 0.01$), tele-support frequency ($\beta = 0.33$, $p < 0.05$), and home-care engagement ($\beta = 0.29$, $p < 0.05$). The long-term renal health of pediatric patients can be enhanced by a multidisciplinary approach and effective nursing leadership, screening in the early stages, and structured home-based instruction.

Keywords: Pediatric nephrology; renal nursing; public health; chronic kidney disease; acute kidney injury

1. INTRODUCTION

Congenital renal anomalies, nephrotic syndrome, chronic kidney disease (CKD), acute kidney injury (AKI), and chronic renal failure are all significant clinical and public health problems in every country of the world. Children with these disorders often have interrupted growth patterns, frequent complications, decreased functional capacity, and increased risks during their lifetime, which are associated with morbidity of the kidneys. The children population is specifically at risk of rapid physiological degradation, which requires early diagnosis, systematic observation, and organised nephrology care in terms of long-term stability. The growing rates of renal problems in infants and children globally are an indication of long-term survival of preterm babies, the broadening of diagnostic tools, genetic predisposition trends, infectious etiologies, and inadequate health-system provision that limits the provision of comprehensive care [1]. Multidisciplinary coordination is currently of central

For correspondence: Dr. Meera S Panicker, *Assistant Professor, Department of Kaumarbhritya (Pedeatrics), College of Ayurveda Bharati Vidyapeeth Deemed to be University, Pune meera.panicker@bharatividyapeeth.edu*
Full list of authors information is available at the end of the article.

significance to maintaining renal wellbeing throughout childhood in nephrology practice. Kidney disease clinics are important settings where physicians and nephrology nurses must collaborate with dietitians, psychologists, and other health care experts to provide patients with continuous care through unified care pathways [2]. In such teams, nephrology nursing staff play a critical role, as they carry out such functions as early detection of renal failure, adherence treatment, avoidance of nephrotic-syndrome complications, renal replacement therapy (RRT) preparation, and routine family counselling. It has been shown that enhanced nursing capability and higher levels of procedural sophistication offer safer clinical settings and can lead to better outcomes in pediatric renal patients [3]. RRT among children is one of the most technically challenging fields of pediatric nephrology. Hemodialysis, peritoneal dialysis, and continuous therapies in the intensive care units demand specific fluid management, paying close attention to complication occurrence, and handling specific devices. The innovations in the field of pediatric ICU draw attention to the necessity of nursing teams that are highly trained to introduce therapies in complex and resource-consumer clinical units [4,5]. Specificity in neonatal kidney practice also requires the ability to make a decision in a brief period of time, a finely-tuned procedure, and contextual clinical judgment. The fast digital revolution in nephrology has brought up new tools that can assist in the clinical decision-making process and in educating nephrology patients. The inclusion of artificial intelligence (AI), multi-agent learning systems and digital POCUS platforms into training programs enhances diagnostic accuracy, procedural confidence and standardised skill development in nephrology trainees and nurses [6]. According to the national and international nephrology societies, there remain priority areas that need to focus on the development of guidelines, which are improved patient-centred care models, the integration of technology, and wider interdisciplinary inclusion in renal health programs [7]. The world practice demonstrates that flexible nephrology programs are important, especially in low-resource settings where an increase in the number of services, oversight of the workforce, and better training may be the keys to improving pediatric renal services [8]. DHTs have now touched many areas of practice in nephrology. The AI-based applications can help clinicians with monitoring, predictive modelling, and early identification of clinical deterioration, making their strategies in the area of pediatric renal care more responsive [9]. Simultaneously, AI generative models enable innovation in kidney care, offering new possibilities of automated interpretation of images, clinical decision-making assistance, and management algorithm optimisation on complicated kidney cases in children [10]. Taken collectively, a series of innovations points to the promising change of integrated nephrology systems, advanced nursing practice, and digitally-enhanced solutions to pediatric renal health promotion.

The considerable advancements are still being made in the field of pediatric nephrology, there are still considerable gaps in the research and practice fields. The recent global health disruptions have seen a swift reorganization of nephrology training programs into a more virtual form of education, altered clinical rotations, and digitally-aided skill development. In spite of these inventions, little attention has been given to integrated models that would bridge clinical nephrology practice with community-based renal promotion and outreach strategies in the community to the health population [11]. An example of nursing leadership in acute dialysis units demonstrates valuable paradigms to cooperate and develop safety policies; nevertheless, the implementation of paradigms in prevention of pediatric renal diseases is not adequately reported [12]. Inequality in population-specificities is still evident in the outcomes of renal disease with reported inequalities within particular ethnic and geographic groups. There is a gap in comprehensive, equity-based nephrology approaches as there is limited literature synthesizing the effects of public health interventions on the renal health trend among various communities in different locations in an integrated manner [13]. Current debates in the field also raise ethical issues associated with pragmatic trials in clinical research, which restricts large-scale assessment of pragmatic practices in pediatric nephrology [14]. The research on the workforce describes the changing needs of nephrologists in the early stage of their careers, but there is limited consensus on the use of multidisciplinary nursing-based renal models to support long-term pediatric outcomes [15].

Combined clinical and community-based health models have a high potential of stabilizing renal functions, assisting in adherence of therapy, and facilitating long-term wellness in renal disease. The transfer sites of the pediatric renal care setting (such as switching between dialysis types or transitions between the children and adolescent services) require organized support systems that help to maintain the continuity and stability [16]. The multidisciplinary collaboration also plays a positive role in the results of the pediatric kidney transplant patients, which leads to a better risk assessment, monitoring, family education, and psychosocial reinforcement [17]. Early screening, prevention of infection, lifestyle change interventions, and community awareness of pediatric populations play significant roles of benefit to primary prevention, and delaying renal impairment progression, which are crucial to the prevention of such disease [18]. Nursing interventions conducted at home are also of added value especially in children with chronic renal disorders who need long term follow-ups. It has been shown that the treatment of adherence, symptom management, and engagement with the family have been improving with the use of the structured home-care programs, which confirms the presence of a solid rationale supporting the use of integrated clinical and community-based models in pediatric nephrology [19]. The current paper is thus a suggestion of an integrated assessment of coordinated nephrology nursing interventions and community-level health initiatives aimed at enhancing renal care outcomes in children across clinical and community practices.

Research Objectives

1. To evaluate the effectiveness of integrated clinical public health strategies and nephrology-focused nursing interventions in improving pediatric renal outcomes.
2. To identify key clinical and community-level factors linked with enhanced long-term kidney function, treatment adherence, and quality of life among pediatric renal patients.

2. METHODOLOGY

2.1 Study Design

The assessment of integrated clinical and community health approaches to pediatric renal care was generated with the assistance of a descriptive observational framework. The design could provide a systematic evaluation of nursing interventions, community-linked practice and clinical patterns that impacted renal outcomes. This construct made it possible to record systematically patient characteristics, exposure to interventions and outcome indicators in real-life pediatric nephrology.

2.2 Study Setting

The research was conducted in the units of nephrology of the pediatric units, dialysis units, and outreach clinics in the community that were linked to the tertiary care institutions. These settings were available to children with renal monitoring, renal replacement therapies, nephroprotective interventions, and structured nursing support programs.

2.3 Study Population and Sampling

The age of the participants was between 0-18 years with a known diagnosis of CKD, AKI, or nephrotic syndrome. The criteria of inclusion were focused on recorded renal assessments, follow-up data, and experience of organised nursing or community health programs. The exclusion criteria were used to eliminate the participants whose clinical data were incomplete or were not related to acute conditions. The purposive sampling method allowed the case to be selected selectively to represent different stages of kidney disease and the intensity of intervention.

2.4 Data Collection Tools

The extraction of data was based on clinical files with laboratory values, blood pressure, renal imaging, and scale on treatment compliance. The details that were given in the nursing logs were associated with education sessions, complication-monitoring activities, tele-support interactions, and home-care instructions. The variables of public health were screening attendance, vaccine revision, nutrition counselling and environmental risk assessment. The clinical information was supplemented with the help of quality-of-life and adherence scales.

2.5 Variables

The independent variables were nursing interventions, the intensity of patient education, support of home-care, telehealth, and involvement in community health. The dependent variables were indicators of renal functions, the frequency of complications, the number of hospitalisations, adherence scores, and quality-of-life indicators. Age, socioeconomic status, comorbidities and the baseline renal stage were confounding factors.

2.6 Data Analysis

Descriptive statistics were used in quantitative analysis as a measure of demographic and clinical distributions. Comparative tests were used to evaluate changes in renal indicators, levels of adherence, and the rate of complications after exposure to planned interventions. The regression modelling helped to determine the predictors with a strong effect on long-term renal stability. Thematically categorised qualitative data were obtained by sorting through nursing logs.

3. RESULTS

3.1 Participant Characteristics

One hundred and twenty pediatric renal patients provided the information to be analysed. The age was between 1 and 17 years with an average age of 9.4 +- 4.2 years. The number of males was 55, and the number of females was 45. It involved AKI (32%), CKD (48%), and nephrotic syndrome (20%). There was a wide range in baseline eGFR, which had a median of 38mL/min/1.73m^2 (range 12-89mL/min/1.73m^2), as indicated in Table 1. The socioeconomic status was divided into 40% low-income, 38% middle-income and 22% high-income.

Table 1. Participant Characteristics by Category (n = 120)

Category	Variable	Value
Demographic Profile	Mean age (years)	9.4 ± 4.2
	Sex (male)	66 (55%)
	Sex (female)	54 (45%)
Clinical Profile	AKI	38 (32%)
	CKD	58 (48%)
	Nephrotic syndrome	24 (20%)
	Baseline eGFR (mL/min/1.73 m²)	Median 38 (12–89)
Socioeconomic Profile	Low income	48 (40%)
	Middle income	46 (38%)
	High income	26 (22%)

3.2 Distribution of Nursing and Public Health Interventions

Various intervention plans were used to support the patients. The level of involvement in the family instruction was high, with 92% receiving education (Table 2). The compliance was 78% and the compliance was used to maintain treatment. The support for home-care was 64, with infection-prevention counselling being at 71% and nutrition counselling being at 57%. Tele-support was 61% and further advice was available throughout follow-up.

Table 2. Distribution of Interventions

Intervention Type	Participants (%)
Education sessions	110 (92%)
Adherence monitoring	94 (78%)
Home-care support	77 (64%)
Infection-prevention counselling	85 (71%)
Nutrition counselling	69 (57%)
Tele-support sessions	73 (61%)

3.3 Trends in Renal Function Over Follow-Up

Follow-up renal function was improved. Figure 1 showed that the mean eGFR improved at 6 and 12 months compared to baseline, with a 38 mL/min/1.73 m^2 and 45 mL/min/1.73 m^2, respectively. This trend indicates renal stability that increases over time of intervention.

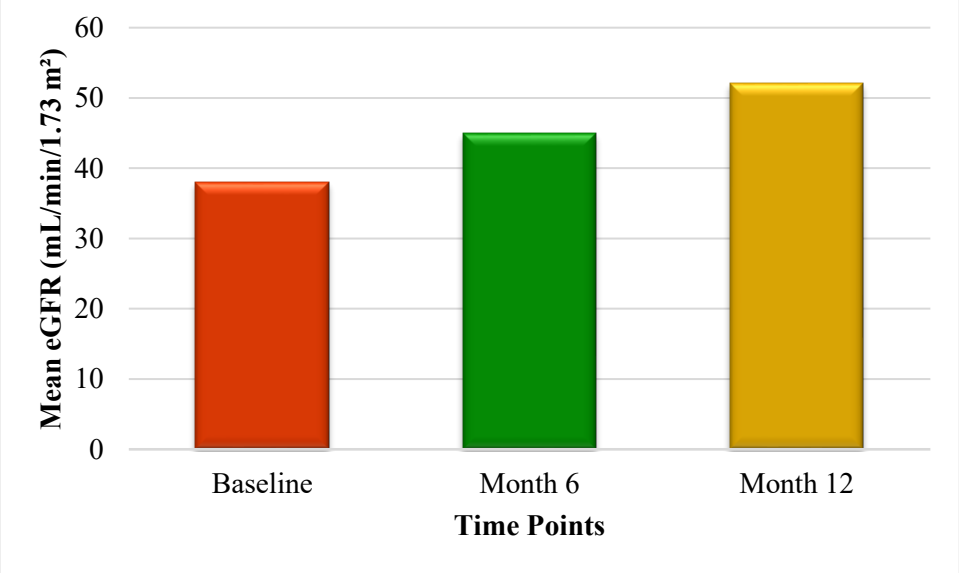

Figure 1. Mean eGFR at Baseline, 6 Months, and 12 Months

3.4 Reduction in Complications and Hospitalisations

There was a significant decrease in the frequency of complications. The reduction in the AKI episodes was 32% to 14%, infection 41% to 19%, and hypertension 36% to 22% (Table 3). Relapses of nephrotic syndrome decreased to 12%. The rate of hospitalisation went down to 0.9 per patient-year.

Table 3. Complications Before and After Interventions

Complication Type	Baseline %	Follow-Up %
AKI episodes	32%	14%
Infections	41%	19%
Hypertension	36%	22%
Nephrotic syndrome relapses	28%	12%
Hospitalisation rate (per patient-year)	1.8	0.9

3.5 Adherence and Quality-of-Life Outcomes

The levels of adherence were significantly increased, as the baseline adherence of 62% and the follow-up adherence of 84% were compared (Figure 2). Structured nursing education and tele-support sessions helped the family improve their treatment routine. The trend of quality-of-life scores was also similar, as the values grew between 48/100 to 71/100, indicating an improvement in emotional stability, symptom management, and functioning. Increased compliance also assisted in minimising the symptom burden with contributions to greater well-being.

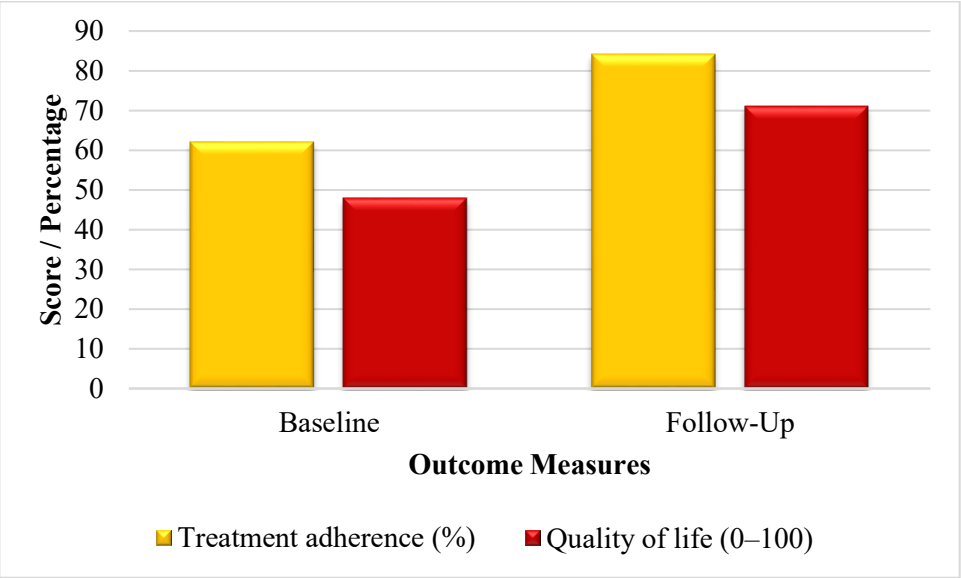

Figure 2. Adherence and Quality-of-Life Scores Before and After Interventions

3.6 Predictors of Improved Renal Outcomes

The predictors of renal improvements were key intervention-related predictors, which were determined using regression modelling. The best impact was on nursing intensity ($\beta = 0.41$, $p < 0.01$), which has a significant effect of the structured clinical support. The participation in the screening early revealed a significant level of relation ($\beta = 0.36$, $p < 0.01$). The frequency of tele-support showed a significant correlation ($\beta = 0.33$, $p < 0.05$), which supports the idea of remote control over the problem of renal care. The home-care engagement was positively related ($\beta = 0.29$, $p < 0.05$), meaning that there was value in the continuous daily support, as indicated in Table 4.

Table 4. Predictors of Renal Outcome Improvement

Predictor	**β Coefficient**	**p-value**
Nursing intensity	0.41	<0.01
Early screening participation	0.36	<0.01
Tele-support frequency	0.33	<0.05
Home-care engagement	0.29	<0.05

4. DISCUSSION

The findings of the study showed that renal functioning improves significantly after a continuous nursing interaction, systematic follow-up, and the organisation of the delivery of interventions. The achieved progressive increase in the mean eGFR between three assessment points implies that the positive clinical practices, regular evaluation, and the planned modifications in the care contributed to enhancing renal stability in both acute and chronic children. Frequent interactions with nursing teams seem to have promoted more consistent treatment, improved symptom identification, and reaction to the early warning signs, resulting in a decrease in cases of worsening. Besides, the better adherence scores indicate better family knowledge about the medication regimen, nutritional requirements, and monitoring symptoms. This probably led to the significant decrease in high blood pressure, infections, and instances of relapse. The benefits of public health strategies were adjoining benefits in the long-term renal health. Educational activities were also used to promote behavioural change in the households to enhance understanding of hygiene, nutrition and daily renal care habits. The concept of screening interventions at an early stage increased the prompt detection of renal burden, leading to quick access to postulated clinical pathways. Home-care instructions and tele-support practices by the community increased uniformity of follow-ups in different socioeconomic groups. All these factors helped families in keeping their care patterns more stable, restricting changes in the severity of the diseases. The synergistic efficacy of integrated clinical-community involvement did not end at isolated improvement. Children who received both structured nephrology follow-up and community-based reinforcement showed better compliance, fewer complications and decreased hospitalisation rates. These results demonstrate that a well-organised care system is capable of maintaining meaningful improvements in a variety of pediatric renal health aspects.

The results of the current research are consistent with the existing body of literature in the sphere of pediatric nephrology and support the previous findings related to the susceptibility of kidneys at an early age, the risk factors in the long term, and the importance of regular monitoring. Surveys on preterm birth outcomes associate premature developmental difficulties with renal dysfunction in adult lives and justify a close follow-up and multifaceted intervention strategies [20]. The use of early evaluation, personalised care, and multi-disciplinary integration is evident in the treatment

of kidney disease in children, a practice that is highlighted in KDIGO guidelines [21] and reflected in the trends of this research. The study of acute kidney injury emphasises the need to identify it early, regularly monitor it, and provide systematic care to children with this condition. It has been reported (as of now) that early clinical response can restrain the long-term harm, which is evident in the enhanced renal stability rates of the cohort in this study [22,23]. The Genomic discovery in the field of CKD studies suggests increasing attention to personalised forecasts and directive monitoring plans, which may be used in the future to adapt similar models of interventions to genetic predispositions [24]. Telehealth in kidney care has been shown to fill any distance, socioeconomic, or access to specialities gap in the pediatric care context [25]. Results of this research indicate parallel enhancement both on adherence and quality-of-life outcomes after tele-support engagement, which supports the previous findings that tele-guided care enhances continuity of care. Nevertheless, despite these common themes, the current research contributes to the existing knowledge by assessing a holistic model of clinical-public-health (integrating nursing interventions, family education, screening programs, and community-based reinforcement) in a single model of care.

Pediatric renal care pathways have a great role played by nursing teams. The results show that structured education and symptom monitoring and home-care reinforcement are associated with more stable kidney functioning and more effective patterns of adherence. Early identification of renal burden is one of the top priorities towards curtailing long-term deterioration. The close contact with the patient offered by nursing can help to identify any minor change in clinical condition in a short time. Added value is provided by public health engagement. Earlier screening establishes better points of entry into clinical care, where children who have risk factors are evaluated at a suitable time. Community-based counselling enhances healthier practices in homes, which increase self-management and daily renal management. Integrated clinical/public health mechanisms favour the congruent communication, a continued clarification and a more robust family potential to handle chronic renal requirements. The research findings promote the use of multidisciplinary models of pediatric renal care on a larger scale. A combination of nursing staff, community health workers, remote caregivers, and family educators is a unified system that can stabilise the disease trends and decrease the number of acute-care units.

The results of the study use information that was obtained in only one clinical network, making the generalisation hard. The increased population in more centres would help in confirming trends in this dataset. The self-report tendencies in the families may have been introduced in adherence and quality-of-life measurements. Observational design limits the study of direct causal relationships of cause-and-effect, regardless of the presence of strong associations among several indicators.

Future studies can be enhanced by testing models of interventions used in other clinical settings that are multicentric and enable a wide range of comparisons. Genomic profiling can help in identifying children who are in high-risk trajectories, and this provides specific pathways of identifying early intervention. Remote monitoring integrating digital technology with artificial intelligence can be used to increase the renal decline detection available, making it proactive. An economic analysis of comprehensive pediatric renal programs would offer much-needed information to policy planning, especially in areas that have limited nephrology services.

5. CONCLUSION

This research has shown that after a duration of engagement of organised nursing interventions and population well-being strategies, there is a significant improvement in the results of renal illnesses in children. The progression of renal function showed good follow-up, and the eGFR value rose to a level of greater stability in children with acute and chronic kidney conditions. The compliance rates among the cohort improved, which was encouraged by specific training, frequent observation, and strengthened contact with families. Quality-of-life ratings also indicated the same, indicating a more extensive benefit, going beyond clinical measures. The frequency of complications decreased in several areas, such as infections, hypertension, AKI episodes, and nephrotic-syndrome relapses. Less frequent rates of hospitalisation also emphasised the reinforced long-term care and more regular outpatient care. Nursing intensity, early screening attendance, frequency of tele-support, and home-care engagement were found as important factors of positive renal trajectories by predictive modelling. These results prove the effectiveness of the coordinated clinical and community intervention in children with long-term preservation of renal disease. The research highlights the importance of incorporating nursing leadership, systematic learning, and community-based programs into the pediatric nephrology practice. The combined model will aid continuous monitoring, high family involvement, and proactive intervention towards renal health needs. These facts justify the necessity to broaden interdisciplinary models that embrace the use of the elements of public health in the process of providing regular pediatric renal care.

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