TELKOMNIKA Telecommunication Computing Electronics and Control
Vol. 24, No. 6, December 2026, pp. 1869~1883
ISSN: 1693-6930, DOI: 10.12928/TELKOMNIKA.v24i6.27763

Effectiveness of mobile and web-based telecommunication in hemodialysis care: a systematic review

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Article Info

Article history:

Received Dec 26, 2025
Revised Jun 27, 2026
Accepted Aug 28, 2026

Keywords:

Adherence
Digital health interventions
Hemodialysis
Patient education
Self-management
Telecommunication system
Telehealth

ABSTRACT

Telecommunication technologies are increasingly used to support education and self-management in hemodialysis (HD) care. This systematic review evaluated the effectiveness of mobile- and web-based interventions across communication models. PubMed, ScienceDirect, and Google Scholar were searched for studies published between 2016 and 2025. Study selection followed PRISMA guidelines, and methodological quality was assessed using Joanna Briggs Institute critical appraisal tools. Fifteen studies met the inclusion criteria. One-way interventions, including short message services (SMS), telephone follow-ups, and educational videos, generally improved engagement and short-term adherence, but evidence of sustained benefits was limited. Interactive approaches incorporating self-monitoring, clinician feedback, and bidirectional communication, particularly smartphone applications and telehealth systems, showed broader improvements in self-management, treatment adherence, quality of life (QoL), and selected clinical indicators, including interdialytic weight gain, dialysis adequacy, and hemoglobin levels. Web-based and asynchronous interventions yielded mixed findings, partly reflecting differences in engagement and personalized feedback. Heterogeneity in interventions, outcomes, study designs, and follow-up periods precluded meta-analysis and limited certainty in the findings. Overall, interactive and clinically integrated telecommunication approaches appear promising for HD care. Larger studies with standardized outcomes and longer follow-up are needed to establish sustained effectiveness.

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1. INTRODUCTION

Chronic kidney disease (CKD) is a major condition with a rising global prevalence approximately 13.4% for all stages (stages 1-5) of the disease with ranked among the top ten causes of death globally [1], [2]. CKD is associated with substantial morbidity by contributes significantly to cardiovascular disease burden and become a leading contributor to global mortality with increasing death rates over the last 20 years [3], [4]. Patients who progress CKD to end-stage renal disease (ESRD) often require renal replacement

therapy to survive and maintain their quality of life (QoL), yet reports suggest that adherence to prescribed regimens including dietary and fluid restrictions remains a challenge in clinical practice. More than 3.57 million people globally depend on hemodialysis (HD) being the most widely used modality [1], [5]. HD involves complex treatment regimens, particularly dietary restrictions, which necessitate effective and continuous patient education to enhance self-efficacy, improve adherence, and enhance health outcomes [6].

Effective self-management for HD patients is essential for reducing complications and improving outcomes. However, non-adherence remains common and highly variable reported that prevalence of non-adherence to diet and fluid restrictions in HD patients can exceed 60% globally for both diet and fluid non-adherence [7]. A meta-analysis of 23 studies with a combined sample of 11,209 HD patients found that around 60% of patients worldwide did not adhere to prescribed dietary and fluid restrictions [8]. Meanwhile, in a Turkish cohort, non-adherence to diet and fluid restrictions was estimated at 39.1% based on clinical parameters, including intrusion detection working group (IDWG) and serum electrolyte values [7]. In other side, correlation study from Indonesia has been reported that poor adherence to fluid restrictions leads to higher IDWG [9]. Meanwhile in a Brazilian prospective cohort, HD patients with IDWG ≥ 4% of dry weight exhibited a twofold increase in all-cause mortality and a tendency toward higher cardiovascular mortality [10]. Non-adherence to prescribed HD regimens is linked to greater complications, more frequent hospitalizations, lower QoL, and shortened survival [11].

Conventional face-to-face (FTF) educational approaches for HD patients are often constrained by limited clinical time, high patient volumes, and variability in patient learning capacity so it can fragment communication and reduce its effectiveness [12]. Patients may feel overwhelmed by complex dietary instructions and fluid management guidelines so may reduce their ability to implement self-care behaviors in daily life [13]. In other side, digital health innovations such as mobile phones, web platforms and short message service (SMS) reminders provide flexible, accessible and interactive channels for communication between health professionals and patients [14]–[16]. These technologies offer personalized, continuous and highly accessible monitoring systems that may enhance patient engagement in managing their condition. Despite their potential, SMS interventions are usually restricted to brief, one-way reminders and do not support personalized feedback or behavior tracking. Mobile applications can deliver richer content and self-monitoring features, but many studies report poor usability, declining engagement over time, and difficulties among older or low-literacy users [17].

Meanwhile, telehealth systems allow direct interaction with healthcare providers, yet their implementation depends on reliable internet access, technical infrastructure, and staff availability, which limits their use in many settings [18]. However, the existing evidence remains fragmented and inconsistent due to interventions vary widely in content, delivery mode, intensity, duration, and outcome measures, making it difficult to compare. While some trials demonstrate significant improvements in adherence and clinical outcomes, others report modest or non-significant effects. Pungchompoo *et al*. [19] in Thailand reported that a six-month integrated telehealth and web-based program improved mental health–related QoL, hemoglobin levels, and dialysis adequacy (Kt/V) among 54 older patients, although low digital literacy remained a key barrier. In contrast, Nadort *et al*. [20] in the Netherlands found that a guided internet-based self-help program with asynchronous coaching did not significantly reduce depression among 190 patients, due to lack of real-time interaction and low motivational support. Variability in methodological approaches, intervention formats and outcome measures may limit the strength of conclusions regarding their impact on patient adherence and health outcomes.

Despite the difference of digital interventions, no systematic review has yet comprehensively classified mobile and web-based telecommunication systems for HD patient education while critically linking their technological features with health outcomes. This review addresses that gap by synthesizing evidence across multiple telecommunication modalities and by comparing interventions according to their communication models and outcome domains. Rather than focusing solely on technology type, this review examines how key system characteristics, including interactivity, self-monitoring, clinician feedback, and integration into routine care, relate to behavioral, psychosocial, and clinical outcomes. By mapping intervention features such as communication mode, interactivity, monitoring, and feedback mechanisms to patient adherence, knowledge, and health indicators, this review provides a technology-oriented perspective. Given the growing dependence on digital technologies in healthcare recent days, it is important to synthesize current evidence on the effectiveness of mobile and web-based telecommunication tools for patient education in HD, thereby providing a clearer evidence base to inform telecommunication-driven health systems. This review provides a clearer evidence base to inform the design and optimization of information and communication technology (ICT)-enabled and telecommunication-driven health systems for HD care.

2. METHODS

2.1. Design, location, time

This review adhered to the preferred reporting items for systematic reviews and meta-analyses (PRISMA) guidelines, but this review was not registered in the International Prospective Register of Systematic Reviews (PROSPERO) database. A meta-analysis was not performed because of substantial heterogeneity across studies in intervention design, delivery mode, duration, populations, and outcome measures. A comprehensive search was conducted to identify original studies that met the following inclusion criteria: (i) experimental studies, including randomized controlled trials (RCTs), quasi-experimental studies, pilot/feasibility studies, and study protocols; (ii) participants undergoing HD; (iii) interventions utilizing mobile and/or web-based telecommunication technologies for patient education or self-management support; (iv) articles available in full text; (v) articles published between January 2016 and August 2025; and (vi) articles written in English or Indonesian.

The literature search was conducted using both free-text and controlled vocabulary (MeSH) terms. The complete search strategy was conducted in August 2025 with keywords: ("Renal Dialysis" [MeSH] OR HD OR hemodialysis OR "renal replacement therapy") AND ("Telemedicine" [MeSH] OR telehealth OR telemedicine OR "mobile health" OR mHealth OR "smartphone application" OR "mobile application" OR SMS OR "text messaging" OR "web-based intervention*" OR "digital health") AND ("Patient Education as Topic" [MeSH] OR "patient education" OR "self-management" OR self-care OR adherence OR compliance). Equivalent search terms and combinations were adapted for ScienceDirect and Google Scholar according to each database's search requirements. The variables extracted from the selected studies were patient educational outcomes, behavioral adherence indicators, and relevant clinical markers. All included studies were explicitly classified into: (i) RCTs, (ii) quasi-experimental studies, (iii) pilot/feasibility studies, and (iv) study protocols.

2.2. Sampling

The selection of studies was guided by the population, intervention, comparator, outcome, and study design (PICOS) framework. The inclusion criteria were: (i) studies conducted in patients receiving maintenance HD; (ii) interventions employing mobile or web-based telecommunication technologies including smartphone applications, SMS messaging, video conferencing, or online platforms; (iii) comparison with standard care or non-digital educational approaches; (iv) outcomes specifically assessing the effectiveness of telecommunication-based education, improvements in patient knowledge, self-management behavior, treatment adherence, satisfaction, and clinical parameters, and (v) full-text availability published between 2016 and 2025. Studies involving non-HD populations (e.g., CKD non-HD, peritoneal dialysis, transplant) were excluded. Studies were excluded if they combined digital education with unrelated health technologies. If mixed populations were reported, only HD-specific data were extracted, or the study was analyzed separately.

2.3. Data collection

We independently carried out a systematic search across four electronic databases. The process included initial identification of articles, title and abstract screening, and retrieval of full-text publications that were potentially relevant. Each record was reviewed and documented according to inclusion criteria. Data from the included experimental studies were extracted systematically together, covering author information, publication year, country, study population, intervention and control conditions, as well as the main outcomes. Telecommunication-based interventions were coded and categorized according to: (i) technology modality (mobile app, SMS, web-based, video conferencing, hybrid); (ii) delivery format (synchronous vs asynchronous); (iii) behavioral strategy (reminder, feedback, self-monitoring, motivational, or combined); and (iv) content focus (diet, fluid, medication, symptom monitoring, or comprehensive self-management). Any disagreements in coding were resolved by consensus.

2.4. Data analysis

The quality appraisal of the included full-text studies was conducted using the Joanna Briggs Institute (JBI) critical appraisal checklist for quasi-experimental and randomized controlled trials, encompassing multiple evaluation domains to assess methodological rigor and potential bias. Each study was categorized as low, moderate, or high risk of bias. Each study was systematically assessed and compared based on key characteristics, including the authors, year of publication, country, study population, types of telecommunication media (mobile- or web-based), intervention features, and the main educational or clinical outcomes related to patient health education in HD. The quality assessment directly informed data interpretation through narrative weighting of higher-quality evidence and sensitivity comparison between high- and non-high-risk studies.

3. RESULT

3.1. Characteristics of study

A systematic literature search was conducted across six databases: PubMed, Google Scholar, Springer, Omission of IEEE, Scopus, and ScienceDirect. Total of 15 articles were included, originating from various countries. Most of the included studies were conducted in Asia, particularly in Iran, China, Thailand, Japan, South Korea, and Turkey. Several studies were also carried out in Australia, while additional evidence came from the United States, the Netherlands, and Poland. Overall, the distribution of studies demonstrates broad geographical diversity, with a clear predominance of research from Asia and Australia, alongside contributions from North America and Europe. This diversity provides a broad international perspective on the research topic.

From an initial search yielding 4,880 records, a systematic screening process was carried out to identify studies evaluating mobile- and web-based telecommunication interventions for HD education. After eliminating 412 duplicate entries, 4,464 records proceeded to title and abstract screening, during which 4,407 were excluded for irrelevance, non-HD populations, or non-experimental designs. A total of 62 full-text articles were then assessed, and 43 were excluded due to insufficient methodological detail, inappropriate intervention type, or not meeting telecommunication criteria. Ultimately, 15 studies met all eligibility requirements and were included in this review.

Figure 1 shows that application-based interventions dominate smartphone-based self-management applications (47%), non-internet based 14%, while telehealth, web-based, and audiovisual-social media each represent 13%. This indicates that mobile applications are the most used media in the reviewed studies. A trend toward mobile and web-based interventions, reflecting the increasing feasibility and accessibility of digital technologies for health communication. Meanwhile traditional media, such as SMS and telephone, were still employed for certain interventions, particularly when simplicity and direct contact were prioritized to HD patients.

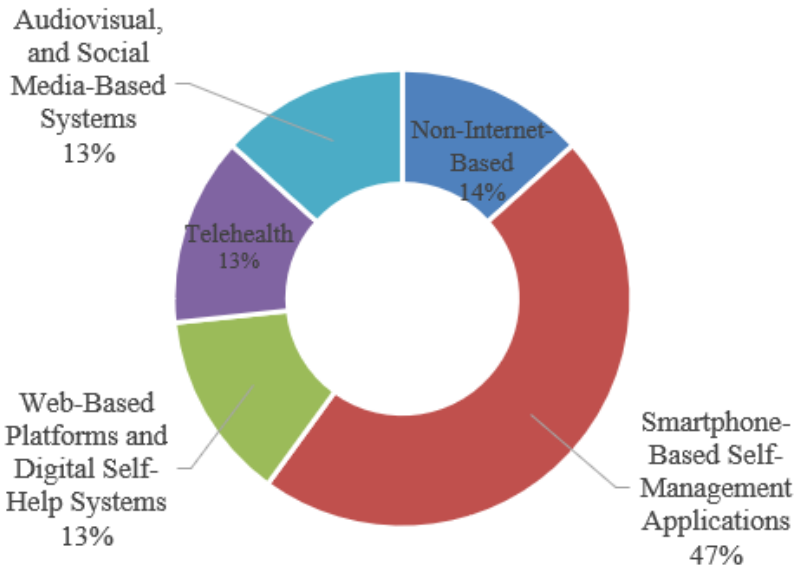


Figure 1. Distribution of studies by tech-media

3.2. Quality appraisal

Most studies demonstrated a low risk of bias, with the majority meeting all 9 criteria in the JBI appraisal checklist (Table 1). These studies consistently showed strong adherence to methodological standards across domains, including participant selection, intervention clarity, and statistical analyses. A smaller proportion of studies exhibited a moderate risk of bias, typically due to issues in D3 (confounding factors) and D4 (similarity of participants in comparison groups), as well as occasional unclear reporting in D2 or D8. Despite these limitations, the methodological weaknesses were not severe enough to invalidate the findings but do indicate areas where reporting and methodological transparency could be improved.

Table 1. Quality appraisal of included study using JBI critical appraisal checklist

No	Author (Year)	D1	D2	D3	D4	D5	D6	D7	D8	D9	Overall appraisal
1	Arad *et al.* (2021) [14]	L	L	L	L	L	L	L	L	L	Low risk of bias (9/9 criteria met)
2	Pungchompoo *et al.* (2024) [19]	L	L	L	L	L	L	L	L	L	Low risk of bias (9/9 criteria met)
3	Hayashi *et al.* (2017) [21]	L	L	H	UC	L	L	L	L	L	Moderate risk of bias (7/9 criteria met)
4	Chen *et al.* (2024) [16]	L	L	L	L	L	L	L	L	L	Low risk of bias (9/9 criteria met)
5	Ni *et al.* (2019) [22]	L	L	H	UC	L	L	L	L	L	Moderate risk of bias (7/9 criteria met)
6	El Khoury *et al.* (2021) [23]	UC	L	H	H	L	L	L	L	L	Moderate risk of bias (6/9 criteria met)
7	Flythe *et al.* (2025) [24]	L	L	L	L	L	L	L	L	L	Low risk of bias (9/9 criteria met)
8	Duman and Karadakovan (2024) [25]	L	L	L	L	L	L	L	L	L	Low risk of bias (9/9 criteria met)
9	Nadort *et al.* (2024) [20]	L	L	L	L	L	L	L	L	L	Low risk of bias (9/9 criteria met)
10	Stevenson *et al.* (2019) [26]	L	UC	H	UC	L	L	L	L	L	Moderate risk of bias (6/9 criteria met)
11	Gouda *et al.* (2025) [27]	L	L	H	UC	L	L	L	L	L	Moderate risk of bias (7/9 criteria met)
12	Torabikhah *et al.* (2023) [28]	L	L	L	L	L	L	L	L	L	Low risk of bias (9/9 criteria met)
13	Khah *et al.* (2023) [15]	L	L	L	L	L	L	L	L	L	Low risk of bias (9/9 criteria met)
14	Kowal *et al.* (2023) [29]	L	L	L	L	L	L	L	L	L	Low risk of bias (9/9 criteria met)
15	Isautier *et al.* (2022) [30]	L	L	L	L	L	L	L	UC	L	Low risk of bias (8/9 criteria met)

This review (Table 2) demonstrates that telecommunication systems ranging from basic modalities such as telephone calls and SMS to more advanced platforms including smartphone applications, telehealth video services, and web-based interfaces are increasingly central to the delivery of supportive care for patients undergoing HD and individuals with CKD. This technological evolution reflects a shift from passive toward more interactive and integrated digital health. The evidence highlights the potential of telecommunications to enhance self-management, strengthen patient provider communication, and improve continuity of care across diverse settings. Across the 15 included studies, interventions were grouped into five thematic categories based on their communication structure and level of interactivity.

3.3. Telecommunication medias

3.3.1. Non-internet-based telecommunication

Two studies used telephone calls and SMS as stand-alone interventions (Table 2). These systems primarily deliver reminders and brief educational messages. Arad *et al.* [14] combined scheduled nurse-led phone calls with daily SMS over three months and reported significant improvements in adherence to fluid, diet, and biochemical markers such as creatinine, phosphate, and Kt/V. Similarly, Stevenson *et al.* [26] found high feasibility and satisfaction with a six-month SMS reminder program. However, these approaches were limited to one-way communication and lacked real-time feedback or behavioral monitoring, restricting personalization and long-term engagement.

Table 2. Non-internet-based telecommunication: telephone and SMS

Author (year)	Country	Study population	Media	Communication model	Key findings	Lack of studies
Arad *et al.* (2021) [14]	Iran	66 HD patients (33 intervention, 33 control)	Telephone and SMS	3-month nurse-led education + follow-up (2×/week calls for 20 min, daily SMS × 90 days) on diet, meds, and fluid restriction adherence.	↑ Adherence, ↑ labs (Kt/V, P, Alb)	Short-term, limited interactivity
Stevenson *et al.* (2019) [26]	Australia	130 adult patients undergoing maintenance HD	SMS one-way (non-internet)	KIDNEYTEXT: 6-month SMS-based program sending 3 weekly messages tailored to renal diet, lifestyle modification, and adherence motivation.	↑ Engagement	No clinical outcomes

3.3.2. Smartphone-based self-management applications

Smartphone applications were the most frequently studied platform (Table 3). These apps typically incorporated education modules, self-monitoring, reminders, and feedback mechanisms. Hayashi *et al.* [21] and Chen *et al.* [16] reported improved self-management behaviors, adherence, and QoL through daily monitoring and two-way nurse feedback. Larger-scale systems such as the electronic patient-reported outcome measure (ePROM)-based SMaRRT-HD platform demonstrated improvements in health-related

quality of life (HRQoL) and reduced hospitalization. However, several studies noted low long-term engagement, limited personalization, and short follow-up periods.

Table 3. Smartphone-based self-management applications

Author (year)	Country	Study population	Media	Communication model	Key findings	Lack of studies
Hayashi *et al.* (2017) [21]	Japan	9 adult HD patients	Smartphone-based app	SMART-D: smartphone-based self-management app for daily monitoring of interdialytic weight gain (IWG), serum K, and P with data sent to medical staff for feedback.	↑ Self-management, ↑ QoL	Very small sample, short duration
Chen *et al.* (2024) [16]	South Korea	76 adult patients undergoing maintenance HD (38 intervention, 38 control)	Smartphone-based app	HD-mHealth: 12-week smartphone-based self-management app with education modules, BP/diet/fluid monitoring, and two-way nurse feedback and goal setting.	↑ Self-efficacy, adherence (fluid and diet), and IWG control, ↑ QoL and ↓ depressive symptoms	No long-term data
Flythe *et al.* (2025) [24]	United States	Up to 2400 HD patients	Smartphone-based app	ePROM system (SMaRRT-HD): monthly digital symptom monitoring with clinician follow-up vs usual care (routine monitoring without follow-up).	↑ HRQoL, ↓ hospitalizations	↓ Workflow integration
Torabikhah *et al.* (2023) [28]	Iran	70 adult HD patients randomized into mHealth group ($n = 35$) and FTF education group ($n = 35$)	Smartphone-based app	mHealth app "Di Care" – 12-week program with dietary and fluid management education, reminders, and self-monitoring vs FTF sessions.	↓ IDWG, ↓ TG, ↓ K	Short-term
Khah *et al.* (2023) [15]	Iran	70 adult HD patients randomly assigned to mHealth (micro-learning app) or FTF education for 1 month.	Smartphone-based app	mHealth app with micro-learning modules that is short, sequential education on treatment, diet, and medication adherence vs FTF sessions.	Both ↑ adherence and perception, ↑ engagement and sustained learning.	Short follow-up and no clinical outcomes
Kowal *et al*. (2023) [29]	Poland	841 app users (44% from two largest HD regions); 60 HD patients completed usability questionnaire	Smartphone-based app	Mobile dietary education app with food/recipe database and renal diet guidance, promoted online and in dialysis units.	↑ Usability	No clinical data
Isautier *et al.* (2022) [30]	Australia	384 adults receiving in-center or home-based HD or peritoneal dialysis from six health districts in Greater Sydney	Smartphone-based app	SUCCESS smartphone app that culturally tailored, 12-month mobile platform for dialysis self-management, including simplified education, self-assessment, and goal-setting.	Feasible	Protocol only

3.3.3. Web-based platforms and digital self-help systems

Web-based systems (Table 4) focused on education, symptom tracking, decision support, and guided self-management. El Khoury *et al.* [23] reported high usability and improved communication confidence using a web and mobile hybrid platform. In contrast, Nadort *et al*. [20] found no significant reduction in depressive symptoms using a guided web-based self-help program, despite moderate feasibility. These findings suggest that web-only systems may require stronger interactive and motivational components to achieve sustained clinical effects.

Table 4. Web-based platforms and digital self-help systems

Author (year)	Country	Study population	Media	Communication model	Key findings	Lack of studies
El Khoury *et al*. (2021) [23]	Australia	16 adults with ESRD on HD	Website and Smartphone based- app	MyKidneyJourney: 8-week web and mobile digital self-management system co-designed with patients and clinicians; included education, symptom tracking, provider communication, and behavior support modules.	↑ Satisfaction, ↑ awareness	No clinical outcomes
Nadort *et al*. (2024) [20]	Netherlands	190 chronic HD patients with depressive symptoms (BDI-II ≥ 10) from 9 hospitals	Website	Guided internet-based self-help (5 PST modules) with asynchronous coach feedback vs. care-as-usual (CAU).	No significant ↓ depression	↓ Personalization, no real-time interaction, ↓ motivational support

3.3.4. Telehealth and videoconference-based care

Telehealth systems incorporating video consultations and remote monitoring were reported in four studies (Table 5). Pungchompoo *et al*. [19] demonstrated improvements in QoL and biochemical outcomes using a home telehealth system combining video visits and web monitoring.

Table 5. Telehealth and videoconference-based care

Author (year)	Country	Study population	Media	Communication model	Key findings	Lack of studies
Pungchompoo *et al*. (2024) [19]	Thailand	54 older people living with HD (≥ 60 years)	Telehealth and web application	6-month integrated home telehealth (iPad + web app): video visits, online monitoring, phone/live counseling, and web-based education.	↑ Mental health-related QoL, ↑ Hb, ↑ Kt/V	Low digital literacy
Ni *et al*. (2019) [22]	China	8,392 maintenance HD patients	Telehealth using WeChat	Telehealth-based dialysis registration system via WeChat for real-time anemia monitoring with automated Hb/Hct reports and physician alerts.	↑ Hemoglobin	Limited patient engagement

3.3.5. Audiovisual and social media-based systems

Innovative formats included video education and social media platforms such as LINE and WeChat (Table 6). These interventions improved knowledge, engagement, and selected behavioral outcomes. Ni *et al*. [22] demonstrated improved anemia monitoring through WeChat. Nevertheless, most lacked analytics, personalization, and long-term outcome data.

Table 6. Audiovisual, gamified, and social media-based systems

Author (year)	Country	Study population	Media	Communication model	Key findings	Lack of studies
Duman and Karadakovan (2024) [25]	Turki	48 adults undergoing maintenance HD (26 intervention, 22 control)	Video-based Educational	Educational video program: 1 video/session (3×/week) for 12 weeks on HD management, symptom coping, and lifestyle; control received standard care.	↑ QoL, ↓ symptoms	↓ Interactivity and feedback
Ni *et al.* (2019) [26]	China	8,392 maintenance HD patients	Telehealth using WeChat	Telehealth-based dialysis registration system via WeChat for real-time anemia monitoring with automated Hb/Hct reports and physician alerts.	↑ Hemoglobin	Limited patient engagement

3.4. Communication type and outcome effectiveness

Interventions using two-way communication models that integrated mobile applications with clinician feedback demonstrated higher patient engagement, greater behavioral change, and better long-term potential compared with one-way systems. In contrast, one-way approaches such as SMS reminders and

video-based education showed only moderate engagement and limited effects on behavior change, with low sustainability over time. These findings (Tables 7 and 8) highlight the importance of interactive, feedback-driven digital platforms in supporting sustained self-management among HD patients.

Table 7. Communication type and outcome effectiveness

Communication type	Behavioral and educational outcomes	Biochemical dialysis indicators	Sustainability
Smartphone app (2-way)	High [16], [28]	High [21], [28]	Moderate
Telehealth (live)	High [19]	Moderate [19], [22]	Moderate
Web-based (async)	Low [20]	Rare	Low
SMS/telephone (1-way)	Low-moderate [26]	Rare	Low
Video-based (1-way)	Low-moderate [25]	Not reported	Low

Table 8. Communication model × sustainability

Model	Engagement	Behavior change	Long-term potential
One-way (SMS, video)	Moderate	Low	Low
Two-way (app + clinician)	High	High	Moderate–High

3.4.1. Behavioral and self-management outcomes

There was highly improved adherence to diet and fluid restrictions were observed in multi-component and two-way systems. Arad *et al.* [14], Chen *et al.* [16], and Torabikhah *et al.* [28] all reported improved dietary and fluid adherence following mobile app–based or nurse-supported interventions. In contrast, the one-way SMS system by Stevenson *et al.* [26] increased engagement but did not assess clinical adherence outcomes. In other side, there was improved psychosocial well-being was mainly seen in telehealth and interactive systems. Pungchompoo *et al.* [19] reported higher mental health–related QoL, while Duman *et al.* [25] showed improved QoL and symptom control using video-based education. Conversely, Nadort *et al*. [20] found no significant reduction in depression using a web-based self-help system without real-time interaction. Meanwhile, Saengyo *et al*. [31] reported increased nutritional knowledge and dietary behavior using Line-based tele-counseling. El Khoury *et al*. [23] observed improved awareness and satisfaction with a web-mobile self-management system, while Kowal *et al.* [29] demonstrated high usability but no clinical outcomes.

3.4.2. Biochemical dialysis indicators

High improvement in biochemical marker and dialysis adequacy was reported. Arad *et al.* [14] showed improved Kt/V, serum phosphorus, and albumin after a 3-month nurse-led SMS and telephone program and Hayashi *et al.* [21] reported reductions in IDWG, serum potassium, and phosphorus using the SMART-D smartphone app. Similarly, Chen *et al.* [16] observed better fluid and diet adherence, IWG control, and QoL, along with reduced depressive symptoms using a smartphone-based self-management platform. Torabikhah *et al*. [28] also demonstrated reductions in IDWG, triglycerides, and potassium after 12 weeks of app-based education. In other side, telehealth systems also improved anemia and dialysis adequacy. Ni *et al.* [22] reported significant increases in hemoglobin through a WeChat-based monitoring system, while Pungchompoo *et al.* [19]found improved hemoglobin and Kt/V after 6 months of home telehealth [19], [22]. Flythe *et al*. [24] also demonstrated reduced hospitalizations and improved HRQoL through the SMaRRT-HD digital symptom monitoring system. High acceptability was reported for smartphone platforms [23], [29], [30]. Low digital literacy [19] and restricted interactivity [25], [26] were frequently reported barriers. These findings suggest that telecommunication interventions may contribute not only to educational outcomes but also to measurable improvements in clinical management and dialysis-related indicators.

3.4.3. Feasibility, acceptability, and user engagement

Several studies focused primarily on feasibility and implementation outcomes. Kowal *et al.* [29] demonstrated high user acceptance of a dietary education application, while El Khoury *et al.* [23] reported increased awareness and satisfaction with a web-mobile self-management system [23], [29]. Despite these positive findings, several implementation barriers were identified. Common limitations included low digital literacy among older adults, declining long-term engagement, workflow integration challenges, and limited personalization features [19]. These barriers may affect the scalability and sustainability of telecommunication interventions in routine HD care.

3.5. Comparative analysis of communication models

The effectiveness of telecommunication interventions appeared to be strongly influenced by the communication model employed. Across studies, two-way communication systems involving clinician feedback consistently demonstrated greater effectiveness than one-way approaches [24]. Applications integrating self-monitoring, personalized feedback, and clinician interaction achieved higher engagement, stronger behavioral change, and better clinical outcomes. Conversely, one-way interventions such as SMS reminders and educational videos primarily improved knowledge and engagement but produced limited evidence of sustained behavioral or clinical improvements [14], [32]. These findings indicate that interactivity and feedback mechanisms may represent key determinants of successful telecommunication-based interventions for HD patients.

4. DISCUSSION

Conventional media including telephone follow-ups and SMS messaging in previous studies, have demonstrated clear benefits in enhancing treatment adherence and patient engagement [6], [14]. Telephone counselling and scheduled SMS reminders were shown to improve attendance, fluid management and overall compliance but these gains are typically short-term and difficult to maintain [14]. However, when compared with more interactive digital platforms, the effectiveness of conventional media appears to be largely dependent on external prompting rather than active patient participation. These interventions primarily function as behavioral cues that encourage adherence to recommended practices but provide limited opportunities for self-monitoring, personalized feedback, or shared decision-making.

In low-resource or low-literacy settings, SMS appears more effective not because it is behaviorally superior, but because it is simple, familiar, and imposes minimal cognitive and technical burden, lowering the threshold for participation. However, SMS does not foster independent self-management [27], [33]. Their accessibility may explain why positive behavioral effects are consistently reported despite relatively limited technological capabilities. Nevertheless, the available evidence suggests that improvements achieved through SMS and telephone-based approaches are often less comprehensive than those observed with smartphone applications or telehealth systems, which can simultaneously support education, monitoring, feedback, and clinician interaction.

Their reliance on one-way communication, absence of real-time feedback, and short implementation periods limit their capacity to support sustained lifestyle modification or complex clinical decision-making [34]. This pattern suggests that conventional telecommunication tools are most effective as entry-level interventions or complementary components within broader digital care pathways rather than as standalone long-term self-management strategies. The mechanisms through which one-way text or call reminders translate into long-term self-management remain unclear, and the lack of interactive feedback likely constrains deeper behavior changes [32], [34]. Most SMS-based interventions also lack adaptive and personalized features, further reducing their potential to foster long-term engagement [35]. Consequently, such interventions are better positioned as entry-level or transitional tools within a stepped digital care model, rather than as standalone solutions for long-term chronic disease management especially HD.

Mobile health applications demonstrate broader and more consistent benefits across behavioral, psychosocial, and biochemical outcomes, including self-efficacy, interdialytic weight gain, QoL, and relevant laboratory markers. Unlike telephone- or SMS-based interventions that primarily provide reminders, mobile applications integrate multiple functions, including self-monitoring, education, goal setting, and clinician feedback, enabling patients to take a more active role in managing their condition. This combination of features may explain the wider range of positive outcomes reported across studies [2], [18], [19]. These advantages arise because apps shift patients from passive recipients of reminders to active interpreters of their own health data, reinforcing self-regulation and perceived control. Across diverse settings, these applications consistently integrate monitoring, education, and bidirectional communication as core mechanisms of action. Recent studies suggest that even brief exposure to digital self-tracking and feedback can enhance patients' awareness of fluid, diet, and symptom control [21], [28]. In smaller studies such as Hayashi *et al.* [21] and Torabikhah *et al.* [28] were limited by short follow-up periods and small sample sizes, indicating that observed behavioral improvements may represent heightened monitoring effects rather than sustained habit formation. This pattern suggests that without long-term behavioral integration, digital gains risk remaining reactive rather than transformative.

Meanwhile larger and more scalable platforms such as SMaRRT-HD in Flythe *et al.* [24] study and the SUCCESS app in Isautier *et al.* [30] study, extend this model by embedding symptom reporting and culturally tailored education into routine care. These systems represent a shift from simple reminder tools to integrated telecommunication infrastructures that enable continuous patient and clinician interaction. Improvements in QoL and hospitalization outcomes indicate effects beyond self-perception, yet limited workflow integration and lack of long-term data reveal a persistent gap between technological potential and

clinical sustainability. Compared with smaller stand-alone interventions, these platforms highlight the potential for digital technologies to support population-level management while maintaining individualized care. The observed improvements in health-related QoL and reductions in hospitalization suggest that the benefits of mobile applications may extend beyond adherence-related outcomes and contribute to broader aspects of chronic disease management [15], [29]. This contrast reinforces that usability alone is insufficient without clinical integration and feedback-driven decision support.

In contrast to mobile-first interventions, web-based and hybrid platforms demonstrated greater variability in clinical impact. Systems such as MyKidneyJourney emphasized co-design, education, and symptom tracking, and were perceived as acceptable and empowering [23]. Similarly, the guided web-based problem-solving intervention evaluated by Nadort *et al.* [20] failed to significantly reduce depressive symptoms. These null findings suggest that asynchronous systems lack the emotional immediacy and accountability needed to sustain psychosocial change [36]. Molnar *et al.* [37] also reported no improvements due to low usage and poor personalization. This indicates that failure often stems from weak engagement architecture rather than from content alone.

Telehealth models that integrate synchronous communication and clinical monitoring appear to generate the most consistent improvements in both psychosocial and biomedical outcomes. The home-based telehealth system evaluated by Pungchompoo *et al.* [19] illustrates how combining video consultations, remote monitoring, and web-based education can move beyond reminder-based care toward continuous care and resulting in improvements in mental health related QoL and dialysis adequacy. In a much larger population, Ni *et al.* [22] demonstrated that adding telecommunication within routine clinical workflows through automated anemia surveillance and physician alerts can significantly improve clinical control at scale even patient engagement is limited. These systems succeed because they close the feedback loop between patient behavior and clinical response, reinforcing accountability and shared decision-making. Across all technologies, engagement and behavioral integration, not technical sophistication, determine success. Low digital literacy, limited access, and declining engagement remain major barriers, especially among older adults and low-resource populations [7], [17].

Audiovisual and social media-based telecommunication tools illustrate how engagement strategies and cultural familiarity can enhance the reach of digital health interventions, yet their clinical impact remains uneven. These platforms were effective for nutrition counselling, anemia monitoring and caregiver engagement, with measurable improvements in knowledge, behavior and treatment monitoring [5], [8]. In contrast, interactive platforms such as Line and WeChat combined familiarity with two-way communication, improving both behavior and biomedical outcomes. The video-based program by Duman *et al.* [25] demonstrates that repeated audiovisual exposure can reduce symptom burden and improve QoL. However, its one-way format and lack of feedback mechanisms limit its capacity to support individualized self-management. The absence of clinical endpoints reinforces that cognitive and attitudinal gains alone do not ensure physiological change. In contrast, social media–based platforms such as Line and WeChat demonstrate existing communication ecosystems can improve feasibility, scalability, and user acceptance. Saengyo *et al.* [31] reported that Line-based caregiver intervention successfully improved dietary knowledge and behaviors through interactive counseling, indicating that familiarity and two-way communication can strengthen behavior change. Meanwhile, the large-scale WeChat anemia monitoring system by Ni *et al.* [22] achieved significant biomedical improvements through automated surveillance and clinician alerts. Overall, the evidence suggests that technology does not change behavior by itself, but it reshapes the environment in which self-regulation either becomes easier or fails.

Beyond individual study findings, a clear gradient of effectiveness emerged across telecommunication modalities. Interventions relying solely on one-way communication, such as SMS reminders and educational videos, were generally effective in improving awareness, engagement, and short-term adherence but showed limited evidence for sustained behavioral or clinical improvements. In contrast, smartphone-based applications and telehealth platforms that incorporated self-monitoring, personalized feedback, and clinician interaction consistently demonstrated broader benefits across behavioral, psychosocial, and biochemical domains. This pattern suggests that the effectiveness of telecommunication interventions is determined less by the technology itself and more by the degree of interactivity, feedback integration, and support for self-regulation. Technologies that actively involve patients in monitoring and interpreting their own health data appear more capable of promoting sustained self-management than passive information-delivery systems.

The findings further support a conceptual continuum of digital care in HD. At the basic level, reminder-based systems function primarily as behavioral prompts [17]. At an intermediate level, educational and self-monitoring applications facilitate patient engagement and self-awareness [21], [32]. At the highest level, integrated telehealth ecosystems combine monitoring, feedback, clinician involvement, and decision support, creating continuous feedback loops that strengthen self-efficacy, adherence, and clinical

management. This continuum may explain why interventions with similar educational content often produce different outcomes, as effectiveness appears to depend on the extent to which the technology supports ongoing interaction and collaborative care rather than information delivery alone.

This conceptual shift is captured on Figure 2 that demonstrates that telecommunication technologies do not directly improve health outcomes. User engagement and self-regulation mediate their effects, and core system features such as communication mode, interactivity, monitoring, feedback, and clinician integration shape these processes [38]. When these features enable continuous feedback loops and collaborative care, they strengthen self-efficacy, adherence, and sustained use, which then drive meaningful clinical and psychosocial improvements, including changes in biomarkers, symptom burden, and QoL [39]. These behavioral gains generate system-level benefits such as continuity of care, improved access and equity, and greater service efficiency only when healthcare systems embed them within routine clinical workflows [40]. However, telecommunication technologies evolve rapidly, which may limit the long-term relevance of current platforms, while emerging artificial intelligence (AI)-based systems show promise in supporting personalization, early risk detection, and real-time clinical decision support [41], [42]. This confirms that digital health functions as a socio-technical system rather than a standalone technological tool.

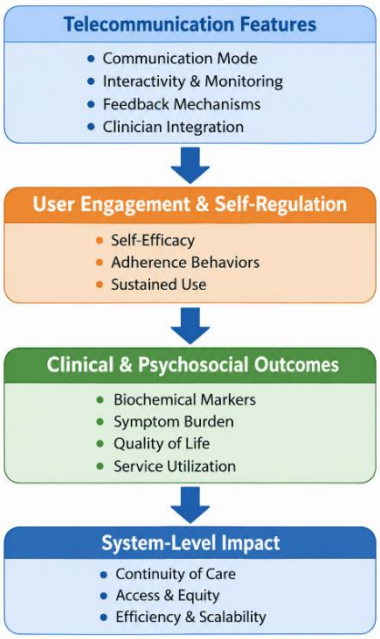


Figure 2. Conceptual model of telecommunication-driven self-management in HD

5. LIMITATION OF STUDIES

Substantial heterogeneity in intervention design, communication models, and outcome measures limited comparability across studies and precluded meta-analysis. Most interventions were short-term, single-center, and involved small samples, with no long-term follow-up evaluation and restricted conclusions about sustainability. Several studies showed moderate risk of bias due to unclear randomization, limited control of confounders, and poor reporting of engagement data. Publication bias was not assessed, and differences in digital literacy, internet access, and device availability further reduced generalizability, particularly among older and underserved populations. Despite following PRISMA guidelines and employing a structured search strategy, this review has several limitations such as review was not prospectively registered in PROSPERO and only articles published in English and Indonesian were included.

6. CONCLUSION

Telecommunication interventions show potential to support self-management in HD care, but their effectiveness depends more on the level of interactivity and clinical integration than on the technology itself. According to the studies, interactive systems incorporating self-monitoring, clinician feedback, and bidirectional communication generally demonstrated more consistent benefits than one-way approaches such as SMS reminders or educational videos. However, the overall strength of evidence remains moderate due to

substantial heterogeneity, short follow-up periods, and the predominance of small or single-center studies. Current evidence therefore supports telecommunication technologies as complementary tools within routine HD care rather than standalone solutions. Future research should prioritize adequately powered, long-term studies with standardized outcomes to determine their sustainability, comparative effectiveness, and integration into clinical practice.

Future research should prioritize the development of standardized, scalable, and patient-centered digital care models that integrate education, self-monitoring, and two-way clinician communication because rapid technological evolution may limit relevance over time. The promising use of AI, such as automated symptom interpretation, risk alerts, and personalized recommendations, may enhance adherence, clinical responsiveness, and patient engagement when supported by validated and ethical data sources. Addressing digital literacy gaps, improving access to technology, and incorporating culturally tailored, adaptive content will be essential to ensure equity across diverse patient populations. In addition, hybrid platforms (mobile, web, and telehealth), caregiver involvement, and integration with electronic health records should be evaluated through large, multicenter randomized trials with long-term follow-up and economic analyses to strengthen clinical applicability.

ACKNOWLEDGMENTS

The authors extend their gratitude to the Postgraduate Program of Electrical Engineering, Faculty of Engineering, Universitas Negeri Surabaya, Surabaya, Indonesia for the academic support and resources that made this review. This article was written to fulfill the academic requirements for graduation. The authors also express their sincere appreciation to all researchers whose studies provided the foundation for this review.

FUNDING INFORMATION

This study received no specific grant from any public, commercial, or not-for-profit funding agency.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
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Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

All participants agreed to the publication of the data and have no conflicts of interest to declare.

DATA AVAILABILITY

The authors confirm that all data supporting the findings of this systematic review are available within the article and its supplementary materials.

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