The Impact of Artificial Intelligence Applications on Nursing Interventions in Kidney Diseases: A Systematic Review

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Annotation

This study aims to conduct a comprehensive review of the current literature on the influence of artificial intelligence (AI) applications on nursing interventions in kidney diseases, and to systematically analyze the data obtained from relevant studies. The findings of this research highlight the evolving role of artificial intelligence in the field of kidney disease nursing, particularly in symptom management. Significant improvements in care quality were observed through the implementation of artificial intelligence models in nursing interventions. Thus, the broader integration of artificial intelligence research in nursing practice is deemed to hold substantial significance.

Keywords: artificial intelligence, artificial intelligence and kidney diseases, artificial intelligence and nursing.

Dirbtinio intelekto taikymo įtaka slaugos intervencijoms sergant inkstų ligomis: sisteminė apžvalga

Santrauka

Šiuo tyrimu siekiama išsamiai apžvelgti dabartinę literatūrą apie dirbtinio intelekto taikymo įtaką slaugos intervencijoms sergant inkstų ligomis ir sistemingai išanalizuoti atitinkamų tyrimų metu gautus duomenis. Tyrimo išvadose pabrėžiamas besikeičiantis dirbtinio intelekto vaidmuo inkstų ligų slaugos srityje, ypač valdant simptomus. Stebėtas reikšmingas priežiūros kokybės pagerėjimas, taikant dirbtinio intelekto modelius slaugos intervencijose. Todėl platesnė dirbtinio intelekto tyrimų integracija į slaugos praktiką laikoma labai svarbia.

Reikšminiai žodžiai: dirbtinis intelektas, dirbtinis intelektas ir inkstų ligos, dirbtinis intelektas ir slauga.

Introduction

Artificial Intelligence (AI) has seamlessly integrated into various facets of everyday life, including healthcare, where it is often defined as the emulation of intelligent human behavior using machines. In the healthcare sector, particularly in nephrology, AI adoption has brought forth a multitude of conveniences, from aggregating patient data to innovating diagnostic tools, thereby enhancing the efficiency and quality of healthcare services. Kidney diseases, owing to their escalating incidence in recent years, have emerged as a significant burden on both families and communities, now classified as chronic diseases (Hong et al., 2021; Chen, Liu et al., 2023).

Nursing care plays a pivotal role in managing kidney diseases, encompassing symptom alleviation, early disease detection, and the regulation of factors contributing to nephron loss, such as blood pressure control and renin-angiotensin system inhibition. The core objectives of care strategies

in kidney disease management include symptom reduction, maintenance of fluid-electrolyte balance, provision of adequate nutrition, pharmacological treatment administration and assessment, enhancement of activity tolerance, prevention of CKD-related complications, and education of patients and families about the disease (Gülpak and Oktay, 2023). Leveraging advancements in technology, healthcare professionals now employ AI-based systems to streamline caregiving processes. The literature abounds with instances of AI utilization across various domains related to kidney diseases, including early diagnosis, risk stratification, diagnostic tool refinement, and symptom management (Van et al., 2019).

Future Directions. In the realm of end-stage kidney disease (ESKD) management, several avenues for future research involving AI are envisaged. Principal among ESKD treatments are kidney replacement therapies like hemodialysis (HD), peritoneal dialysis (PD), and kidney transplantation. Notably, around 21% of chronic kidney disease patients undergoing hemodialysis receive treatment for anemia. Future research may explore AI's potential in predicting future hemoglobin concentrations, optimizing erythropoietin-stimulating agent (ESA) and iron dosages in hemodialysis patients (Yao, Zhang et al., 2021).

Another promising application of AI in dialysis lies in the development of wearable dialysis devices, colloquially known as wearable artificial kidneys. These devices enable real-time analysis of patient data, dialysis parameters, and equipment alarms, providing instantaneous feedback responses (Karademirci et al., 2015). Overall, the integration of AI in kidney disease treatment and symptom management holds promise for illuminating future clinical research endeavors.

The research problem is expressed in research questions:

- What are the areas of nephrology nursing where artificial intelligence is applied?
- How much are artificial intelligence researches involved in nephrology nursing practice?

This systematic review aimed to accomplish the following objectives:

1. Examining the areas of nephrology nursing where artificial ıntelligence ıs applied,
2. Determining the ıntegration of artificial ıntelligence research in nephrology nursing practice,
3. Identifying the limitations of artificial ıntelligence in kidney disease management.

Methodology

This research adopts a systematic review approach and encompasses the period from March 2019 to March 2024. English indexes from Pubmed, Scopus, and EBSCOhost databases were systematically searched using key terms such as "artificial intelligence," "artificial intelligence and kidney diseases," and "artificial intelligence and kidney diseases and nursing." Only articles with full text were considered for inclusion, and the selection process adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

A total of four studies meeting the inclusion criteria were identified through the systematic searches. These comprised one retrospective study and three randomized controlled prospective studies. Evaluation tools utilized in these studies included the SF36 Quality of Life Scale, LINE Chatbot Satisfaction Survey, and various clinical parameters. Topics covered in the randomized controlled studies included artificial intelligence-based nutritional management in chronic kidney disease, home peritoneal dialysis management with artificial intelligence-supported programs, and the impact of artificial intelligence-based nursing care plans.

Search and Screening Strategy

The research followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines during the systematic review process. The EBSCOhost, PubMed, and Scopus databases were utilized for the study. Randomized controlled trials and retrospective cohort studies conducted between 2019 and 2024 were included. The titles, abstracts, and full texts of the screened studies were independently evaluated by researchers based on eligibility criteria, discussed to reach a consensus, and irrelevant studies were excluded from the review (see Fıgure 1).

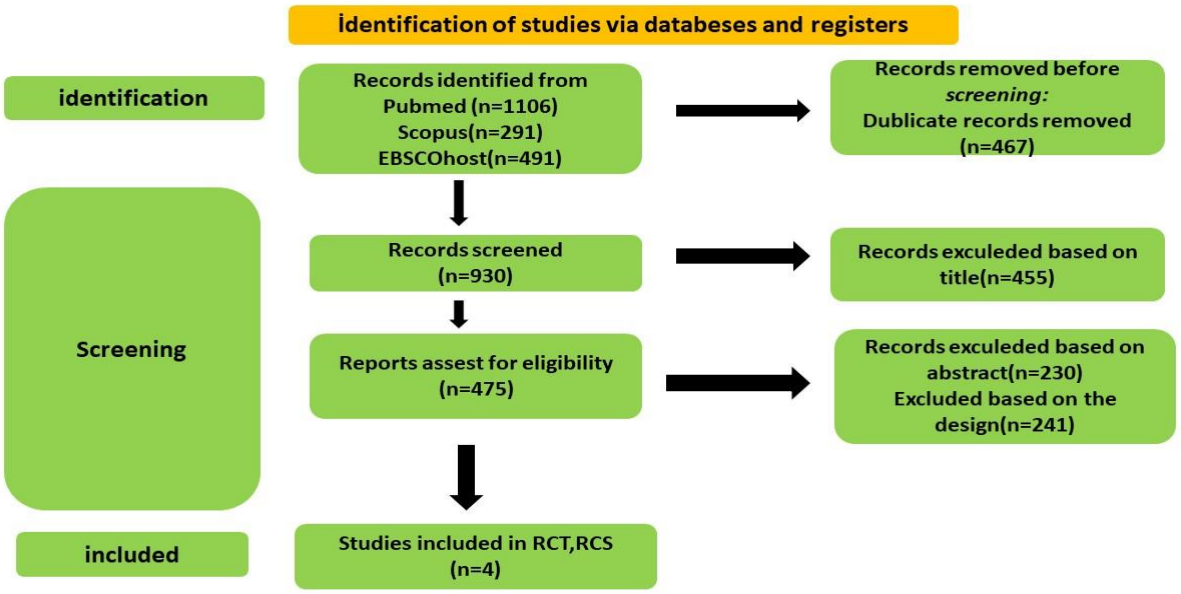

Figure 1. PRISMA 2022 flow diagram.

Research Characteristics

The general characteristics of the studies included in the research are provided in Table 1.

Table 1

General Characteristics of the Studies

Author	Purpose	The type of research	Scale used	Conclusion
Xing Chen, 2022	Evaluating the Implementation Value of the "Internet + Hospital-to-Home" Nutrition Care Model in the Management of Nutrition Care for Chronic Kidney Disease Using Wavelet Transform Algorithm Developed Based on Computed Tomography (CT) Images	N=120 Randomized controlled trial	Anthropometric Indicators (triceps skinfold and arm muscle circumference), Nutrition Risk Screening 2002 (NRS 2002), SF-36 Short Form, Satisfaction Survey Form	The artificial intelligence-based application demonstrated the potential to significantly improve the prognosis of stage 3-5 patients in the nutrition nursing model
Chunyan Zhao, 2022	Investigating the Impact of a Comprehensive Nursing Plan Based on Artificial Intelligence Algorithms on Ultrasonographic Evaluation in Patients with Diabetic Kidney Disease	N=74 rkt	SF-36 Quality of Life, Color Doppler Measurement	It has been demonstrated that artificial intelligence algorithms can play a significant role in the analysis of ultrasound images
Ching-i Cheng, 2023	To assess the implementation of LINE Chatbot Artificial Intelligence in improving self-care skills for patients undergoing peritoneal dialysis due to the increasing prevalence of digital and social media applications in Taiwan	N=440 Kesitsel	Likert 1-5 scale-based LINE Chatbot satisfaction survey	The use of artificial intelligence technology has reduced the peritonitis rate from 0.93 per 100 patient-months to 0.8 per 100 patient-months
Wei Liu, 2023	Improving Kidney Outcomes in Patients with Non-Diabetic Chronic Kidney Disease through Artificial Intelligence-Based Health Coaching Mobile Application	Retrospektif Kohort	Clinical parameters(proteinüri, Blood Pressure)	The use of the KidneyOnline smart care system is associated with a reduction in the risk of adverse kidney outcomes in non-diabetic chronic kidney disease (CKD) patients.

Results of the research

In this study, four studies related to the application of artificial intelligence in nephrology nursing were considered. Chen et al. (2022) conducted a study involving 120 kidney patients and obtained positive results in nutrition care for chronic kidney diseases. In their study, Chen et al. (2022) brought together the hospital-to-home continuous nutrition nursing model, commonly used in chronic diseases, with internet technology. While patients in the control group (n=60) used the traditional nutrition nursing model, patients in the experimental group (n=60) utilized the Internet + traditional nutrition nursing model. To evaluate the application effect of the nutrition nursing model in both patient groups, an artificial intelligence tool called the IWT algorithm, anthropometric measurements, laboratory biochemical tests, and 320-slice low-dose perfusion computed tomography images based on other questionnaire scores were applied. Measurements were evaluated every 6 months. As a result, it was found that the traditional nutrition nursing model, when applied with the artificial intelligence-based internet support model, was more individualized and improved the physical quality of life of stage 3-5 patients while also providing positive outcomes in their emotional state and disease prognosis (Chen et al., 2022).

Another study utilizing artificial intelligence in nephrology nursing applications was conducted by Zhao et al. (2022). Diabetic kidney disease (DKD), a chronic kidney disease resulting from the long-term progression of diabetes, is one of the most likely and serious microvascular diseases among diabetes complications and is also one of the main factors leading to end-stage kidney disease. Effective management of chronic kidney disease can provide many benefits such as psychological relief for patients, prevention of infection, coordination of medication and treatment, and prevention of complications. Based on this information, Zhao et al. evaluated the impact of a comprehensive nursing program on patients with diabetic kidney disease using an intelligent algorithm-based ultrasound image. The individuals in the study were divided into Group A (control group without nursing intervention) and Group B (group receiving comprehensive nursing intervention), and 32 healthy adults were also included as a control group. All participants in the experimental group underwent an ultrasound examination in the fasting state and supine position, and the blood flow parameters of the renal aorta, intrarenal artery, and interlobar artery at the renal hilum were measured. The kidney function of patients in Group B improved better after nursing, compared to Group A. Additionally, the incidence of complications was lower in patients in Group B. After nursing intervention, the quality of life scores of patients in Group B were also found to be higher. As a result, the study showed that comprehensive nursing intervention in individuals with diabetic kidney disease helped improve kidney function and reduce the risk of complications. Moreover, it demonstrated that artificial intelligence algorithms could play a significant role in the analysis of ultrasound images (Zhao et al., 2022).

Another study using artificial intelligence in nephrology nursing applications was conducted in Taiwan. Due to the increase in digital and social media applications in Taiwan, the application of LINE Chatbot Artificial Intelligence was aimed to improve the self-care skills of patients undergoing peritoneal dialysis. Cheng et al. (2023) designed an automatically responsive Chatbot system and divided it into six interaction interfaces, including operation videos of peritoneal dialysis technique, clinical reminders, home care, hospital registration service, nutrition guide, among others. They investigated patient satisfaction with the LINE Chatbot through a Likert 1-5 point-based survey three months later. Although 440 patients participated in the Chatbot study and used the Chatbot, only 297 patients returned the satisfaction survey. It was found that 91.7% of the participants agreed on the 'General satisfaction with the Patient Smart Chatbot application'. Additionally, 86.6% of the patients had scores of 4 and above. Another important outcome of the study was the decrease in the peritonitis rate from 0.93 to 0.8 with the use of artificial intelligence techniques (Cheng et al., 2023).

In contrast to other studies, a retrospective cohort study was conducted in another study. Wei Lu et al. conducted a retrospective cohort study to improve kidney outcomes in non-diabetic chronic kidney disease patients through an artificial intelligence-based health coaching mobile application. The analysis of the study was conducted with a total of 2060 patients registered in the KidneyOnline application from 2017 to 2021. Patients were divided into KidneyOnline smart system group and

traditional care group. The intervention group received center-based follow-up with the KidneyOnline intelligent patient care system, which is a nurse-led, patient-centered, collaborative management system. Health-related data uploaded by patients were merged using deep learning optical character recognition. Personalized data generated by artificial intelligence included lifestyle intervention recommendations, early warnings, real-time questions and answers, and personalized follow-up plans. Patients in the traditional group received professional recommendations from nephrologists through regular clinic visits but did not have access to the services provided by artificial intelligence and health coach teams. After enrollment in the study, patients were followed for at least 3 months until death or initiation of renal replacement therapy. As a result, in the KidneyOnline smart patient care system group, it was found that the estimated glomerular filtration rate (eGFR) and compound kidney outcome risk independent of proteinuria were significantly reduced. The use of the KidneyOnline smart care system was associated with a decrease in the risk of adverse kidney outcomes in non-diabetic chronic kidney disease patients (Liu et al., 2023).

Discussion: Limitations of artificial ıntelligence in kidney diseases

The diagnosis and treatment of kidney diseases have been significantly improved with the support of artificial intelligence (AI)-enabled technologies. However, there are certain limitations to AI applications. Firstly, the training of AI models requires large and accurate datasets. In complex health issues such as kidney diseases, collecting such datasets and using them in accordance with ethical rules can be a challenging process (Wu et al., 2024). Additionally, AI models have limited generalizability; that is, it may not always be possible to apply the condition of one patient to others. Furthermore, AI systems can never fulfill subjective assessment criteria (Wu et al., 2024). Therefore, while AI technologies serve as important tools in the diagnosis and treatment of kidney diseases, the domain of healthcare professionals providing humane care and treatment to humans will continue to be significant.

Conclusion

With the increasing global population, the number of patients receiving care from nurses has also increased. The rising number of patients increases the workload of nurses and may compromise the quality of care. Innovative solutions such as artificial intelligence and robotic technologies are needed to address the nursing shortage. Artificial intelligence is a software and hardware system designed to solve complex problems, while robotic technologies are tools in healthcare where artificial intelligence is applied. Studies have shown that AI-based interventions yield efficient results.

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