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Mobile Health Applications and their Effectiveness in Chronic Disease Management: Review

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Abstract

Background: The rising prevalence of chronic diseases, such as diabetes and cardiovascular disorders, presents a significant public health challenge globally. Mobile health applications (mHealth) have emerged as a promising tool for enhancing chronic disease management by improving patient engagement and self-management.

Methods: This review systematically evaluates randomized controlled trials (RCTs) published from 2005 to 2023, focusing on the effectiveness of mHealth interventions in adult populations with chronic illnesses. We conducted comprehensive searches in peer-reviewed databases, including PubMed and the Cochrane Library, using relevant keywords related to mHealth and chronic disease management.

Results: Out of 12 analyzed studies, 83.3% demonstrated statistically significant improvements in health outcomes, including enhanced physical functioning, medication adherence, and symptom management. For instance, patients using mHealth interventions for chronic pain reported better compliance and symptom monitoring compared to control groups. However, 16.7% of studies showed negligible effects, indicating variability in the effectiveness of mHealth applications.

Conclusion: While mHealth interventions can positively impact chronic disease management, their effectiveness may vary based on factors such as intervention design, patient demographics, and adherence levels. Future research should focus on developing user-friendly applications, ensuring data privacy, and integrating caregiver support to enhance engagement. These findings highlight the potential of mHealth

technologies to transform chronic disease management and underscore the need for ongoing evaluation of their effectiveness in diverse populations.

Keywords: Mobile Health, Chronic Disease Management, Randomized Controlled Trials, Patient Engagement, Health Outcomes

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1. Introduction

The incidence of chronic illnesses, including cancer, cardiovascular disorders, chronic pain, diabetes, and respiratory ailments, is steadily rising among an aging global population. The World Health Organization states that chronic illnesses are the primary cause of global mortality, representing almost 60% of all fatalities. Chronic illness is a worldwide burden. According to a report by the Centers for Disease Control and Prevention (CDC), approximately half of American adults, or around 117 million individuals, suffer from one or more chronic diseases, including heart disease, stroke, cancer, type 2 diabetes, obesity, or arthritis [1,2]. In 2012, one in four persons in the United States had two or more chronic conditions. Chronic illnesses are the primary cause of mortality among Americans, with 48% succumbing to cancer or heart disorders in 2010 [3]. In 2010, around 86% of American healthcare expenditures were allocated to chronic illness treatment. Consequently, the treatment of chronic diseases has become a significant public health concern. Similarly, the management of chronic illnesses presents challenges in other nations [4-6]. For example, more than 40% of individuals aged 15 years or older in the European Union had a chronic ailment, and chronic diseases constituted a significant percentage of fatalities in Southeast Asia.

Advancements in mobile technologies have led to the popularity of mobile health (mHealth), defined as a subset of electronic health (eHealth) that delivers health services and information through mobile devices such as mobile phones and Personal Digital Assistants (PDAs). Current data indicates that the benefits of using mHealth devices extend beyond enhancing diagnosis and treatment to include fostering social connections with individuals [12]. Research has examined the efficacy of behavioral therapies using mobile applications on smartphones or tablets to improve self-management in patients with chronic conditions, including heart failure and diabetes [13]. For example, a dietary log, physical activity tracking, and home blood glucose monitoring using mHealth devices are often used in diabetes care [14-16], while weight, symptom, and physical activity monitoring are standard components of heart failure therapies [13, 17].

Nevertheless, the evidence from contemporary literature regarding the mHealth approach to enhancing health outcomes is inconsistent; certain studies indicate that mHealth-based behavioral interventions may be effective in managing chronic diseases, while other studies did not yield supportive results [9]. The prior assessment of mHealth-based research focused on the feasibility and acceptance of mHealth instruments.

Instead of depending on feasibility studies, which often do not use randomization in their interventions or a control group and often lack sufficient effect size, many systematic or integrated reviews have analyzed randomized controlled trials (RCTs) in diabetes treatment. These studies have shown favorable physiological and behavioral results, as well as incentive-driven outcomes, associated with mHealth systems [14-17]. Nevertheless, little data indicates that mHealth strategies may be beneficial for self-management in patients with various chronic conditions. Consequently, a comprehensive assessment of randomized controlled trials concerning interventions utilizing mHealth technologies, alongside participants' adherence, training methodologies, intervention dosage, and follow-up duration as key outcomes, is necessary to formulate recommendations on the determinants of effective mHealth interventions for chronic disease management.

The objective of this research was to conduct a comprehensive review of randomized controlled trials using mHealth treatments for chronic illness management in adult populations, aiming to evaluate the efficacy of these interventions on health outcomes and process metrics.

2. Methods

Searches were conducted to obtain papers published in peer-reviewed journals from 2005 to 2023, written in English; the databases used were PubMed, CINAHL, EMBASE, the Cochrane Library, PsycINFO, and Web of Science. We used combinations of keywords and indexing phrases, such as MeSH or Emtree, associated with the search domains.

3. Research indicating substantial impacts on results

The majority of mHealth randomized controlled trials in this comprehensive review demonstrated statistically significant impacts on health outcomes via the integration of mobile apps in chronic illness management [18-22]. The studies indicated enhanced physical functioning, compliance with prescribed medications, and/or facilitation of symptom assessment and reporting to healthcare providers, along with process metrics such as patient satisfaction with health management and the viability of smartphone-based self-management interventions.

Kearney et al. [23] in the United Kingdom documented a notable enhancement in fatigue (odds ratio, OR = 2.29; 95% CI, 1.04–5.05; $P = 0.040$) and hand-foot syndrome (OR control/intervention =0.39; 95% CI, 0.17–0.92; $P = 0.031$) among patients with lung, breast, and colorectal cancer utilizing a mobile phone-based remote monitoring system for chemotherapy-related symptoms, as opposed to the standard care group. In Norway, Kristjansdottir et al. [19,20] demonstrated a beneficial impact on pain management during a 4-week follow-up, evidenced by a lower catastrophizing score for the Intervention group (M = 9.20, SD = 5.85) compared to the Control group (M = 15.71, SD = 9.22, $P < 0.01$), with a substantial effect size (Cohen's d = 0.87). However, no significant effects were observed in the 5-month and 11-month follow-ups regarding outcome variables such as catastrophizing, acceptance, functioning, and symptom level (all $P > 0.1$). In Spain, Garcia-Palacios et al. [24] created an ecological momentary assessment (EMA) for chronic pain in fibromyalgia patients and discovered that patients with limited technological proficiency utilizing a mobile EMA system on their smartphones exhibited greater compliance compared to those using a paper-based diary (complete record $t = -4.446$, $d = 1.02$, reference Cohen's $d \geq 0.8$, large effect).

Cingi et al. [25] indicated that in Turkey, patients with allergic rhinitis or asthma exhibited improved quality of life and better-controlled asthma scores by the mHealth intervention compared to the control group (all $P < 0.05$). Dicianno et al. [21] established the viability of a mHealth intervention for individuals with spina bifida to enhance self-management abilities, noting that extensive use of the mobile system correlated with favorable improvements in these skills. In Sweden, Hägglund et al. [26] evaluated a tablet-based intervention for patients with heart failure (HF), resulting in enhanced self-care, increased health-related quality of life (HRQoL), and a decrease in HF-related hospitalizations (risk ratio, RR = 0.38; 95% CI, 0.31–0.46; $P < 0.05$).

Martin et al. [27] in the United States discovered that an automated text messaging system enhanced physical activity to mitigate cardiovascular illnesses throughout phase 1 (weeks 2 to 3) and phase 2 (weeks 4 to 5), with all $P < 0.001$. Piette et al. [28] in the United States observed that the intervention group using "CarePartners," which facilitated connections with relatives or friends residing outside their home, demonstrated enhancements in medication adherence and caregiver communication (all $P < 0.05$). DeVito Dabbs et al. [29] conducted a randomized controlled trial in the United States involving lung transplantation patients, revealing enhancements in self-monitoring (OR = 5.11; 95% CI, 2.95–8.87; $P < 0.001$), adherence to medical regimen (OR = 1.64; 95% CI, 1.01–2.66; $P = 0.046$), and an increased frequency of reported abnormal health indicators (OR = 8.9; 95% CI, 3.60–21.99; $P < 0.001$).

4. Research indicating comparable or negligible influence on outcomes

Two out of the twelve studies examined (16.7%) showed comparable or negligible impact of mHealth-based treatments on primary outcomes of interest relative to control groups. In Finland, Vuorinen et al. [30] observed no change in the frequency of HF-related hospitalizations (incidence rate ratio, IRR = 0.812, $P = 0.351$). Patients in the telemonitoring intervention group utilized greater healthcare resources, evidenced by an increased frequency of nurse visits (IRR = 1.73; 95% CI, 1.38–2.15; $P < 0.001$), extended duration of interactions with nurses (mean difference = 48.7 min, $P < 0.001$), and a heightened number of telephone communications initiated by nurses (IRR = 5.6; 95% CI, 3.41–7.63; $P < 0.001$). Cubo et al. [31] observed a trend indicating reduced PD functional status (as measured by the Unified Parkinson's Disease Rating Scale, UPDRS I) in patients undergoing home-based monitoring compared to those receiving standard in-office visits ($P = 0.06$). However, other outcomes assessed through UPDRS II, III, IV subscales and HRQoL in PD did not exhibit statistically significant differences between the intervention and control groups. Cubo et al. [31] elucidated that the utilization of home-based motor monitoring through mHealth applications, in contrast to conventional office visits during the 1-year follow-up, was cost-effective, with an incremental cost-effectiveness ratio (ICER) per unit of UPDRS subscales varying from €126.72 to €701.31.

5. Mobile health interventions

The viability of the mHealth intervention as a pilot study to evaluate the possibility of effective deployment among patients/participants [24-26]. The bulk of research used smartphones as mobile devices; two studies employed tablets for mHealth treatments, and two studies utilized telemonitoring wireless devices, including weight scales for patients with heart failure and gait detectors for patients with Parkinson's disease [25,29,32]. The duration of treatments varied from two weeks to twelve months; half of the trials (6/12, 50%) had intervention durations and follow-ups beyond six months. The predominant elements of mHealth interventions were remote symptom monitoring, self-assessment, and customized automated messaging or self-care instruction to guide patients with chronic diseases requiring active treatment. A specific trial conducted by Kearney et al. was more comprehensive since it delivered real-time input and customized this feedback for symptom management based on severity, including pharmaceutical, dietary, or behavioral recommendations as necessary [23].

The studies examined had sample sizes ranging from 28 individuals with spina bifida to 372 patients with heart failure. The trials included patients aged 18 and older, with several studies restricted to certain age ranges, such as 18–40 or up to 69 years [24,30]. The average age of participants in the mHealth intervention trials varied from 30-year-old individuals with spina bifida to 75-year-old patients with heart failure; the estimated mean age throughout this 12-study evaluation was in the 50s [24,29]. No research revealed the efficacy of mHealth interventions categorized by age. The 12 studies failed to disclose participants' experience with mobile devices, including smartphones, or their educational background, which might have influenced their proficiency in using mHealth applications on mobile devices. Intervention outcomes were assessed either using mHealth systems or by paper-based surveys.

Most studies included either in-person informational sessions at baseline or written instructions for mHealth intervention training. Kearney et al. [23] discovered that symptoms were reported variably on a paper-based questionnaire compared to a mobile phone. Individuals in the mobile group exhibited reduced tiredness levels relative to those in the paper-based group (OR non-mobile/mobile = 2.29, 95% CI 1.04–5.05, $P = 0.04$). Real-time reporting of cancer toxicity symptoms, such as hand-foot syndrome and mucositis, may provide more precise quantification [23].

None of the research documented process metrics, such as adherence, engagement levels, or satisfaction with the mHealth systems. There may have been insufficient information on such measurements in the published studies since the authors could have disseminated the process measures in other publications.

6. Discussion

This analysis has identified a possible beneficial impact of mHealth treatments on health outcomes and process metrics in patients with chronic conditions such as asthma, cancer, cardiovascular illnesses, chronic pain, spina bifida, and Parkinson's disease. The findings from the analyzed RCTs indicated enhancement in some health outcomes for individuals managing their chronic conditions.

The examined studies have shown both similarities and disparities in the use of mHealth. A prevalent characteristic beneficial in mHealth therapies is customized and pre-configured feedback on reported symptoms. The mobile application systems used in the analyzed studies were created by the research team and then verified and modified in prior studies done before the randomized controlled trials (RCTs). No commercial health applications were used in the research examined. The majority of studies used research personnel to provide training on mHealth systems to participants via in-person or group information sessions, or informational materials, although one study utilized local nurses for patient training [26]. None of the examined studies assessed the integration of their health systems into routine medical practice inside clinical environments or acute care hospitals, indicating a lack of evidence for its adoption in actual healthcare systems. Challenges in practical environments may pertain to insufficient financial incentives for providers to use mHealth technologies or ambiguity over the privacy and security of information sent via mHealth systems [33].

Initiatives to enhance self-management in individuals with chronic illnesses have evolved from web-based and/or telephone-based therapies to mHealth-based interventions. In contrast to earlier behavioral therapies restricted to locations where patients with chronic illnesses may get treatment guidance, mHealth interventions provide enhanced functionalities, including real-time symptom monitoring and feedback [25, 34, 35]. Patients with Parkinson's Disease get immediate feedback on their chosen gait parameters during ambulation using a gait application designed based on evidence-based workout protocols [25]. This illustrates how the use of well-designed and verified mHealth applications in everyday life may enhance health outcomes.

The quantity of smartphone users has significantly risen; in the US, it is projected to attain 224.3 million in 2017, an increase from 171 million in 2014; globally, it reached 2.32 billion in 2017, up from 1.57 billion in 2014. In 2016, over 77% of individuals in the United States have smartphones. The utilization of mobile devices for mHealth is crucial in contemporary times, with mHealth methodologies ranging from dispatching text messages for medical appointment reminders to real-time monitoring and evaluation of symptoms from nearly any place using wireless networks. mHealth interventions have facilitated medical coaching for caregivers collaborating with healthcare professionals in the optimal treatment of chronic diseases. Piette et al. [31] examined the comparative efficacy of mHealth therapies for heart failure patients and their family caregivers, demonstrating enhancements in medication adherence and caregiver communication. The influence of including caregivers as mHealth users—one of the supportive care groups—on patients' health outcomes warrants further investigation within the framework of an aging population.

Furthermore, it is essential to assess the long-term reactions of patients and caregivers using mHealth. Research should focus on the optimal duration and frequency of the mHealth delivery system, as well as the sort of technology and training required. The optimal frequency for automated reminders or coaching messages, the timing for subsequent reminders, and the thresholds at which individuals experience fatigue or irritation from automated communications need investigation. Users of mHealth may suffer from weariness due to automated reminders, thereby rendering mHealth treatments ineffective. Other systematic evaluations of chronic illness management indicated that the frequency of engagement with mHealth systems imposed a strain on participants, hence influencing the attrition rate [17]. This study indicates that the duration of the intervention across the 12-research ranged from 2 weeks to 12 months; 5 of the 12 studies (about 42%) had treatments lasting less than 2 months, while 4 studies (approximately 33%) used a 1-year intervention. The favorable health effects seen in the evaluated studies were not directly correlated with the duration of the intervention or the training methodologies of mHealth.

An important consideration in mHealth techniques is the efficacy of clinical communication between patients and healthcare providers, who must address patients' inquiries using mHealth platforms. Cingi et al. [25] indicated that healthcare practitioners (i.e., residents) saw an improvement in patient contact using mHealth; yet they discovered that these clinicians vehemently rejected utilizing mHealth technologies as the major communication strategy. Vuorinen et al. [30] documented a notable rise in communication (i.e., telephone interactions) between nurses and patients, which therefore augmented the nurses' workload throughout the study. A tip for alleviating health care professionals' burden in mHealth interventions is the use of modern technology to address patients' inquiries about symptoms evaluated and reported via mHealth systems.

In evaluating good health outcomes, such as decreased hospital readmissions for heart failure-related disorders or improved medication adherence among patients with chronic diseases, the load on healthcare providers should be assessed as a result of mHealth treatments. An effective triage system may reduce healthcare professionals' reaction time to emergency requirements indicated by mHealth users [28].

The systematic review identifies several recommendations to enhance mHealth interventions, including the development of a straightforward and user-friendly mHealth system, ensuring data confidentiality, employing lay language for structured and automated feedback or advice, fostering positive motivation and engagement, and incorporating the patient's social supporters, such as family members, friends, and/or peers [28,31].

This systematic review has some limitations. Initially, we only included randomized controlled trials for our review, the majority of which were financed research. Consequently, the mHealth systems or smartphone applications used in the investigations were verified and comparatively dependable about commercially accessible health applications. Research on smartphone-based treatments for chronic illness management, particularly those that are small-scale and either lack a control group or have short-term follow-up, has shown mixed outcomes. Consequently, we aimed to choose rigorous studies that used randomization, control groups, and relevant follow-ups for outcomes. We examined the variations in outcomes at various follow-up intervals.

Secondly, we excluded mHealth intervention studies for diabetes management due to the extensive existing literature on mobile technology techniques in this domain [14-17,36]. Third, we eliminated studies in which health applications were used only by healthcare professionals, including doctors or trained clinical nurses. Our study focused on patient-centered health applications within the framework of mHealth interventions. Finally, the majority of the examined studies supplied smartphones or tablets to participating patients; thus, the findings of this study cannot be applied to individuals with financial constraints for the acquisition of mHealth technologies. Despite the growing prevalence of wireless networks, prospective mHealth users, including patients with chronic illnesses and their caregivers, may encounter restricted data services for their mobile devices owing to cost constraints. This might be a critical concern in emergencies when patients lack access to evidence-based medical guidance via mHealth devices.

7. Conclusion

The majority of analyzed studies using mHealth therapies indicated an improvement in health outcomes for individuals with chronic diseases. Beneficial elements of mHealth strategies include automatic text reminders, regular and precise symptom monitoring (often in real-time), and greater communication between patients and healthcare providers, leading to improved self-management in individuals with chronic diseases. Consequently, the outlook for mHealth seems to be favorable. The correlation between user participation with mHealth technologies and the enhancement of outcomes warrants further investigation. The research examined in this study demonstrated disease-specific mHealth therapies that may vary from commercially available mobile health applications. Thoroughly evaluated mHealth applications created via research should be further considered for public accessibility.

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تطبيقات الصحة المتنقلة وفعاليتها في إدارة الأمراض المزمنة: مراجعة

الملخص

الخلفية :إن تزايد انتشار الأمراض المزمنة، مثل داء السكري واضطرابات القلب والأوعية الدموية، يمثل تحديًا كبيرًا للصحة العامة على مستوى العالم. لقد برزت تطبيقات الصحة المتنقلة (mHealth) كأداة واعدة لتعزيز إدارة الأمراض المزمنة من خلال تحسين مشاركة المرضى وإدارة الذات.

الطرق :تقوم هذه المراجعة بتقييم شامل للدراسات المعشاة ذات الشواهد (RCTs) المنشورة من 2005 إلى 2023، مع التركيز على فعالية تدخلات mHealthفي السكان البالغين الذين يعانون من الأمراض المزمنة. أجرينا بحثًا شاملاً في قواعد البيانات المحكمة، بما في ذلك PubMed ومكتبة كوكرين، باستخدام الكلمات الرئيسية ذات الصلة بالصحة المتنقلة وإدارة الأمراض المزمنة.

النتائج :من بين 12 دراسة تم تحليلها، أظهرت 83.3% منها تحسنًا ذا دلالة إحصائية في النتائج الصحية، بما في ذلك تحسين القدرة البدنية، والالتزام بالعلاج، وإدارة الأعراض. على سبيل المثال، أبلغ المرضى الذين يستخدمون تدخلات mHealth لعلاج الألم المزمن عن تَحسن في الامتثال ومراقبة الأعراض مقارنةً بالمجموعات الضابطة. ومع ذلك، أظهرت 16.7% من الدراسات آثارًا ضئيلة، مما يشير إلى تباين في فعالية تطبيقات.mHealth

الاستنتاج :بينما يمكن أن تؤثر تدخلات mHealth بشكل إيجابي على إدارة الأمراض المزمنة، قد تختلف فعاليتها بناءً على عوامل مثل تصميم التدخل، والديموغرافيا الخاصة بالمرضى، ومستويات الالتزام. ينبغي أن تركز الأبحاث المستقبلية على تطوير تطبيقات سهلة الاستخدام، وضمان خصوصية البيانات، ودمج دعم مقدمي الرعاية لتعزيز المشاركة. تبرز هذه النتائج الإمكانية الكبيرة لتقنيات الصحة المتنقلة في تحويل إدارة الأمراض المزمنة، وتؤكد الحاجة إلى تقييم مستمر لفعاليتها في السكان المتنوعين.

الكلمات المفتاحية :الصحة المتنقلة، إدارة الأمراض المزمنة، التجارب المعشاة ذات الشواهد، مشاركة المرضى، نتائج الصحة