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REMOTE PATIENT MONITORING WITH WEARABLE DEVICES AND MOBILE HEALTH SYSTEMS FOR CHRONIC DISEASES: CLINICAL EFFECTIVENESS, CHALLENGES, AND FUTURE PROSPECTS – A REVIEW

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ABSTRACT

Background: The rapid advancement of technology makes it possible to achieve improvements in medical services and patient adherence. It also enables the early detection of disease exacerbations and improves the management of chronic conditions outside the clinical setting. Digital health tools such as wearable sensors and mobile applications can enhance patients' perceived competence.
Objectives: This aim of this review was to analyze the available scientific data on the use of remote monitoring (via wearables devices and mobile healthcare systems) in patients with chronic diseases. The analysis focused on their effectiveness, safety, and practical potential.
Methods: A literature review on remote monitoring of patients with chronic diseases was conducted using the PubMed, Embase and Medline databases for publications in English language from 2015 to 2026. The analysis included clinical trials, metanalyses, studies validating remote monitoring devices, and guidelines issued by scientific societies. The selection of studies was based on predefined inclusion and exclusion criteria. The results were presented as a qualitative analysis.
Conclusions: Remote patient monitoring and digital interventions, combined with active clinical support, improve blood pressure control, exercise capacity, therapy engagement, and adherence, and reduce hospitalizations for cardiovascular disease. In respiratory diseases, RPM technology provides accurate vital sign measurements, although it does not always lead to better clinical outcomes. In type 2 diabetes, comprehensive digital interventions support glycemic control and healthy behaviors, while in neurological rehabilitation, wearable systems and machine learning-based applications improve limbs motor function. Despite the advantages and demonstrated effectiveness of remote patient monitoring (RPM) and wearable device–based interventions, technological complexity and limited digital literacy are significant implementation barriers that may limit long-term engagement.

KEYWORDS

Remote Monitoring, Wearable Devices, Digital Health, mHealth, Telemedicine, Chronic Diseases

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1. Introduction

The increase in life expectancy is a significant challenge for society. It places growing pressure on healthcare systems that already operate with limited resources. This problem is especially visible in primary care. The management of chronic diseases, such as diabetes, hypertension, and pulmonary disorders, requires accurate diagnosis and the initiation of appropriate therapy. It also involves adherence to medical recommendations and regular adjustment of medication doses. Traditionally, this is done during in-person visits with primary care physicians [1, 2]. However, even when appropriate medical care is provided, individuals with chronic conditions frequently experience persistent symptoms and limitations in daily functioning, necessitating sustained engagement in self-care to maintain physical, social, and mental health. This growing emphasis on self-management has increased the need for tools that support continuous monitoring, patient engagement, and timely clinical oversight beyond traditional clinical encounters [3, 4].

In this context, continuous advances in digital technologies have led to the widespread adoption of wearable devices, including smartwatches, fitness trackers, and chest strap heart rate monitors in daily life. Recent innovations have facilitated patient-centric recording and sharing health-related data with smartphones. Biometric data monitored through remote patient monitoring include vital signs such as blood pressure (BP), heart rate (HR), saturation (SpO2), blood glucose levels, and skin temperature. Secure transmission of such patient-generated data to clinicians could facilitate personalized health pathway management, risk factor monitoring, and asynchronous clinical feedback [5].

Wearable devices are predominantly developed for consumer use rather than clinical applications. Nonetheless, there is growing interest in assessing their potential to enhance health outcomes and quality of life in patients with chronic conditions [6].

2. Methods

2.1 Data collection

The study was conducted as a narrative literature review with a structured search strategy to synthesize current evidence, using three databases: PubMed, Embase, MEDLINE and including English-language articles published between 2015 and 2026.

The keywords “remote patient monitoring”, “RPM” “telemonitoring”, “telehealth”, “wearables”, “wearable devices”, “mobile health”, “mHealth” “smartwatch”, “digital health”, “chronic diseases” were used in combination with Boolean operators (OR, AND) to refine the search.

2.2 Inclusion and Exclusion Criteria

Studies investigated populations who received RPM interventions for chronic cardiovascular, pulmonary, metabolic, and neurological diseases. Oncological and psychiatric diseases were not considered. Study populations included adult people of any, gender, or life state except for pregnant individuals. The analysis encompassed randomized clinical trials (RCTs) or cohort studies. Marketing materials, articles focusing solely on teleconsultations without any component of health parameter monitoring, and single case reports were excluded.

2.3 Study selection process

The publication selection process consisted of two stages. In the first stage, an initial assessment of the titles and abstract was conducted to determine their relevance to the review’s scope. Subsequently, articles meeting the preliminary criteria underwent a detailed full-text analysis for final inclusion in the study, in accordance with previously defined inclusion criteria. In this process, particular attention was paid to the methodological quality of the studies. Ultimately, six studies related to hypertension, eight studies on heart diseases (including coronary artery disease and heart failure), five studies on pulmonary diseases, five studies on diabetes, and three studies on post-stroke neurological disorders were included.

2.4 Data extraction

Data were extracted from each included study on study design, patient characteristics, monitoring technologies, assessed health parameters, and reported clinical outcomes. Owing to heterogeneity across study designs and outcome measures, a qualitative descriptive synthesis was performed, with findings organized into thematic categories.

3. Research Results

3.1 Effectiveness of Remote Monitoring of Patients with Hypertension

The analysis of the studies revealed considerable variability in the effectiveness of digital and telemedicine interventions in improving blood pressure control and treatment adherence. These differences were associated with the complexity of the interventions, the degree of healthcare professional involvement, the characteristics of the study populations, and the outcome assessment methods.

Participants using the mobile app, which combined medication reminders, Bluetooth blood pressure monitoring, and real-time feedback, achieved significantly greater reductions in systolic blood pressure (SBP) at months 1, 3, 6, and 9 compared with the control group. Mean SBP decreased from approximately 152 mmHg at baseline to about 121 mmHg at 9 months, while it remained higher in the control group. A greater proportion of participants in the intervention group reached their blood pressure targets. Adherence to treatment in this group was very high, ranging from approximately 89% to 95% [7]. Patients receiving home telemonitoring and pharmaceutical care achieved better blood pressure control than those receiving standard care. After 6 and 12 months, the percentage of patients with controlled blood pressure was almost twice as high in the intervention group (about 57% vs. 30%). This effect persisted after the intervention ended. After 18 months, blood pressure control was observed in 71.8% of patients in the intervention group, compared to 57.1% in the control group. The intervention group also showed greater reductions in both systolic and diastolic blood pressure, with systolic blood pressure decreasing by about 10 mmHg over the course of the intervention [8].

Other studies primarily focused on self-monitoring, reminders, or passive data reporting using mobile health (mHealth) systems, without systematic feedback to inform therapeutic adjustments. In these studies, improvements in blood pressure were observed over time, but these changes were comparable to those achieved with standard care [9, 10, 11, 12].

Taken together, the analyzed studies indicate that digital interventions integrated with active clinical support lead to statistically significant improvements in both adherence to recommendations and blood pressure control in patients receiving care [7, 8]. Interventions limited to reminders, education, or self-reporting of data enhance patient engagement but have a less consistent impact on actual adherence and blood pressure control [9, 11].

3.2 Clinical and Behavioral Efficacy of RPM in Coronary Artery Disease and Heart Failure

In the population of patients with chronic coronary heart disease (CHD), the greatest clinical benefits were observed in studies using multiparameter telemonitoring (a 24-hour dynamic electrocardiogram (ECG), a sphygmomanometer, and a glucometer) combined with ongoing virtual clinical intervention. A randomized trial of 1,248 elderly patients demonstrated a significant reduction in the risk of hospitalization (HR 0.59, $p<0.0001$) and the incidence of major adverse cardiovascular events (HR 0.60, $p=0.0012$) in the remote monitoring group compared with usual care [13].

Remote cardiac rehabilitation interventions using wearable devices led to improved physical performance, as measured by peak oxygen consumption (peak VO_2) and exercise tolerance, with a favorable safety profile [14, 15]. In patients assigned a home exercise program and provided with a wearable device (Fitbit Sense) equipped with a real-time monitoring system, both peak VO_2 and anaerobic threshold VO_2 increased significantly from baseline after 12 weeks. These improvements were observed in the group receiving online coaching ($p=0.001$) as well as in the group without coaching ($p=0.002$) [14].

Furthermore, the use of RPM in patients with CHD increased physical activity and adherence to rehabilitation recommendations. Another study demonstrated a sustained increase in step count among patients with ischemic heart disease (IHD), which persisted even after the financial incentive phase ended [16].

In the heart failure (HF) population, RPM interventions improved health behaviors, self-care, treatment adherence, and symptom control [17, 18, 19, 20]. However, the effect on reducing exacerbations and hospitalizations was less clear. The use of a mobile app for remote monitoring and a digital therapeutics (DTx) module with automated HF medication suggestions was associated with a reduction in hospitalization frequency [19]. In contrast, a large study including 1,437 hospitalized HF patients did not demonstrate a reduction in rehospitalization or mortality, despite the use of intensive telemonitoring and health coaching [17]. Among the analyzed studies, there was no statistically significant evidence that digital interventions improved quality of life (QoL) [20].

3.3 Digital and Wearable Technologies in the Management of Patients with Pulmonary Diseases

Studies evaluating distinct remote monitoring models in patients with chronic obstructive pulmonary disease (COPD), asthma, and obstructive sleep apnea (OSA) were included in the analysis. The assessed interventions comprised mHealth systems, wearable technologies for vital-sign monitoring, mobile spirometry, telemonitoring continuous positive airway pressure (CPAP), and predictive algorithms for exacerbation risk.

The analysis demonstrated that the evaluated measurement technologies exhibited high accuracy and repeatability. Smartwatch-based SpO_2 assessment showed a strong correlation with arterial blood gas analysis ($r \approx 0.95$) and a low measurement error, supporting its clinical validity [21]. Mobile spirometry (ambulatory mSpirometer synchronized with a smartphone application) in patients with asthma demonstrated very high agreement with standard clinical spirometry ($r \approx 0.99$), high repeatability (intraclass correlation coefficient [ICC] = 0.93), and good patient adherence (85%) [22].

Remote monitoring technologies in chronic respiratory diseases have demonstrated accurate measurement performance; however, no statistically significant improvements have been observed in relevant clinical outcomes. Despite regular use of the tested technology by patients with COPD, those assigned to RPM showed no improvements in self-management skills, disease knowledge, symptoms, visits to the emergency department or hospital admissions compared with a standard care group [23, 24]. A trend toward shorter hospitalizations and stays in the intensive care unit (ICU) was observed in the telemonitored group, but it did not reach statistical significance [24]. Remote monitoring of CPAP therapy did not lead to any additional improvements in adherence or in the apnea-hypopnea index (AHI) among patients with symptomatic severe OSA, compared with a group receiving standard CPAP treatment without RPM [25].

In a cohort of 110 patients with COPD (>27,000 measurement sessions), a predictive algorithm based on trend analysis of vital signs was developed. During home monitoring, patients exhibited early physiological changes preceding exacerbations, including decreases in SpO_2 and increases in heart rate and respiratory rate. The model demonstrated a sensitivity of 60–80% and a specificity of 36–68%, which may indicate moderate predictive performance [26].

3.4 Effectiveness and Acceptability of Remote Interventions in Type 2 Diabetes

A study on remote patient monitoring (RPM) in patients with type 2 diabetes indicated that interventions based on mHealth technologies, telemonitoring, continuous glucose monitoring (CGM), and physical activity monitoring applications can significantly support glycemic and blood pressure control, as well as improve patient health behaviors. Their effectiveness is particularly pronounced when interventions are comprehensive, individualized, and integrating education, clinical parameter monitoring, and behavioral support [27].

The use of CGM combined with educational tele-visits led to significant reductions in glycosylated hemoglobin (HbA1c) (0.65% greater reduction, p=0.008), greater weight loss (2.17 kg difference, *p*=0.029), and increased patient satisfaction compared with standard care [28].

In another study, remote monitoring of exercise programs via apps and telemetric heart rate monitors resulted in a significantly greater increase in cardiopulmonary endurance (mean difference – 2.0 bpm vs 1.0 bpm; p=0.02) and reductions in body fat percentage (p=0.01), although changes in HbA1c were not statistically significant [29].

Comprehensive interventions that combine telemonitoring with education, support for diet, physical activity, self-care, medication management, and psychological support demonstrated additional behavioral benefits, including increased self-efficacy, reduced diabetes-related distress, and improved self-care practices. These benefits were achieved at a modest additional cost compared with simpler telemonitoring approaches [30].

In a study conducted in older patients with diabetes and hypertension, telemonitoring of regular blood pressure and glucose measurements led to significant reductions in systolic blood pressure (p=0.001) and HbA1c (p=0.002) compared with standard care, while no significant effects were observed on quality of life [31].

3.5 Application of Wearable Devices, Mobile Systems, and Machine Learning Algorithms in Post-Stroke Rehabilitation

A review of the available research indicates that the application of RPM technology in stroke rehabilitation includes mobile training systems, wearable devices for neuromodulation, remote blood pressure monitoring, and systems based on smartwatches and machine learning (ML) algorithms.

Patients using the myoelectric interface for neurorehabilitation training (MINT) and therapeutic games demonstrated improvements in training outcomes and reductions in muscle co-activation. The therapy was well tolerated by participants [32].

Improvements in upper limb motor function have been observed in patients following chronic stroke who received a wearable device delivering paired acoustic and transcutaneous electrical stimulation at the motor threshold level, targeting the forearm extensor muscles (p=0.019). Similar improvements were reported in patients using a home-based rehabilitation (HBR) system that can recognize and record the type and frequency of exercises performed via a smartwatch and smartphone app equipped with machine learning (ML) (p=0.02). In both cases, these interventions showed superior outcomes compared with standard care [33, 34].

4. Discussion

4.1 Development and Effectiveness of Remote Patient Monitoring and Telemedicine in Modern Healthcare

Until recently, healthcare services were delivered primarily in institutional settings such as clinics and hospitals, where diagnosis and patient monitoring depended on specialized, costly equipment that was not easily portable. The growing need to extend care beyond these settings has contributed to the development of RPM systems, a rapidly expanding field of digital medicine that offers substantial potential to improve the assessment of clinical parameters, support adherence to therapy, and foster health-promoting behaviors [36].

According to the results of this review and available meta-analyses, the clinical outcomes achieved with telemedicine are comparable to those obtained with standard care, while telemedicine offers additional benefits in certain populations. [37, 38]. It is important to emphasize that, although there is evidence of the potential impact of telemedicine and RPM on reducing mortality, hospitalization rates, and improving quality of life in patients with certain chronic conditions, further research is required to confirm these effects conclusively. Therefore, further well-designed studies with larger cohorts, diverse patient populations, and long-term outcome tracking are needed. Such studies can statistically determine the effectiveness of interventions, identify the most effective components of RPM, and fully assess their impact on patients' health and quality of life.

It is worth noting that the most beneficial effects were observed in models integrated with active support from the medical team, automatic data transmission, and the ability to rapidly modify therapy. Interventions based solely on self-monitoring, reminders, or passive data reporting demonstrated lower and less consistent clinical effectiveness. These findings suggest that the effectiveness and sustainability of RPM implementation depend on the level of involvement of medical staff, the complexity of the intervention, the adaptation of technology to patient needs, limitations related to digital competence and user burden, as well as the motivation of the patients themselves. This indicates that future mHealth treatment strategies should focus on integrating digital systems into routine clinical care, simplifying technological solutions, and tailoring interventions to maximize clinical benefits and sustain long-term patient engagement.

4.2 Barriers and Limitations to the Implementation of Remote Patient Monitoring in Clinical Practice

Significant barriers to the adoption of RPM technology and wearable devices included technological challenges, limited digital literacy, and the user burden associated with daily system use. One of the main reasons for withdrawal was difficulty in using mHealth technology. The authors emphasize that simplifying the intervention is necessary to improve participant retention [5]. It was also highlighted that more complex interventions may be challenging for older adults and require careful patient selection to avoid excessive burden [31]. Research shows difficulties in maintaining long-term engagement in a home-based activity program using wearable devices [34, 35].

4.3 Advancements and Future Directions in Remote Patient Monitoring Technologies

Furthermore, the continued development of these systems requires standardization, enhanced security and privacy measures, energy optimization, and the design of more user-friendly solutions. Future research should focus on increasing technological reliability, fully integrating clinical data, and fostering social acceptance, all of which are crucial for the effective implementation of RPM in clinical practice.

Looking ahead, the development of wearable technologies, biometric sensors, and IoT devices, combined with artificial intelligence and machine learning algorithms, offers great potential for remote patient monitoring [39]. Real-time, precise tracking of parameters such as blood pressure, heart rate, oxygen saturation, and blood glucose can not only help detect health deterioration early but also support automated therapeutic recommendations and the optimization of treatment and rehabilitation plans. In addition, analyzing large patient data sets can improve the management of healthcare resources, increase patient safety, and make the overall system more efficient.

5. Conclusions

After reviewing all included studies, it can be observed that remote monitoring systems have become increasingly popular worldwide in recent years. Although the primary objectives of the studies varied, most aimed to compare treatment outcomes between patients using remote monitoring systems and control groups receiving usual care. The studies assessed both the management of vital parameters and patients' subjective evaluations of their health status. The analyzed populations demonstrated substantial variability in age, ethnicity, socioeconomic status, and disease burden. RPM approaches employed encompassed wearable devices, integrated clinical systems, and behavioral-educational interventions.

The strongest clinical evidence supports interventions that combine automated data transfer with active involvement of medical staff and the capacity to rapidly adjust therapy. In patients with hypertension and type 2 diabetes, such approaches lead to improved control of clinical parameters, including blood pressure and HbA1c, as well as enhanced adherence to treatment. For individuals with coronary artery disease, multiparameter telemonitoring systems integrated with continuous clinical oversight have been shown to reduce the risk of hospitalization and major cardiovascular events. In post-stroke rehabilitation, wearable devices and machine learning–based systems facilitate improvements in motor function and enable effective home-based therapy.

Evidence from studies in heart failure and chronic lung disease remains inconclusive. Although the measurement devices employed were accurate and reliable, their use did not result in statistically significant improvements in quality of life or reductions in mortality and hospitalization rates.

However, to definitively assess the effectiveness of RPM systems in managing patients with chronic diseases, further studies involving larger and more diverse patient populations are required.

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