Available online at https://sextante-ensb.com

Revista Sextante

ISSN : 2665-3923

Volume: 34 Issue: 01 (2026)

Effectiveness of Nurse-Led Remote Patient Monitoring and Digital Health Interventions for Chronic Disease Management: Integrating Wearable Sensors, Telehealth Consultations, Patient-Reported Outcomes, Medication Adherence Assessment, and Longitudinal Clinical Monitoring for Improving Treatment Compliance and Health-Related Quality of Life

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Article History
Received September 19th, 2026
Accepted November 15th, 2026
Published November 27th, 2026

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Abstract
Prevalent, chronic diseases including type 2 diabetes, hypertension, heart failure, chronic obstructive pulmonary disease and chronic kidney disease mandate monitoring that can not be accomplished at episodic clinic visits, but which is continuous ongoing surveillance. Over the last decade, nurse-led remote patient monitoring (RPM) and digital health interventions, integrating wearable sensors, telehealth consultations, electronic patient-reported outcomes (ePROs), and medication adherence assessment, has emerged to fill these inter-visit gaps. This review brings together and discusses systematic reviews, meta-analyses, randomized trials and implementation evaluations to review the architecture, clinical effectiveness and sustainability of nurse-led digital chronic care. Successful programs function as closed socio-technical feedback loops in which nurses interpret transmitted data, deliver customized education and engage disease management services as appropriate. Multi-sensor wearable platforms detected impending heart failure decompensation about 11.5 days before clinical presentation. Compared to usual care, nurse-led interventions decreased HbA1c by an estimated 0.5 to 0.6 percentage points and systolic blood pressure by around 4 mm Hg; glycemic benefits declined after six months. Compared with usual care, nurse-led heart failure telemonitoring was associated with fewer hospitalizations (OR 0.70), while mortality benefits were mainly reported at 12 months. Generic health-related quality-of-life measures frequently generated null pooled effects, while disease-specific instruments, including the KCCQ and MLHFQ, and depression outcomes revealed greater benefits. Objective adherence reporting was uncommon, varied widely, and smart pillbox evidence largely pertinent to usability studies. Alert fatigue, lack of electronic health record interoperability, safety concerns, and variable cost-effectiveness limited implementation; all-or-none benefit far exceeded willingness-to-pay thresholds. Overall, nurse-led RPM is most effective when targeted at high-risk patients and supported by multi-parameter sensing, protocolized escalation, and integrated workflows. Future research should prioritize standardized adherence, quality-of-life, and long-term economic endpoints.

Keywords: nurse-led care; remote patient monitoring; digital health; wearable sensors; telehealth; patient-reported outcomes; medication adherence; chronic disease management; health-related quality of life

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1. Introduction

Global population aging and better survival rates from illnesses have led to a steady rise in chronic conditions such as type 2 diabetes mellitus (T2DM), hypertension, heart failure (HF), chronic obstructive pulmonary disease (COPD) and chronic kidney disease (CKD). These conditions are placing term clinical and economic pressure on health systems. It is estimated that 50% of patients who are prescribed long-term medications do not fully follow their treatment plans (Sabaté, 2003). However, adherence levels of 80% or higher are often used as benchmarks in adherence studies and industry reports, as they are considered necessary for achieving the therapeutic outcomes. Traditional outpatient appointments are spaced apart, creating long gaps between visits. During these gaps, patients may experience worsening health, symptom progression or medication non-adherence changes that often go unnoticed until the patient reaches the emergency department (Vest et al., 2017).

To close these gaps, remote patient monitoring has become increasingly common. This approach uses tools to transmit health data collected at home such as vital signs, behaviors or symptoms directly to clinicians. These data are then often combined with consultations. Nurses play a role in this process. Their training includes long-term monitoring of physiology, teaching patients how to manage their health, using motivational interviewing techniques, involving caregivers and following clinical protocols for escalation when needed. Studies that look at patient and caregiver experiences show that people appreciate the presence of a nurse. They see nurses as points of contact who build trust and encourage responsibility in home-based care (Noah et al., 2018).

Even though wearable biosensors, smart pillboxes and electronic patient-reported outcome systems are being adopted quickly, the integration of these technologies across diseases remains scattered. There is still no view across technologies, clinical goals or economic evaluations. It is difficult to separate the benefit provided by nurses from the benefit of simply transmitting device data. There are also differences in outcomes such as hospitalization rates and mortality that need to be aligned. In addition, there are real-world challenges around work processes and reimbursement models. These issues call for an comprehensive evaluation. This review brings together findings from peer-reviewed reviews, meta-analyses, clinical trials and implementation studies. It focuses specifically on nurse-led patient monitoring and digital chronic care ecosystems (Hailu et al., 2024).

2. Architecture of Nurse-Led Digital Health and Remote Patient Monitoring Ecosystems

When nurse-led remote care operates as a closed socio-technical feedback loop instead of passive hardware deployment, it is called high-performing. Following principles of Chronic Care Model, community-based programs include decisions, education, self-management assistance, plan out outcomes, and establish two-way communication with the patients and proactive nursing teams through tailored self-management support, decision support and planned regular longitudinal evaluation (Osterberg & Blaschke, 2005). All three sectors of remote monitoring ecosystems across economic evaluations are categorized by three levels of patient involvement: low participation with just automated device transmission, medium participation with professional involvement to avert complications such as nurse calls and questionnaires, and highly engaged active participation through strong methodology providing education, intensity work out, and e-learning(optimizing behavioral change and compliance) (Peterson et al., 2007).

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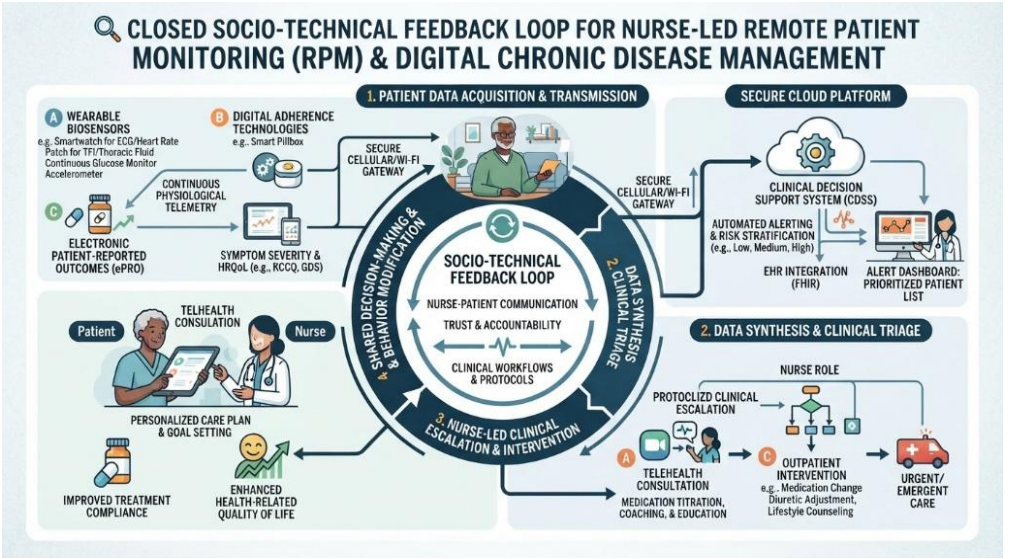

Figure 1: Conceptual Architecture of Nurse-Led Remote Patient Monitoring Ecosystem

2.1 Digital Modalities, Mobile Platforms, and Nursing Care Roles

A systematic review of 40 sole RCTs (44 papers; sample sizes 45–1,665, mean 205, SD = 266; participant ages 18–82 years) found that nurse-led remote digital support mainly employs websites (25%, 10/40) and mobile applications (25%, 10/40), followed by dedicated novel monitoring systems (23%, 9/40), short message service (SMS) text messaging (10%, 4/40), combined modalities (8%, 3/40), email (5%, 2/40), and video-based platforms (5%, 2/40) (Mauro et al., 2019). Longitudinal trial dynamics illustrate a shift from early-2000s videophones and basic web portals toward third-party and investigator-developed mobile applications and multi-component websites in recent years, with hybrid education-plus-messaging models growing rapidly from 2018 onwards. Mobile applications turned out to be the most successful digital modality with respect to all outcome domains investigated, and in older adults, video-based programs were found to be more effective than telephone-only, patients unless telephone contact paired with remote physiological monitoring (Ong et al., 2016).

Nursing support clustered into four operational workflows in the 40 trials within the sample. In 35% (14/40) of studies, nurses directly responded to data about patients' health including their blood glucose, BP, body weight, or depression symptoms that were transmitted via Health Hub devices (50%), web portal (29%), smartphones (14%), or landline interactive voice response (7%) to trigger follow-up via telephone calls (50%), SMS (14%), mobile app chat (14%), online messaging (7%), video-conferencing (7%), or mixed channels (7%) (Koehler et al., 2018). Another 33% (13/40) of studies integrated customized virtual health education to real-time online messaging (77% of these hybrid trials published from 2018 onward; Inge S. et al., 2015), 20% (8/40) administered scheduled or as needed virtual appointments, and 13% (5/40) provided either synchronous or asynchronous virtual health education. Contact frequency differed widely between trials: 28% (11/40) of trials adopted an as-needed intervention, 30% (8/40) daily, 20% (8/40) weekly, 10% (4/40) twice weekly, 2.5% (3/40) a mix of scheduled and on-demand intervention, 2.5% (3/40) biweekly or less, and 7.5% (3/40) of which consisted of nurse-generated digital without direct contact (Inglis et al., 2015).

2.2 Wearable Biosensors and Longitudinal Physiological Telemetry

A newly developed and present-day method of remote methods for patients determined to respond well to management based upon telemetry (either passive or active) study: first-generation telemonitoring heavily relied on home BP cuff, glucometer and weight scale episodic measurements, or manual patient entry of data. Current non-invasive RPM architectures increasingly incorporates wearable biosensors which can track its continuous or nocturnal physiology before symptoms even become noticeable. Advancements wearable biosensors now let us capture continual

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data in the remote period before manifestation of symptoms (Chaudhry et al., 2010). In heart failure care, activity monitors such as wearable accelerometers measure reductions in physical activity associated with hospitalization while wearable electrocardiogram (ECG) recorders, photoplethysmography (PPG) sensors, smartwatches, and wearable defibrillators surveil rhythm changes and rising nocturnal heart rates that may foreshadow imminent decompensation (Chaudhry et al., 2010).

Highlights: Wearable thoracic fluid content and thoracic fluid impedance (TFI) sensors are a non-invasive way to keep an eye on the signs of fluid buildup in the lungs for outpatient management. Demonstrated predictive power: the combining of multi-sensor algorithms; the MUSIC SICTH in MAwsT StTting ofHfOLD in Usai ALARM. In a clinical trial (MUSIC), a model that incorporated TFI, electrocardiographic waveforms, and accelerometer-derived physical activity effects could have detected acute decompensated heart failure (ADHF) events on average 11.5 days before they presented clinically, with a sensitivity of 63 percent and a specificity of 92 percent (Elechi et al., 2025). This approach might offer nearly two weeks of pre-symptomatic detection ahead of admission, providing a critical opening for nurse-led clinical review and prompt outpatient intervention (Hajat & Stein, 2018).

2.3 Electronic Patient-Reported Outcomes and Symptom Surveillance

Electronic patient-reported outcome (ePRO) systems, which are often used alongside passive physiological telemetry, gather structured patient evaluations of symptom severity, functional status, and psychological well-being between routine clinic visits (Parikh et al., 2023). Digital ePRO surveys administered weekly in oncology settings, for instance, for a duration up to one year are considered a physical barrier to prompt, all-encompassing symptom reporting by clinicians. Functional status and HRQoL are monitored through several validated patient-reported instruments like the KCCQ, MLHFQ, EQ-5D; SF-36; SGRQ; and GDS across studies of RPM trials in chronic cardiovascular, respiratory, renal and neurological conditions. In contrast, randomized evidence on the added clinical value of independent and weekly ePRO alert systems within nurse-led cardiometabolic, respiratory, or renal RPM versus oncology is still inconclusive (Awadallah et al., 2026).

Table 1. Typology of Nurse-Led Digital Intervention Modalities, Nursing Roles, and Sensor Architectures

Ecosystem Dimension	Specific Modalities and Components	Observed Distribution or Capabilities	Key Clinical and Operational Implications
Primary digital platforms	Mobile apps, websites, novel monitoring hubs, SMS, video platforms, email	Across 40 RCTs: websites 25%, mobile apps 25%, novel hubs 23%, SMS 10%, combined 8%, video 5%, email 5%	Mobile apps yielded the strongest overall effectiveness; video outperformed audio-only outreach in older adults
Nursing intervention models	Alert-driven data response, virtual appointments, virtual education, hybrid education + chat	Across 40 RCTs: incoming data response 35%, combined education + chat 33%, virtual appointments 20%, education only 13%	Hybrid models combining education and real-time messaging expanded sharply from 2018 onward
Contact and transmission cadence	Automated continuous upload, manual entry, scheduled outreach, ad-hoc alert triage	Contact frequency: as-needed 28%, daily 20%, weekly 20%, twice weekly 10%, scheduled + ad-hoc 7.5%, ≤biweekly 7.5%, content only 7.5%	Automated upload supported 82.7%–90% device adherence, whereas manual entry creates user burden
Wearable and physiological sensors	Accelerometers, wearable ECG/PPG, smartwatches, wearable defibrillators, TFI sensors, BP cuffs, glucometers, scales	Multi-sensor algorithm (TFI + ECG + accelerometry) predicted ADHF 11.5 days pre-presentation (63% sensitivity, 92% specificity)	Multi-parameter wearables identify pre-symptomatic decompensation earlier than episodic symptom or weight checks
Medication and symptom tracking	Electronic/cellular smart pillboxes, IR/ambient light pill sensors, ePRO surveys	Smart pillboxes cache offline openings and trigger outreach after missed-dose thresholds (e.g., >20% missed for 3 days)	Objective time-stamped dosing logs avoid self-report bias; structured ePRO protocols are best established in oncology

3. Medication Adherence Assessment and Digital Adherence Technologies

Still, objective assessment of treatment compliance remains an untapped area of research in telemonitoring trials. Adherence outcomes were among the few clinical endpoints reported by 12% (12/96) of interactive two-way telemonitoring trials included in a systematic review, and the heterogeneity of these definitions precluded a quantitative meta-analysis. In prospective trials that extracted electronically harvested device adherence, automated data upload

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achieved 82.7% adherence at 1 month and 90% at 12 months for two different cases vs. 81% at 1 month using manual upload (Leo et al., 2022). Combining telemetry with structured educational videos (Motivi system) also reduced missing data across six weeks vs no telemetry (Docobo system). Among nurse-led digital RCTs specifically reporting treatment compliance, only 50% (5/10) reported statistically relevant improvements ($p < 0.05$) and 50% (5/10) for no difference (Kilfoy et al., 2025), what more a heart failure telemonitoring meta-analysis detected the non-significant positive point estimate for medication compliance (OR 1.67, 95% CI 0.92–3.02). In a larger review of 14 adherence RCTs, multicomponent interventions that include structured behavioral follow-up showed significant 12-month increases in self-reported adherence (77.70% vs. 23.4%, $p < 0.001$) and Medication Adherence Report Scale (MARS) scores (7.68 vs. 4.47, $p < 0.001$) (Wang et al., 2024).

Digital adherence technologies log time-stamped compartment openings via infrared beams or ambient light sensors and send local LED, audible, or smartphone notifications (Cu et al., 2021). These technologies also substitute for retrospective self-report in objective dose level surveillance. In the ASCENT Project Technical Brief, multi-country tuberculosis implementation data evidenced very high patient usability, six-month battery life, offline event memory storage, and reusable electronics ($53.75 per kit, with 36 months of global mobile data). However, the impact of device size raised portability and stigma issues and the dependence on 2G cellular networks limited deployment in parts of the world (de Kruijf-Carter et al., 2023). A prototype automated pillbox obtained 98.6% dispensing accuracy, 98% sensor detection, a System Usability Scale Score of 84/100, and an absolute adherence increase of 3.3% over baseline (92.0% vs 88.7%; 95% CI 1.2%–5.4%) in laboratory and small-scale usability testing, however, yet another bench prototype found microcontroller clock drift for which you have to do regular cloud synchronization (Al-hussaniy & Oraibi, 2026).

Targeted demand and practical barriers in patient acceptability and transitional-care RCT findings. Odishi et al. (2026) examined the perspectives of people living in the healthcare systems of low- and middle-income countries (LMIC) on systems and programs to provide care to patients after hospital discharge, especially changing things that showed the greatest unmet need. Of our sample of 344 adults aged 40+ who were on ≥1 oral medication in primary care in Hong Kong, 49.1% reported that they accidentally missed at least one dose, and 70.6% were willing to use a free smart pillbox; patients with heart disease were more likely to use this technology (adjusted OR [aOR] 3.67), as were patients who reported that they had missed doses in the past (aOR 2.44), as were those who had a higher daily pill burden (aOR 1.16 per medication), as were those with higher income (aOR 2.30), but willingness to use was lower in older patients (aOR 0.95) (Sekhon et al., 2026). This is one of many technologies already on the market: fear of large, thick, preloaded devices, clinicians logging medication schedules, insurance early refills policies and dismanaged discharge workflow. A cluster-RCT (NCT03475030) of patients discharged home on five or more chronic medications (carried out by the Primary Care Research Centre), had the electronic pillboxes with each weekly in blister tray prefilled that – whenever a missed dose persisted beyond 20% for three consecutive days – sent out alerts for missed doses and alerted clinical pharmacists. In process evaluation, using the Consolidated Framework for Implementation Research (CFIR), major scaling barriers included device bulkiness, clinicians time to enter medication schedules, and<…> (Markle-Reid et al., 2023). Commercial platforms and industry announcements have marketed cellular pillboxes listed by the FDA and app-linked Remote Therapeutic Monitoring (RTM) services referencing CMS reimbursement codes, but no independent, multi-year peer-reviewed RCTs demonstrating that commercial RTM pillboxes actually cause improved clinical endpoints were found among the reported RCTs (Chartrand et al., 2023).

4. Clinical Effectiveness Across Major Chronic Conditions

Across chronic disease populations, nurse-led remote interventions produce their most consistent quantitative effects on intermediate cardiometabolic risk factors and heart failure hospitalizations, whereas all-cause mortality and disease-specific symptom outcomes depend heavily on follow-up duration, intervention protocol, and sensor architecture (Lee et al., 2022).

4.1 Cardiometabolic Disease: Type 2 Diabetes and Hypertension

I notice that diabetes and cardiovascular or hypertensive conditions make up the share of nurse-led digital randomized controlled trials. In a 2024 review, they represented 28 % (11 out of 40) of all trials and in a 2026 meta-analysis of 69 controlled trials, they were the largest disease groups. In the 2026 random-effects meta-analysis, which included nine randomized controlled trials, nurse-led self-management interventions lowered HbA1c by 0.53 percentage points compared with usual care (Vest et al., 2017). The mean difference was -0.53 %. The 95 % confidence

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interval ranged from -0.85 to -0.21. The p-value was 0.001. The heterogeneity statistic I^2 was 88.2 %. The Hartung-Knapp confidence interval extended from -0.89 to -0.16. Leave-one-out analyses consistently produced estimates from -0.40 to -0.59 percentage points (Krutke, 2025).

A 2025 meta-analysis of thirteen controlled trials, which included 2,294 patients with type 2 diabetes, looked at nurse-led telephone follow-up. It found that HbA1c fell by 0.59 percentage points, with a 95 % confidence interval from -0.85 to -0.34. The p-value was than 0.00001, I^2 was 87 % and Egger's test gave a p-value of 0.108. In contrast, a larger group of 96 studies that used interactive two-way telemonitoring showed a but still significant, reduction of 0.33 percentage points (95 % CI -0.57 to -0.09, $p = 0.008$, $I^2 = 99$ %) (Amjadi, 2026).

I see that the details of the intervention and how long the follow-up lasts can change how much HbA1c improves. In analyses of the 2025 telephone meta-analysis for type 2 diabetes, the biggest HbA1c drops happened with structured multi-component protocols that included medication, diet, exercise and glucose monitoring. Those protocols delivered sixteen follow-ups, had sessions that lasted 20 to 25 minutes and were scheduled every two weeks. They produced a difference of -0.92 % ($p = 0.02$). Sessions that lasted 20 to 25 minutes gave a difference of -1.23 % ($p < 0.001$). Biweekly intervals gave a difference of -1.29 % ($p = 0.03$). Also, protocols that had twelve sessions each week gave mean differences between -0.87 % and -0.93 %. On the hand, nurse-led telerehabilitation across five type 2 diabetes studies did not significantly affect HbA1c, showing a mean difference of 0.19 % (95 % CI -0.19 to 0.57, $p = 0.32$) (Zhang et al., 2024).

A key finding from the 2026 meta-analysis is that the effect of nurse-led interventions on HbA1c weakens over time. At six months or less, the mean difference was -0.71 % (95 % CI -1.19 to -0.24). After six months, the mean difference dropped to -0.22 % (95 % CI -0.46 to 0.02). The result was no longer statistically significant (Li et al., 2025).

In real-world and safety-net groups that serve. Minority people, nurse-led mobile health and remote management programmes still work well and improve HbA1c after 12 months. For example, the CHANGE 2 study showed mean HbA1c falling from 8.4 % to 7.8 % among 69 paired participants. Another study with 215 patients in a controlled design found that 12-month HbA1c was lower at 7.84 % compared with 9.45 % in a comparison group and new chronic complications were fewer at 8.0 % versus 29.9 % ($p < 0.001$) (Ruksakulpiwat et al., 2025).

When it comes to blood pressure, combined data from randomized controlled trials show a small but useful drop in blood pressure. Nurse-led self-management in five trials lowered blood pressure by 4.20 mm Hg (95 % CI -7.18 to -1.22, $p = 0.006$, $I^2 = 53.4$ %). The Hartung-Knapp interval was wider because there were a few trials. A larger set of two-way telemonitoring studies lowered blood pressure by 3.85 mm Hg (95 % CI -7.03 to -0.68, $p = 0.02$, $I^2 = 100$ %). In a subgroup of two community-based nurse-led telerehabilitation studies, systolic blood pressure fell by 10.48 mm Hg (95 % CI 2.68–18.28, $p = 0.008$) (Sutton et al., 2026).

4.2 Chronic Heart Failure and Acute Decompensation Prevention

Heart failure after leaving the hospital is a concern. 24% Of patients die within a year of being admitted. Nurse-led remote monitoring for heart failure usually involves tracking at home of weight, blood pressure, heart rate and symptoms. A nurse then reviews this information. Decides if a doctor needs to step in (Wang et al., 2024). A July 2026 meta-analysis in The Journal of Cardiovascular Nursing found that nurse-led remote monitoring cut heart failure hospitalizations compared with care (OR 0.70, 95% CI 0.48–0.85; $p < 0.01$). The pooled numbers for death (OR 0.64, 95% CI 0.41–1.01; $p = 0.05$), length of hospital stay (MD −0.42 days, 95% CI −1.22 to 0.38; $p = 0.31$) and emergency hospitalizations (MD −0.09, 95% CI −0.33 to 0.15; $p = 0.45$) were not statistically significant in that same analysis (Vest et al., 2017).

Looking at remote monitoring reviews helps explain why death and hospitalization results shift depending on how long you follow patients and what kind of sensors are used. In a review of 96 studies on two-way remote monitoring, death from any cause at 12 months dropped significantly (RR 0.71, 95% CI 0.56–0.89; $p = 0.003$; $I^2 = 0\%$). At 6 months, though, the death rate was not significant (RR 0.86, 95% CI 0.68–1.07; $p = 0.18$). Overall hospitalization showed a trend that was neutral to slightly up but not significant (RR 1.02, 95% CI 0.85–1.23; $p = 0.81$; $I^2 = 79\%$) (Sabaté, 2003). The reviewers suggested that early alerts from monitoring may lead to patients being admitted sooner for stabilization. This keeps short-term hospitalization numbers steady while preventing decompensation outside the hospital by 12 months. When remote monitoring uses sensors that track ECG or physical activity, 8 out of 10 studies evaluated showed meaningful drops in clinical outcomes or hospitalizations (Vegesna et al., 2017). On the hand, a randomized trial that combined telephone health coaching with remote monitoring after a heart failure hospitalization (NCT01360203) did not reduce 180-day readmissions. This shows that monitoring after discharge without clinical

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escalation or multi-parameter triage does not always curb early readmissions (Inglis et al., 2015).

One big gap in heart failure remote monitoring research is medication optimization. Four-pillar GDMT titration is often not done well in care and reviews of non-invasive remote monitoring note that telemetry data are used to guide medical management and therapy changes. A December 2025 systematic review of non-invasive heart failure remote monitoring found that specific numerical titration outcomes, like target-dose attainment rates or quantitative medication-adjustment metrics, were not available in the literature it synthesized (Ong et al., 2016).

Table 2. Pooled Quantitative Effects and Disease-Specific Outcomes from Systematic Reviews and Meta-Analyses

Study or Synthesis	Population and Scope	Primary Outcome	Pooled Effect Estimate (95% CI)	Heterogeneity, Significance, and Caveats
Nurse-Led Self-Management Meta-Analysis (2026)	Adults with chronic diseases (69 RCTs qualitative; 9 HbA1c, 5 SBP)	HbA1c (%)	MD −0.53% (−0.85 to −0.21)	p = 0.001, I^2 = 88.2%; stronger at ≤6 mo (−0.71%) than >6 mo (−0.22%, NS)
Nurse-Led Self-Management Meta-Analysis (2026)	Adults with chronic diseases (5 SBP trials)	Systolic BP (mm Hg)	MD −4.20 mm Hg (−7.18 to −1.22)	p = 0.006, I^2 = 53.4%; Hartung-Knapp interval wider due to small study count
T2DM Telephone Meta-Analysis (2025)	T2DM adults (13 RCTs, n = 2,294)	HbA1c (%)	MD −0.59% (−0.85 to −0.34)	p < 0.00001, I^2 = 87%; 20–25 min sessions (−1.23%) and biweekly intervals (−1.29%) performed best
Interactive 2-Way RPM Review (2022)	Chronic diseases (96 studies; general RPM)	12-mo all-cause mortality	RR 0.71 (0.56 to 0.89)	p = 0.003, I^2 = 0%; 6-mo mortality NS (RR 0.86, p = 0.18)
Interactive 2-Way RPM Review (2022)	Chronic diseases (96 studies; general RPM)	Blood pressure and HbA1c	BP: MD −3.85 mm Hg (−7.03 to −0.68); HbA1c: MD −0.33% (−0.57 to −0.09)	BP p = 0.02 (I^2 = 100%); HbA1c p = 0.008 (I^2 = 99%); Hospitalization NS (RR 1.02, p = 0.81)
HF Nurse Telemonitoring Meta-Analysis (2026)	Chronic heart failure	HF hospitalization and mortality	HF hosp: OR 0.70 (0.48 to 0.85); Mortality: OR 0.64 (0.41 to 1.01)	HF hosp p < 0.01; mortality p = 0.05; LOS (MD −0.42 d, p = 0.31) and ED hosp NS
Nurse-Led Telerehabilitation Review (2022)	Community chronic diseases (26 studies)	Cardiac and COPD QoL; HTN SBP; T2D HbA1c	Cardiac QoL: SMD 0.45 (0.09 to 0.81); COPD QoL: SMD 0.18 (0.05 to 0.31); HTN SBP: MD 10.48 (2.68 to 18.28)	Cardiac p = 0.01; COPD p = 0.007 (I^2 = 0%); HTN p = 0.008; T2D HbA1c NS (MD 0.19, p = 0.32)
CKD Nurse-Led Meta-Analysis	Adults with CKD (10 RCTs, n = 964)	Symptoms, sleep, pain, fatigue, overall health, depression	Statistically significant SMD gains across 6 domains	Physical functioning, role-physical, disease burden, satisfaction, and emotional well-being NS

5. Impact on Treatment Compliance, Self-Management, and Health-Related Quality of Life

A clear pattern runs through the literature. Generic quality-of-life measures often come back with pooled results. Disease-specific or psychological tools frequently show real improvement. Take the 96-study review of two-way telemonitoring. Pooled quality of life did not reach significance (MD 1.45, 95% CI −0.10 to 3.00; p = 0.07; I^2 = 80%). Among the 13 studies synthesized qualitatively, 31% (4/13) reported a quality-of-life gain with telemonitoring. 69% (9/13) Found no difference. 8% (1/13) Found usual care scored better on the SGRQ at two and six months (Awadallah et al., 2026). A systematic review of hospital-to-home RPM care transitions tells a story. It found patient mobility and functional status, yet the findings on broader physical and mental health symptoms were inconclusive. On top of that, both the 2026 69-RCT meta-analysis and the 2024 40-RCT review reported that mixed instruments blocked any quantitative pooling of quality-of-life and adherence outcomes (Al-hussaniy & Oraibi, 2026).

When researchers use cardiac, respiratory or psychosocial scales, though, nurse-led digital interventions show clearer gains. In heart failure trials using the KCCQ, multi-parameter wearable monitoring (TFI, ECG, heart rate, respiratory rate, activity and posture) produced a 22-point gain within the group. It also produced a significant 12-point difference between groups at 90 days (p = 0.004) (Hajat & Stein, 2018). Two 1-year telehealth trials without -sensor wearables, by contrast, showed non-significant between-group differences of 1.00 point (p = 0.97) and 3.67 points. Studies using the MLHFQ showed between-group gains: 7.1 points at 6 weeks (p = 0.04), 10 points at 18 months (p = 0.014) and 13 points at 24 months (p = 0.016). EuroQol gains backed this up (+6.6 points at 45 days, p < 0.01). So did

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SF-36 improvements in Physical Component Summary (+1.59, p = 0.011) and Mental Component Summary (+1.3 to +4.66, p < 0.05) scores (Parikh et al., 2023). Telerehabilitation meta-analyses also confirmed quality-of-life gains in cardiac disease (SMD 0.45) and COPD (SMD 0.18). Across nurse-led RCTs looking at mental health, 78% (7/9) reported significant improvement in depression and 100% (2/2) in anxiety. Still, 2 trials measuring depressive symptoms found no significant difference (Hajat & Stein, 2018).

Table 3. Health-Related Quality of Life and Self-Management Outcomes Across Validated Instruments

Outcome Domain and Instrument	Condition or Context	Representative Trial or Pooled Findings	Direction and Statistical Significance
KCCQ (Heart Failure)	HF multi-sensor RPM vs standard telehealth	Boehmer 2024 (90 d): +22 within-group, +12 between-group (p = 0.004); Bekelman 2015 (1 yr): +1.00 (p = 0.97); Cichosz 2020 (1 yr): +3.67 (NS)	Significant in 90-day multi-sensor RPM; NS in 1-yr non-wearable telehealth trials
MLHFQ (Heart Failure)	HF nurse-assisted and home telemonitoring	Dorsch 2021 (6 wk): 7.1 pts (p = 0.04); Mizukawa 2019: 10 pts at 18 mo (p = 0.014), 13 pts at 24 mo (p = 0.016); Blum 2014: −18 pts within-group (p < 0.001)	Consistently favorable short- and long-term HF-specific QoL
SF-36 and EuroQol	Heart failure telemonitoring	Koehler 2021 (1 yr): PCS +1.59 (p = 0.011), MCS +1.3 (p = 0.024); Cichosz 2020: MCS +4.66 (p < 0.01); Hernandez-Quiles 2024 (45 d EuroQol): +6.6 (p < 0.01)	Significant physical and mental component gains in HF RCTs
Pooled Generic HRQoL	Multi-disease 2-way telemonitoring	Pooled MD 1.45 (95% CI −0.10 to 3.00; p = 0.07; I^2 = 80%); 4/13 improved, 9/13 NS, 1/13 favored usual care (SGRQ)	Non-significant overall across heterogeneous chronic conditions
Psychosocial and Mental Health	Mixed chronic diseases; COPD	Nurse-led digital RCTs: depression improved in 7/9 (78%), anxiety in 2/2 (100%), depressive symptoms 0/2; COPD telerehab: anxiety SMD 0.14 (p = 0.04), depression SMD 0.15 (p = 0.02)	Strong positive impact on clinical depression and anxiety outcomes
Self-Care and Self-Efficacy	Mixed chronic, cardiac, T2DM, HF primary care	Self-efficacy improved in 4/9 (44%) and self-care in 4/9 (44%); Cardiac management MD 6.36 (p = 0.04); T2DM SMD 1.20; HF monitoring p < 0.001	Positive when paired with active coaching; passive models risk reducing self-efficacy

6. Implementation Barriers, Nursing Workflow, and Economic Sustainability

Scaling nurse-led RPM from clinical trials into durable health-system operations requires overcoming substantial cognitive workload, interoperability deficits, patient safety mismatches, and uneven cost-effectiveness evidence (Vest et al., 2017).

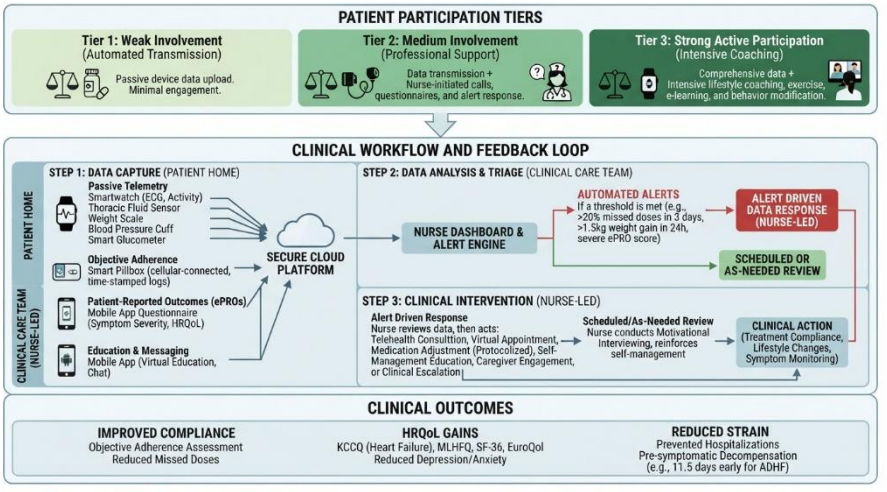

Figure 2: Multi-Tier Patient Participation and Clinical Escalation Workflow

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6.1 Alert Fatigue, EHR Interoperability, and Patient Safety Risks

A systematic review of healthcare practitioners experiences with telemonitoring identified most clinically important phenomenon as high telemetry volume and data-sifting burden associated with a surge in clinician workload. This most often meant that the nurse had to discern healthy physiological noise from clinically relevant deterioration amid a constantly flowing stream of data, due to continuous monitoring. As such, most studies included in the review reported an increase in practitioner workload, only a few mentioned reduced or unchanged outpatient burden (Amjadi, 2026). This could result in looking skeptically at diagnostic results from consumer wearables – it's normal for clinicians to abandon or question a diagnosis of atrial fibrillation from commercial wrist pulse data in comparison with medical-grade ECG devices which has been associated with alert fatigue, making clear the need for improved digital protocols and an effective digital alert management system, as noted in remote post-surgical nurse research (Krutke, 2025).

Telemedicine-related technological fragmentation exacerbates this nursing burden. Biomedical telemetry collected through vendor portals and mobile apps often fails to be consolidated into or native EHR workflows to manage this burden is hard because of the lack of a data framework for device manufacturers to use, and health systems that prohibit third-party API connections to maintain legal data protection (Awadallah et al., 2026). The transition towards Fast Healthcare Interoperability Resources (FHIR) interoperability; automated clinical decision-support systems (CDSS); and cellular-enabled devices has been suggested as a means of streamlining nurse triage. On the patient side, workflow misalignment creates safety and psychological risks: patients often believe that the practitioners are constantly watching incoming feeds day and night and may miss to call emergency services in acute circumstances, while device error alerts or unreviewed abnormal readings induces patient anxiety (Al-hussaniy & Oraibi, 2026). Complex device interfaces also disorient older adults, and continuous remote observation risks privacy apprehension over third-party cloud storage or a perception of constant surveillance (Lee et al., 2022).

6.2 Economic Evaluations, Cost-Effectiveness, and Reimbursement Frameworks

Universal deployment across unselected or lower-risk cohorts can also be economically unviable. An evaluation of an effective UK telemonitoring of vital-signs system (Henderson), found an ICER of £297,000/QALY due to higher equipment costs without considerable QALY gains; similarly, a universal telehealthcare for all COPD patients and second-generation social telecare in the Whole Systems Demonstrator cluster-randomised controlled trial, could not achieve together-hearted willingness-to-pay limits (Ong et al., 2016). In addition, watching over Level 3 high intensity monitoring (requiring extensive behavioural coaching) creates more up-stream and down-stream clinical labor as well as patient time costs even though this has an impact on quality of life (Hailu et al., 2024). Adding to the effect of these tradeoffs, a 2025 scoping review of 40 RPM economic studies (20 cost-effectiveness and 13 cost-utility analyses) noted minimal adherence to Consolidated Health Economic Evaluation Reporting Standards (CHEERS 2022) – particularly in cost transparency and sensitivity testing, echoing former methodological evaluations showing that 79% of studies did not assess subgroup heterogeneity, 43% did not make missing-data adjustments, and 40% performed no sensitivity analyses. In the US healthcare industry billing guidance, Medicare RPM CPT codes (99091, 99453, 99454, 99457, 99458) and CMS RTM codes as funding mechanisms for the nursing triage and device operations, but peer-reviewed investigations of long-term reimbursement policy sustainability are scarce (Noah et al. , 2018).

Table 4. Implementation Barriers, Operational Trade-Offs, and Economic Evaluation Findings

Domain	Observed Barrier or Economic Finding	Supporting Evidence and Magnitude	Strategic Mitigation or Policy Requirement
Clinical workload and alert fatigue	High volume of uncurated telemetry and false positives increases nurse workload	Most practitioner studies report higher workload; commercial wearables lack diagnostic trust vs medical ECG	Standardized escalation thresholds, CDSS filtering, and explicit alert governance
EHR and device interoperability	Siloed vendor portals and restricted API access hinder clinical documentation	Multi-vendor formats prevent aggregation; health systems restrict third-party EHR access	FHIR-compliant data pipelines and cellular-enabled devices integrated natively into EHRs
Patient safety and usability	Assumed 24/7 surveillance delays urgent care; device complexity and bulk burden older adults	Alert-induced patient anxiety; smart pillbox willingness declines with age (aOR 0.95); discharge workflow friction	Explicit non-24/7 expectations, accessible UI design, and caregiver engagement

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Domain	Observed Barrier or Economic Finding	Supporting Evidence and Magnitude	Strategic Mitigation or Policy Requirement
Payer vs provider economics	Cost-effective long-term in targeted CVD, but unfavorable when deployed universally	US CVD 5-yr ICER $18,515/QALY; UK vital-signs telemonitoring ICER £297,000/QALY; universal COPD/telecare unfavorable	Risk-stratified patient selection and sustainable RPM/RTM reimbursement models
Economic evaluation quality	Inconsistent cost valuation and poor CHEERS 2022 reporting limit cross-study comparability	79% omitted heterogeneity analysis, 43% missing-data methods, 40% sensitivity analysis; weak CHEERS 2022 adherence	Standardized economic reporting capturing nursing labor, device costs, and non-health process impacts

7. Conclusion

Nurse-led patient monitoring and digital health interventions give a real way to keep patients with long-term illnesses in check even when they are not in a clinic, but the benefit of these programs depends on how the programs are made and run instead of just on the gadgets themselves. Evidence shows that the nurse's job of looking at the numbers, teaching patients and calling for help is the key to success. The steady gains appeared in heart-related health measures, such as lower HbA1c levels, lower systolic blood pressure and fewer hospital visits for heart failure. Adding sensors to a wearable device can help spot trouble early and tests that look at life quality and depression that are tied to a specific disease improved more clearly than broad tests that look at all health. Still, there are limits. The win in blood sugar control fades after about six months. The effects on death and hospital stays vary depending on how long the study lasts and how many sensors are used. Good reports of how well patients stick to the plan're rarely given and when they are given, the rules for measuring them are not the same. Studies on pillboxes mostly talk about whether people can use them and whether the idea works, but they do not show clear extra benefit and the extra value of electronic patient-reported alert systems outside of cancer care is not known. Doctors and nurses feel tired of many alerts, electronic health records do not talk to each other well, people worry about patient safety and the cost benefit looks bad for patients who are not at high risk, all of which hold back large rollout. Health systems should therefore aim nurse-led patient monitoring at patients who are at high risk, combine several sensors with clear rules for when to step up care and put the device data into the everyday work of nurses. Future studies should use the rules for measuring how well patients follow the plan and their life quality, should follow patients longer, should compare the nurse's role separately from the device's data and should do economic reviews that follow accepted rules.

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