

Digital Health in Kidney Care: The Role of Telemonitoring in Enhancing Self-Management Among Patients with Chronic Kidney Disease

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ABSTRACT

Chronic kidney disease (CKD) requires long-term, continuous self-management to prevent disease progression and reduce complications. However, maintaining patient adherence and engagement in daily self-care remains a major challenge. The rapid development of digital health, particularly telemonitoring, offers new opportunities to strengthen self-management by enabling continuous home-based monitoring, real-time feedback, and enhanced patient-provider communication. This study aims to analyze the role of telemonitoring in improving self-management among patients with CKD and to identify the system design and adherence-related factors that determine successful implementation. A systematic literature review was conducted following the PRISMA framework, using articles published between 2020 and 2025 retrieved from Scopus, PubMed, Web of Science, and Google Scholar. The findings indicate that telemonitoring significantly improves key dimensions of self-management, including self-efficacy, treatment adherence, symptom awareness, patient engagement, and satisfaction with care. Clinical benefits include improved blood pressure control and enhanced early detection of complications. Nevertheless, long-term adherence remains a critical barrier, strongly influenced by system usability, monitoring burden, digital literacy, and integration within clinical workflows. In conclusion, telemonitoring represents a powerful instrument for strengthening CKD self-management, but its real-world effectiveness depends on human-centered system design, continuous professional support, and tailored strategies to sustain patient adherence over time.

Keyword: *Chronic kidney disease; Digital health; Self-management; Telemonitoring; Patient adherence.*

INTRODUCTION

Chronic kidney disease (CKD) represents one of the most pressing global health challenges of the twenty-first century. The condition is progressive, irreversible, and associated with substantial morbidity, mortality, and economic burden on healthcare systems worldwide. The long-term management of CKD requires continuous clinical monitoring, strict adherence

to medication, dietary regulation, blood pressure control, fluid balance management, and sustained patient engagement in daily self-care behaviors. Despite significant advances in nephrology, achieving consistent and effective self-management among patients with CKD remains a persistent and unresolved problem (Okpechi et al., 2023; Zoccali et al., 2025). The emergence of digital health has transformed contemporary models of chronic disease management by introducing technology-enabled approaches that extend clinical care beyond hospital walls. Telemonitoring, as a core component of digital health, enables remote and continuous monitoring of patients' physiological data, including blood pressure, body weight, dialysis parameters, medication adherence, and activity levels, while facilitating real-time communication between patients and healthcare professionals. In CKD care, telemonitoring has been widely promoted as a strategic tool for strengthening patient self-management and improving clinical outcomes (Canaud et al., 2023; Canaud et al., 2024).

The accelerated adoption of telemonitoring in kidney care has been driven by increasing healthcare demand, workforce limitations, and the need for more patient-centered, cost-effective, and sustainable care models. Empirical evidence demonstrates that telemonitoring interventions can improve blood pressure control, support timely therapeutic adjustments, and enhance patients' engagement in their own care processes (Okpechi et al., 2022; Muneer et al., 2022; Hui et al., 2024). These improvements are particularly important given that blood pressure control is a central determinant of CKD progression and cardiovascular risk (Okpechi et al., 2023). However, despite these promising clinical benefits, a significant and increasingly visible implementation problem persists. Real-world application of telemonitoring systems often fails to achieve the expected level of long-term patient adherence and sustained behavioral change. The Telemechron study revealed that although telemonitoring allowed intensive home-based monitoring and timely therapy adjustments, long-term adherence among CKD patients was remarkably low, reaching only 8.8 percent, while many participants perceived the monitoring process as burdensome, particularly when measurement frequency was high (Jayousi et al., 2025). This phenomenon highlights a fundamental tension between technological capability and human engagement, indicating that digital innovation alone does not guarantee improved self-management.

Consistent findings across multiple studies suggest that while telemonitoring and mHealth interventions enhance patients' self-efficacy, knowledge, dietary control, fluid management, and overall satisfaction with care, their effects on long-term clinical outcomes remain variable and context-dependent (Yang et al., 2020; De Almeida et al., 2023; Ng et al., 2025). These mixed results suggest that the success of telemonitoring interventions is not merely a function of technological sophistication but is critically influenced by system design, patient experience, behavioral support mechanisms, and integration into routine clinical workflows. From a behavioral perspective,

telemonitoring supports self-management through multiple interrelated mechanisms. It strengthens patient empowerment and self-efficacy by increasing symptom awareness, reinforcing responsibility for health behaviors, and promoting active engagement in disease management. Qualitative evidence indicates that regular monitoring “forces patients to become more aware” and “makes them feel accountable for their own health,” which directly supports the development of sustainable self-management behaviors (Delvallée et al., 2023; Pieroni et al., 2023; Yang et al., 2020). In addition, telemonitoring facilitates systematic home-based tracking of key CKD parameters, enabling healthcare teams to provide personalized education, reinforce healthy behaviors, and adjust treatment plans more responsively (Okpechi et al., 2022; Canaud et al., 2023; Canaud et al., 2024).

Furthermore, the continuous communication enabled by telemonitoring platforms significantly enhances patients’ psychological well-being by reducing uncertainty, anxiety, and feelings of isolation. Patients report greater reassurance and emotional security when they perceive that healthcare professionals are closely monitoring their condition, even at a distance (Delvallée et al., 2023; De Almeida et al., 2023). This psychosocial dimension of telemonitoring is essential in CKD care, where emotional distress and treatment fatigue often undermine long-term adherence. Despite these benefits, the implementation of telemonitoring faces persistent structural and individual-level barriers. Major challenges include the time burden of frequent measurements, technical difficulties, low digital literacy, insufficient immediate feedback, and increased workload for nurses and physicians who must manage large volumes of patient-generated data (Jayousi et al., 2025; Delvallée et al., 2023; Pieroni et al., 2023; Graham-Brown et al., 2022). These barriers help explain why telemonitoring interventions that perform well in controlled research settings often underperform when deployed in routine clinical practice.

Multiple studies have identified key facilitating factors that determine the success of telemonitoring systems. These include simple and intuitive user interfaces, realistic monitoring frequency, effective reminder and notification systems, meaningful personalized feedback, and seamless integration into existing clinical workflows (Jayousi et al., 2025; Delvallée et al., 2023; Yang et al., 2020; Canaud et al., 2024). Without these elements, telemonitoring risks becoming an additional burden rather than an empowering tool for patients and healthcare professionals. A review of the research trajectory from 2020 to 2025 reveals a clear shift in scholarly focus. Early studies concentrated on technological feasibility and clinical efficacy, whereas more recent research emphasizes implementation science, user experience, sustainability, and system integration (Thijs et al., 2020; Okpechi et al., 2023; Jayousi et al., 2025; Ng et al., 2025). This shift reflects growing recognition that digital health success depends on socio-technical alignment rather than technology alone.

Despite the expanding body of literature, a significant research gap remains. Existing studies largely examine clinical outcomes, patient behaviors, and system performance in isolation, without sufficiently integrating the relationships between system design, patient adherence, psychosocial mechanisms, and long-term self-management outcomes. Moreover, limited attention has been given to understanding why adherence remains low despite demonstrated clinical benefits and how telemonitoring systems can be optimized to sustain patient engagement over time (Jayousi et al., 2025; Delvallée et al., 2023; Pieroni et al., 2023). The novelty of this study lies in its integrative analytical approach that synthesizes evidence on digital health, telemonitoring system design, patient adherence, and self-management mechanisms within CKD care. Rather than merely cataloging the benefits of telemonitoring, this study examines how technological, behavioral, and organizational factors interact to determine real-world effectiveness and sustainability of telemonitoring-based CKD management. Accordingly, the primary objective of this study is to systematically analyze the role of telemonitoring in enhancing self-management among patients with chronic kidney disease and to identify the key system design and adherence-related factors that determine its successful implementation in modern healthcare practice.

METHODOLOGY

This study employed a systematic literature review design to examine the role of telemonitoring in enhancing self-management among patients with chronic kidney disease and to identify the system design and adherence-related factors that influence successful implementation. The review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure methodological rigor and transparency. Data were collected from major academic databases, including Scopus, PubMed, Web of Science, and Google Scholar. The search strategy combined key terms such as “chronic kidney disease,” “telemonitoring,” “digital health,” “self-management,” and “patient adherence,” with Boolean operators to refine results. Inclusion criteria consisted of peer-reviewed journal articles published between 2020 and 2025, written in English, focusing on adult CKD patients, and explicitly addressing telemonitoring or digital health interventions related to self-management. Exclusion criteria included conference proceedings, editorials, opinion papers, pediatric studies, and articles without full-text availability. The screening process involved title and abstract review, followed by full-text assessment for eligibility.

Data analysis was conducted using a qualitative thematic synthesis approach. Relevant information from each selected article was extracted into a structured data matrix capturing study characteristics, intervention type, outcomes related to self-management, adherence patterns, system design features, facilitators, and barriers to implementation. The extracted data were coded inductively to identify recurring themes and relationships between

telemonitoring, patient adherence, and self-management mechanisms. Cross-study comparison was then performed to integrate findings and generate higher-order analytical categories that explain how technological design and behavioral factors interact to influence the effectiveness of telemonitoring in CKD care. This analytic process enabled the development of an integrated interpretive framework that connects digital health system characteristics with patient engagement and long-term self-management outcomes.

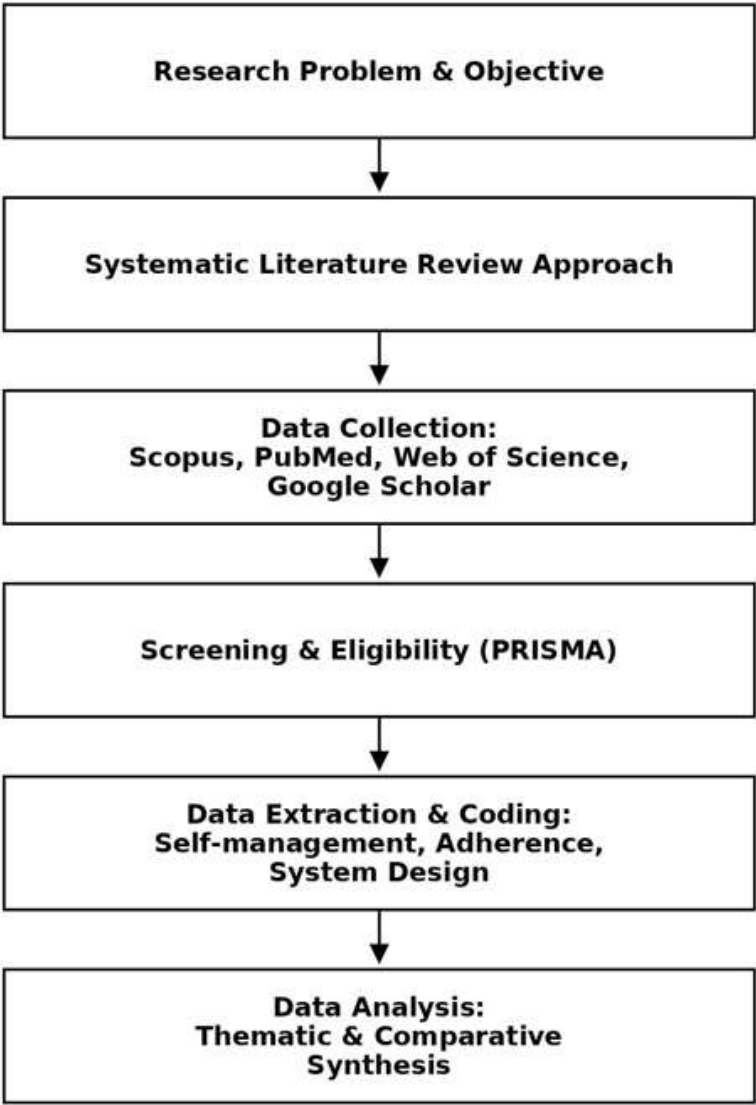


Figure 1. Research Methodology Flow

RESULTS AND DISCUSSION

The synthesis of the selected studies reveals consistent patterns regarding the effectiveness of digital health and telemonitoring interventions in supporting self-management among patients with chronic kidney disease. To systematically present the key findings derived from the literature review, Table 1 summarizes the major intervention models, target populations, self-

management outcomes, clinical impacts, implementation challenges, and success factors reported across the reviewed studies.

Table 1. Synthesis of Evidence on Digital Health and Telemonitoring in CKD Self-Management

Intervention Focus	Target Population	Key Self-Management Outcomes	Clinical Impact
General CKD Telemonitoring (Pre-dialysis & Dialysis)	Non-dialysis and dialysis CKD patients	Improved self-monitoring, enhanced awareness of symptoms, better treatment adjustment; however, long-term adherence remains low (8.8%) and monitoring burden increases with high frequency	Improved treatment optimization and early complication detection
Home Blood Pressure Telemonitoring (HBPT)	Hypertensive CKD patients	Improved self-monitoring of BP, better medication adherence, increased patient engagement	Reduction of systolic BP by approximately 8–9 mmHg; modest improvement in renal function
mHealth & Telehealth in Dialysis Care	Hemodialysis and peritoneal dialysis patients	Increased self-efficacy, improved dietary and fluid control, enhanced disease knowledge, higher patient satisfaction	Generally positive clinical trends, though heterogeneous
Telemonitoring in Chronic Disease Management	Patients with chronic conditions including CKD	Greater motivation, symptom awareness, emotional security, increased confidence in self-care	Improved perceived quality of care and patient experience
Digital Health	Advanced CKD	Empowered self-	Potential to delay

Integration in Advanced CKD	and comorbid patients	management, improved engagement with multidisciplinary care	disease progression and reduce hospitalizations
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Table 1 demonstrates that digital health and telemonitoring interventions contribute significantly to strengthening self-management capacities in patients with chronic kidney disease across different stages of illness and care modalities. Across all intervention types, improvements were consistently observed in patients' self-monitoring behaviors, treatment adherence, symptom awareness, and engagement with care processes. Particularly, home blood pressure telemonitoring showed a clinically meaningful reduction in systolic blood pressure of approximately 8–9 mmHg, reinforcing the central role of blood pressure control in CKD self-management. However, the table also highlights substantial implementation challenges that limit the sustainability of these interventions.

The most prominent barriers include low long-term adherence, monitoring fatigue, technical difficulties, limited digital literacy, and increased workload for healthcare professionals. These challenges explain the discrepancy between strong short-term clinical outcomes and weaker long-term effectiveness observed in real-world practice. Importantly, the evidence indicates that the success of telemonitoring is not determined solely by technological capability but depends heavily on human-centered system design and organizational integration. User-friendly interfaces, realistic monitoring schedules, personalized feedback, continuous patient education, and seamless incorporation into clinical workflows emerge as decisive factors in sustaining patient engagement and maximizing self-management outcomes. Overall, the findings suggest that while digital health and telemonitoring offer powerful tools for enhancing CKD self-management, their real-world impact is critically shaped by how well technology, patient behavior, and healthcare systems are aligned.

The primary objective of this study was to analyze the role of telemonitoring in enhancing self-management among patients with chronic kidney disease and to identify the key system design and adherence-related factors that determine the success of its implementation. The findings summarized in Table 1 provide strong empirical support for this objective by demonstrating that digital health interventions, particularly telemonitoring, substantially improve core components of self-management, including patient engagement, symptom awareness, treatment adherence, self-efficacy, and satisfaction with care. These outcomes align with the broader transformation of chronic disease management toward technology-supported, patient-centered care models, where patients are no longer passive recipients of care but active partners in disease management. The evidence synthesized in this study shows

that telemonitoring in general CKD populations enables more intensive monitoring and timely therapeutic adjustments, which are essential for preventing complications and slowing disease progression. However, the remarkably low long-term adherence rate of 8.8 percent reported in the Telemechron study reveals a critical implementation gap that cannot be ignored (Jayousi et al., 2025). This discrepancy between clinical potential and real-world sustainability reflects a fundamental challenge in digital health: technological capability alone is insufficient to ensure durable behavioral change. Similar concerns were observed in the mixed-methods trial by Pieroni et al. (2023), where patients reported that although telemonitoring improved clinical oversight and safety, frequent measurements often created fatigue and psychological burden, ultimately reducing long-term engagement.

The home blood pressure telemonitoring findings further strengthen the conclusion that telemonitoring meaningfully enhances self-management. The consistent reduction in systolic blood pressure of approximately 8–9 mmHg reported across multiple studies is clinically significant, given the strong association between blood pressure control and CKD progression (Okpechi et al., 2023; Okpechi et al., 2022; Muneer et al., 2022). Improved blood pressure management reflects not only better clinical outcomes but also enhanced patient participation in self-care behaviors such as medication adherence, lifestyle modification, and regular monitoring. This supports the interpretation that telemonitoring directly reinforces self-management competencies through continuous feedback and behavioral reinforcement. Among dialysis patients, the role of mHealth and telehealth interventions appears particularly impactful. The majority of studies reviewed reported significant improvements in self-efficacy, disease knowledge, dietary and fluid management, and patient satisfaction, even though clinical outcomes remained heterogeneous (Yang et al., 2020; De Almeida et al., 2023; Ng et al., 2025). These findings highlight an important conceptual distinction: telemonitoring's most immediate and consistent contribution lies in strengthening the behavioral and psychological foundations of self-management rather than producing uniform physiological outcomes. From a long-term perspective, improvements in self-efficacy and disease understanding are critical predictors of sustained adherence and reduced complication risk.

The qualitative synthesis by Creber et al. (2023) and the meta-analysis by Leo et al. (2021) further corroborate these conclusions by demonstrating that telemonitoring increases patient motivation, symptom awareness, and perceived security. Patients consistently report feeling more connected to healthcare providers, more confident in managing their conditions, and more reassured by continuous monitoring. These psychosocial benefits play a central role in the long-term sustainability of self-management behaviors, particularly in chronic diseases characterized by treatment fatigue and emotional distress. The mechanisms through which telemonitoring enhances self-management are multifaceted and mutually reinforcing. First, telemonitoring strengthens patient empowerment and self-efficacy by increasing accountability, disease awareness,

and perceived control over health outcomes. Qualitative findings indicate that patients often describe telemonitoring as “forcing vigilance” and fostering personal responsibility for health behaviors (Delvallée et al., 2023; Pieroni et al., 2023). Such cognitive and emotional shifts are essential for transforming passive compliance into active self-management.

Second, telemonitoring enables systematic home-based monitoring of critical health parameters, including blood pressure, weight, physical activity, dialysis indicators, and medication use. These data are not merely recorded but actively integrated into clinical decision-making, educational interventions, and behavioral coaching, allowing healthcare teams to personalize care and intervene early when deterioration is detected (Okpechi et al., 2022; Canaud et al., 2023; Canaud et al., 2024). This continuous data-feedback loop reinforces healthy behaviors and strengthens the patient’s sense of competence in managing the disease. Third, telemonitoring enhances communication and emotional support through sustained interaction with healthcare professionals. The rapid feedback and regular contact facilitated by digital platforms reduce anxiety, uncertainty, and feelings of isolation, all of which are known to undermine adherence in chronic illness populations (Delvallée et al., 2023; De Almeida et al., 2023).

Emotional reassurance thus becomes an integral component of the self-management process, complementing technical monitoring functions. Despite these substantial benefits, the findings also reveal persistent barriers that threaten the long-term viability of telemonitoring programs. The most prominent obstacles include measurement burden, technical difficulties, limited digital literacy, insufficient feedback, and increased workload for healthcare professionals (Jayousi et al., 2025; Delvallée et al., 2023; Graham-Brown et al., 2022). These challenges illustrate that telemonitoring systems operate within complex socio-technical environments where technological efficiency must be carefully balanced against human capacity and organizational constraints.

Importantly, the evidence suggests that the success of telemonitoring is highly contingent upon system design and implementation strategy. Studies consistently identify simple and intuitive interfaces, realistic monitoring frequencies, effective reminder systems, personalized feedback, and integration into routine clinical workflows as decisive success factors (Jayousi et al., 2025; Delvallée et al., 2023; Canaud et al., 2024). When these elements are absent, telemonitoring risks becoming an additional burden rather than a supportive tool, thereby undermining adherence and diminishing clinical value. The temporal evolution of telemonitoring research from 2020 to 2025 reflects a broader maturation of the field. Early studies primarily addressed technological feasibility and short-term clinical outcomes, whereas more recent research emphasizes sustainability, user experience, health system integration, and equity of access (Thijs et al., 2020; Graham-Brown et al., 2022; Hui et al., 2024; Spethmann et al., 2024). This shift underscores growing recognition that the long-term success of digital health interventions depends less on technological novelty and more on their alignment with patient behavior, professional

practice, and organizational capacity. Within this context, the present study contributes to the literature by offering an integrated interpretation of how telemonitoring influences self-management through behavioral, psychological, technological, and organizational pathways. The findings demonstrate that telemonitoring can substantially enhance self-management in CKD, but only when systems are designed around the lived realities of patients and healthcare providers. This insight directly addresses the research objective and fills a critical gap in existing scholarship, which has often examined clinical outcomes and technological performance in isolation.

From a practical standpoint, these findings have important implications for the future development of digital kidney care. Healthcare systems must move beyond technology-centered implementation toward human-centered design, where usability, patient capacity, professional workflow, and emotional support are treated as core components of intervention effectiveness. Moreover, strategies for sustaining patient adherence must extend beyond technical training to include continuous motivational support, adaptive monitoring schedules, and personalized care pathways. In conclusion, the discussion confirms that digital health and telemonitoring possess significant potential to transform CKD self-management, but their real-world impact is determined by the delicate interplay between system design, patient adherence, and healthcare delivery structures. By aligning technology with human behavior and organizational context, telemonitoring can evolve from a promising innovation into a sustainable cornerstone of modern kidney care.

CONCLUSION

This study set out to analyze the role of telemonitoring in enhancing self-management among patients with chronic kidney disease and to identify the system design and adherence-related factors that determine the success of its implementation. The findings demonstrate that digital health and telemonitoring interventions significantly strengthen key dimensions of self-management, including patient engagement, symptom awareness, treatment adherence, self-efficacy, and satisfaction with care. Telemonitoring supports these improvements through continuous home-based monitoring, timely clinical feedback, enhanced patient-provider communication, and sustained emotional support, all of which collectively empower patients to take a more active role in managing their disease. However, the study also confirms that the effectiveness of telemonitoring in real-world practice is not guaranteed by technological sophistication alone. Long-term adherence remains a critical challenge, strongly influenced by system usability, monitoring burden, digital literacy, and integration within existing clinical workflows. Telemonitoring systems that are poorly designed or insufficiently supported by healthcare professionals risk becoming burdensome, thereby reducing patient engagement and undermining their potential benefits. Overall, the conclusion affirms that telemonitoring can serve as a powerful instrument for improving self-management in chronic kidney disease, but its success depends fundamentally

on human-centered system design, continuous professional support, and targeted strategies to sustain patient adherence over time. Aligning technological innovation with patient behavior and healthcare system capacity is therefore essential for ensuring the long-term effectiveness and sustainability of digital kidney care.

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