Health Review

Use of Digital Smartphone Applications for Blood Pressure Monitoring: An Integrative Review

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Abstract: With the purpose of identifying in the literature and describing the scientific evidence for the use of smartphone applications for blood pressure monitoring, this study is an integrative literature review, employing a qualitative approach conducted with studies from 2014 to 2024, accessed via the Virtual Health Library (VHL) portal. The research resulted in 10 articles addressing the use of digital technology in smartphones and answering the following guiding question: What is the effectiveness of this technology for diagnostic purposes and blood pressure control? This study showed that digital smartphone applications are effective for blood pressure monitoring, providing important information for both patients and healthcare professionals. The evidence found indicates that digital applications are effective in monitoring blood pressure variations; however, they are not effective for diagnostic purposes but can be used to complement existing data.

Keywords: Smartphone, Ambulatory Blood Pressure Monitoring, Hypertension.

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1. Introduction

Systemic arterial hypertension (SAH) is classified by a frequent increase in blood pressure (BP), meaning systolic blood pressure (SBP) equal to or greater than 140 mmHg and/or diastolic blood pressure (DBP) equal to or greater than 90 mmHg, on at least two different occasions, in the absence of antihypertensive medication. It is advisable, when possible, to validate such measurements through BP assessment outside the clinical setting, using methods such as Ambulatory Blood Pressure Monitoring (ABPM), Home Blood Pressure Monitoring (HBPM), or Self-Measured Blood Pressure (SMBP) [1].

SAH is part of the group of non-communicable chronic diseases (NCDs) and is included in the Sustainable Development Goals, proposed by the Ministry of Health. The aim is to reduce by one-third the mortality caused by NCDs by 2030, mainly through prevention and treatment strategies such as correct medication use and lifestyle modifications, including reducing alcohol consumption and smoking, adopting a healthy diet, and practicing physical activity. These measures can help prevent and minimize cardiovascular complications that lead to premature death [2].

SAH is clearly a public health issue, evident in the evaluation of individual diseases, where hypertension is responsible for the largest share of direct costs (59% — more than R$ 2 billion per year), followed by diabetes (30%) and obesity (11%) [3]. It is frequently associated with structural and functional changes in target organs (heart, brain, kidneys, and blood vessels) and metabolic alterations, leading to an increased risk of fatal and non-fatal cardiovascular events [4].

Therefore, self-care becomes essential for controlling this comorbidity, which involves lifestyle changes and frequent BP monitoring to avoid health complications. The

two main consequences of poor BP control are therapeutic inertia and low adherence to antihypertensive treatment. One strategy to improve therapeutic adherence is the use of digital tools, which facilitate better adherence to treatment, potentially leading to improved BP control [5]. The hypothesis of this study is that smartphone applications integrated with BP monitoring are effective interventions in the management of clinical data, medication, and daily care for hypertensive patients. In light of this, the research question arises: *What are the scientific evidence supporting the use of mobile smartphone applications for blood pressure monitoring?*.

Digital therapeutic support is a new approach that can facilitate both non-pharmacological and/or pharmacological treatment of systemic arterial hypertension, using software programs like smartphone apps. This tool can encourage patients to engage in self-care and lifestyle changes, with the expected outcomes of improving overall health, reducing the risk of future cardiovascular events, and integrating healthy habits into daily routines. Thus, the aim of this study was to describe the scientific evidence on the use of technologies for the monitoring of systemic arterial hypertension, using digital smartphone applications.

2. Methods

2.1 Study type

This study is an integrative literature review, which allows for a broader presentation of information on a specific topic. The integrative review is a study method that aims to identify, analyze, and synthesize results obtained in studies on a topic in a comprehensive, systematic, and organized manner [6]. This study consists of an integrative review and followed the following steps: 1) Formulation of the research problem question; 2) Definition of inclusion and exclusion criteria for material to be analyzed; 3) Designation of information to be extracted from the studies and data collection, structuring them; 4) Analysis of the studies included in the integrative review; 5) Evaluation of the results; 6) Identification of the review/synthesis [7].

This type of study is organized through the following phases: choosing the topic and developing the guiding question; establishing the inclusion and exclusion criteria; data collection through a structured instrument; data analysis; discussion, and presentation of the results found [8].

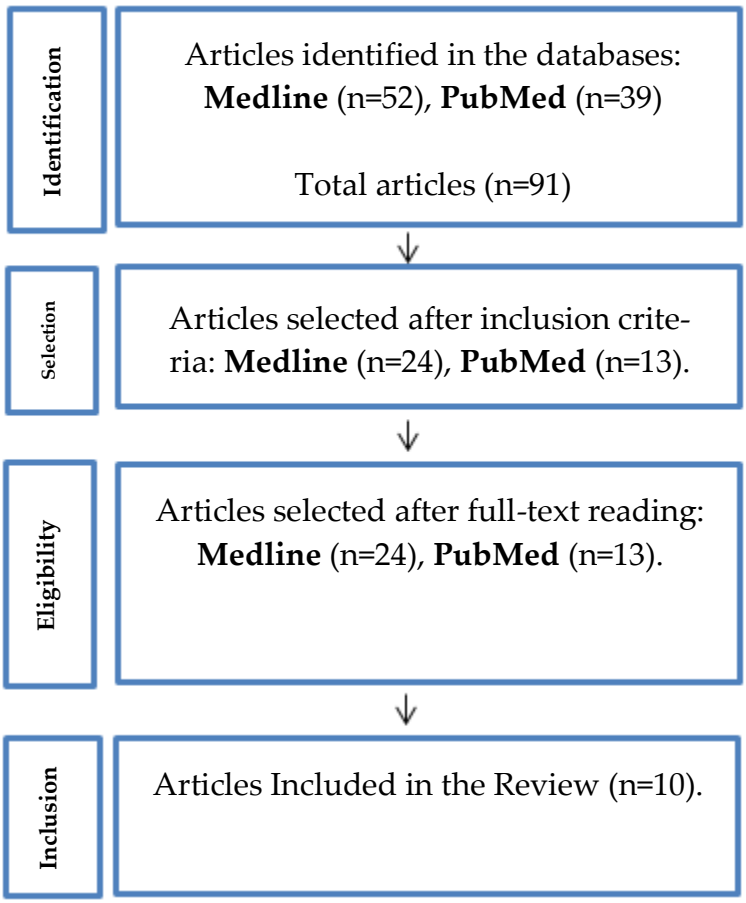
2.2 Data Collection

The process of searching for articles in the literature was carried out on the Virtual Health Library (VHL) portal. The included studies were from the following databases: Medical Literature Analysis and Retrieval System Online (MEDLINE) and U.S. National Library of Medicine (PUBMED). The research was conducted by cross-referencing the following Health Science Descriptors (DeCS/MeSH): "smartphone", "ambulatory blood pressure monitoring", "hypertension" / "smartphone, Blood Pressure Monitoring, Ambulatory, hypertension". The terms were combined using the Boolean operators "and" [9].

Inclusion criteria were original electronic articles available in full, published between 2014 and 2024, as this time frame represents the highest concentration of content related to the use of mobile applications for blood pressure monitoring. Additional inclusion criteria were articles in Portuguese and English, free access, and alignment with the research objective. Exclusion criteria included articles not freely available, as well as reviews, books, dissertations, theses, conference proceedings, and duplicate articles across databases. Data collection was conducted between February and April 2024, using an adapted data collection instrument [9].

After selecting the articles based on the inclusion criteria, they were organized and arranged in a table in ascending order of publication, by the following topics: title, authorship, and year of publication, study type, and results, allowing for the comparison of different ideas presented in the analyzed publications (Figure 1).

Figure 1. PRISMA flowchart of the research process organized by database, including 10 articles after all stages.



3. Results

The preliminary search of articles resulted in 52 publications in MEDLINE and 39 in PUBMED. After reading the full-text articles, based on the inclusion criteria, 10 studies were selected, showing a predominance of publications in international journals within the field of medicine, with nursing involvement (6) and nursing alone (4). Regarding the publication years of the studies, articles were found from the period between 2018 and 2022.

In terms of study type, there was a predominance of articles involving randomized controlled clinical trials (n=4), randomized clinical trials (n=3), prospective observational cohort studies (n=1), multicenter open-label pilot randomized trials (n=1), and five-way open randomized controlled studies (n=1). The results indicate evidence of the quality of adherence to BP monitoring and medication therapy using m-health systems, which are either used directly or serve as inspiration for the development of other technologies. Furthermore, they demonstrate the relationship between the use of mobile applications on smartphones and self-care, promoting the treatment of hypertension (SAH) versus the use of this technology as a diagnostic method for SAH. It shows its effectiveness when continuously associated with the care practices provided by healthcare professionals (Table 1).

Among the studies presented, all of them offered health education as technological training for the usability of the applications. In six studies (E1, E2, E3, E4, E6, and E7), the applications were shown to be viable for blood pressure monitoring and significantly increased therapeutic adherence. However, in study (E9), the use of mobile technologies

was not effective in achieving the objective of diagnosing hypertension. In three other studies (E5, E8, E10), it was demonstrated that there was no difference in blood pressure control between digital monitoring without intervention and manual monitoring.

Table 1. Description of the related articles, including title, authorship, year of publication, and results.

Study	Reference	Main Findings
E1	[19]	Fifty hypertensive stroke survivors (ages 40-85) were divided into two groups (one using the app and the other as a control) and followed for 90 days to assess app usability and impact on BP control. The mHealth system showed a statistically significant difference in BP control (82% vs. 64%).
E2	[17]	Conducted with 484 participants with a mean age of 60, this study aimed to test the efficacy of using HBPM combined with a smartphone monitoring app via Bluetooth connectivity. Participants were divided into two groups: a control group with sporadic measurements and an intervention group that measured BP three to seven times a week. Nurses evaluated the data, concluding a variation of 25% vs. 8% between the intervention and control groups, demonstrating the effectiveness of smartphone digital apps for BP control.
E3	[20]	To assess the viability and effectiveness of a mHealth app for BP control, 60 stroke survivors with an average age of 60 were divided into an intervention group (using the smartphone app) and a control group, both guided by nurses. The app stored BP data and listed medications to assist in treatment adherence. BP was <140/90 mmHg in 66.7% of the intervention group compared to 46.7% in the control, demonstrating the app's efficacy in BP control.
E4	[12]	This study, involving patients aged 40 to 70, aimed to compare the effectiveness of a handwritten log vs. a BP monitoring app (mHealth), with the app connected directly to the BP device via Bluetooth. It found that both handwritten and app-based monitoring were effective as long as participants adhered to BP measurements, with no significant difference between the methods.
E5	[18]	This study aimed to compare BP monitoring using two apps, in control and intervention groups with participants aged 18-85. The control group used an app integrated with a BP device, while the intervention group used an app that also offered tips on lifestyle changes and diet. The reduction in SBP was similar in both groups (up to 10 mmHg), with no significant difference between the apps.
E6	[16]	Involving participants aged 30-60, this study aimed to evaluate the effectiveness of BP self-management using a mobile app in combination with a low-sodium, low-fat diet. The study showed an increase in medication adherence of 7.4% in the intervention group and 5% in the control group, with average SBP ranging from 108-113.5 mmHg in the intervention group and 115-114.3 mmHg in the control group.
E7	[15]	Conducted with 390 hypertensive patients aged 20-64 who were not on antihypertensive medication, this study investigated the effectiveness of digital therapeutics using the HERB software. Patients were divided into two groups: one using software plus lifestyle modifications and the other making lifestyle changes only. The digital therapy group showed a 3.9 mmHg reduction in BP compared to 1.3 mmHg in the control group.

E8	[14]	Involving 146 participants aged 57-65, this study compared the HERB software for BP monitoring with manual BP log-keeping. The HERB app reduced morning SBP by -3.1 mmHg after 16 weeks of use, but after 24 weeks, it was not effective for 24-hour BP reduction.
E9	[11]	Involving participants aged 61-70, this study compared HBPM assisted by a mobile BP monitoring app with clinic BP measurements and ABPM for hypertension diagnosis. The app showed high sensitivity (92%), but patient-reported BP differed from app-recorded data, suggesting possible manual BP manipulation. Thus, HBPM + the app may complement but not replace ABPM or HBPM for diagnosis.
E10	[13]	This study evaluated whether enhanced BP self-monitoring combined with a monitoring app is more effective than self-monitoring alone. Involving patients with an average age of 58, the intervention group used a BP monitor plus an app, while the control group used only the BP device. The study found a BP variation of just 3% between the groups (<140/90 mmHg), indicating no significant benefit of enhanced monitoring.

Some studies revealed the specific digital application used in the research. Among them, three studies used the same m-Health software application, where two of them were designed to assist in the treatment of hypertensive patients who had suffered a stroke as a complication of hypertension. Another two studies used the HERB software application, which is primarily characterized by combining medication therapeutic inertia with lifestyle changes. The EmmaHBPM application was defined as an important method for complementing the diagnosis of hypertension. Additionally, two studies used applications from the same brand as the blood pressure monitor, specifically the OMRON application. One study used the Blood Pressure Management Application (BPMAP). In one of the studies, the application from the monitor's brand was also used, but the name or brand of the device was not disclosed in the study.

4. Discussion

This study showed that digital smartphone applications are effective for blood pressure (BP) monitoring, generating important information for both patients and healthcare professionals, being significant for patient decision-making as well as therapeutic measures. Hypertension (HTN) can be a silent disease because it often presents no initial symptoms, leaving patients more susceptible to complications from hypertension due to a lack of diagnosis and early treatment. This confirms the idea that symptoms are one of the key characteristics of disease perception. In the absence of symptoms, the revelation of elevated BP levels during measurement indicates that something is wrong, confirming the disease [10]. The asymptomatic nature of hypertension makes its discovery often incidental.

First and foremost, HTN diagnosis should be conducted through diagnostic methods. In study E9, the use of digital applications for diagnostic purposes was addressed, showing that these monitoring applications are not effective compared to more reliable methods like Ambulatory Blood Pressure Monitoring (ABPM) and Home Blood Pressure Monitoring (HBPM), although they can be used as a complement to HBPM and for BP control. In summary, accurate BP verification is essential for proper diagnosis and monitoring, which is traditionally performed in a clinical setting with a mercury sphygmomanometer or an automatic oscillometric device. The study also points out that convenient and quick readings can be confusing and lead to incorrect diagnoses, given the existence of hypertension subtypes, such as masked hypertension and white coat hypertension. BP measured outside the clinical setting has a stronger association with cardiovascular risk factors, making HBPM and 24-hour ABPM the most recommended methods for diagnosing systemic arterial hypertension [11].

Due to the silent nature of the disease, BP monitoring should be done regardless of symptom presence. Monitoring and controlling hypertension must be conducted regularly, and technology is increasingly integrated into people's daily lives, facilitating this process for patients. The connectivity between BP measurement devices and smartphones enables data storage and reduces the risk of losing this information. In study E4, the difference between using a digital monitoring application and a handwritten logbook was evaluated, revealing that both methods are effective for monitoring as long as patients remain consistent with the monitoring, whether digital or manual [12]. However, study E10 reports no difference between using a monitoring device with an app versus using the device alone, as both have the same efficacy [13].

Regarding BP monitoring and control, with a focus on reducing BP, study E8 aimed at reducing 24-hour BP but did not show promising results when using the HERB Mobile software compared to manual record-keeping. However, other studies demonstrate that digital applications transmitting data from BP devices are effective for BP monitoring and control [14]. In study E7, using the same software (HERB Mobile), combined with lifestyle changes, proved effective for reducing 24-hour BP control [15]. Similarly, study E6 highlights the beneficial result of 24-hour BP reduction when using the Blood Pressure Management Application (BPMAP) along with a low-sodium, low-fat diet [16].

According to the study E2, Bluetooth technology is innovative and meets requirements for compatibility, transmission, sensors, custom software, and low energy consumption, making it more accessible and acceptable, especially in resource-limited settings. It is a smart technology that can engage patients in disease self-management. These resources support self-management practices and decision-making based on the clinical data obtained, such as engaging in physical exercise, adopting specific dietary habits, and taking medications [17]. Furthermore, the coaching app used in study E5 applies cognitive-behavioral therapy to promote self-management and healthy behaviors, including diet, physical activity, and medication adherence. This app also uses reminders for daily BP measurements [18].

Additionally, this technology helps prevent data loss and thus avoids therapeutic inertia, as BP data is directly stored on the smartphone and organized. In some applications, the data can even be shared with the healthcare team, as shown in study E1, where BP data was made available to the interprofessional care team, allowing for responsive medication adjustments [19]. However, general limitations exist across all studies. In study E3, intermittent Internet connectivity issues were a problem. Since the study population was predominantly elderly, smartphone usability was also a limiting factor, even though all studies provided training on app use. This is still a challenge due to memory issues in elderly patients [20].

Although many individuals with hypertension are aware of the disease's progression, they are not always willing to engage in self-care practices. This hinders disease control, which is considered a public health problem [22]. In this context, using smartphone digital technology is ideal for BP monitoring and control, without additional costs to the individual, showing promising results in managing hypertension. Although not mentioned in the studies reviewed, there is a Brazilian national intervention application called Elfie, which is an innovative and free digital solution, validated by the Brazilian Society of Cardiology, the Brazilian Diabetes Society, and the National Diabetes Care Association. Inspired by other technologies with greater impact on treatment adherence and reduced healthcare costs, it also serves as an educational tool through gamification and applicability during patient self-monitoring. It includes encouragement for lifestyle changes and enhances treatment commitment with features such as medication reminder boxes, prescription validity tracking, BP monitoring, and health parameter history storage. All clinical information is summarized and aligned for medical sharing. Among the users of this app, the majority are aged between 40 and 60 [3].

Health education must be continuously integrated into patients' lives, particularly through the use of technologies that facilitate hypertension management. These

technologies require proper and effective training for their use and should be reinforced during every medical visit. Health education provided by professionals is challenging because treatment depends on hypertensive patients participating and seeking to change unhealthy habits, such as poor diet, sedentary lifestyle, and medication nonadherence [21]..

5. Conclusion

The analyzed studies demonstrated the viability and efficacy of digital devices for home BP monitoring, BP control, and medication adherence. They also show that this technology is important for connecting patients with healthcare professionals for BP data evaluation and subsequent health interventions, though it is not effective for diagnostic purposes. However, it can be complementary when used alongside other methods. These tools help increase the implementation of self-monitoring and BP reduction measures.

This technological approach proves relevant for reducing public health costs resulting from hypertension complications, as it involves patient self-care measures with clinical utility, good accessibility, low cost, good reproducibility, and prognostic value. The use of digital technologies for BP monitoring is associated with increased patient adherence to treatment, while also allowing for health education. These tools encourage patients to be more involved in their treatment and track their prognosis, eventually improving BP control and reducing the likelihood of hypertension-related complications.

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