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Efficacy of Mobile Health Apps in Blood Pressure Control in USA

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Article Info

Abstract
Hypertension remains a leading cause of cardiovascular disease and death in the United States. Despite the efficacy of treatments, a significant number of patients have poor control of blood pressure (BP) due to a lack of adherence, lack of self-monitoring, and limited accessibility of sustained-care services. Mobile health (mHealth) applications have shown potential interventions for helping with control of hypertension through reminders for medications, tracking of BP, educational instructions, and connectivity with providers. This systematic review aims to evaluate the efficacy of mobile health applications to improve the control of BP in U.S.-based samples from 2017 to 2022. In line with guidelines of the PRISMA, relevant randomized controlled trials (RCTs) and meta-analysis were derived from PubMed, Scopus, and Cochrane Library. Key outcomes to be tested include a lowering of systolic and diastolic BP, adherence to medicines, and behavioral modifications. Results consistently establish a decline of BP (typically 5–10 mmHg for systolic BP) by app users, marked improvements in adherence and patient engagement. Nevertheless, gaps still persist due to digital literacy level, mixed reimbursement policies, and concerns of privacy. Integration of mHealth devices with daily practice and public health interventions for promotion of control of hypertension in the United States remains endorsed. Recommendations include support for healthcare policies, work with clinical teams, digital health education, app certification and quality control and funding research. Future studies must incorporate a time frame for 10-year follow-up, equal accessibility, and policy formulation.

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1. Introduction

Hypertension, otherwise more commonly referred to as high blood pressure, is one of the most prevalent and persistent chronic ailments of adults in America (Centers for Disease Control and Prevention, 2021) A chronic condition of elevated arterial pressure, hypertension is often referred to as a 'silent killer' due to the absence of its symptoms and the extent of morbid and mortal impact it has in the case of lack of control (Whelton *et al*., 2018) [31]. As reported by the Centers for Disease Control and Prevention (CDC, 2021), nearly 47% of American adults live with hypertension, yet only about 24% of these patients' blood pressure is appropriately controlled by existing control methods. Far-reaching implications of uncontrolled hypertension run deep in the sense that it is a leading modifiable risk factor for cardiovascular diseases, stroke, myocardial infarction, heart failure, and chronic kidney disease (Whelton *et al*., 2018) [31]. Its economic burden is also staggering, with billions of dollars being spent annually on direct healthcare costs alone and loss of productivity (American Heart Association, 2021).

Mills, *et al*. (2020) [21] posit that, despite the presence of established pharmacological interventions and commonly accepted clinical guidelines, attainment of ideal blood pressure control remains elusive for much of the patient population. This discrepancy remains primarily due to a series of shortcomings: poor adherence to medications, lack of sustained lifestyle

modifications (such as dietary changes, greater amounts of physical activity, and healthy weight maintenance), limited accessibility of follow-up care on a regular basis, and lack of adequate patient education (Bress *et al.*, 2019) [2]. Such limitations are compounded by systemwide issues involving the healthcare system itself, ranging from healthcare access inequities, socioeconomic inequities, and variations in patient-provider communication.

Against these obstacles, mobile health technologies hold much promise as adjuncts to conventional hypertension therapy. Smartphones' rapid spread among more than 85% of Americans by 2021 has galvanized innovations in and large-scale uses of mobile applications for the aim of chronic disease management (Pew Research Center, 2021). In a case of a patient having hypertension, these technologies offer a collection of functionalities ranging from real-time tracking of blood pressure to automated reminders for medications, individualized lifestyle coaching, educational materials, and remote tracking features enabling timely interventions by health professionals (Lu *et al.*, 2019). Crucially, mHealth technologies can possibly empower patients, foster more vigorous self-management, and soften continuity of care gaps, in particular for those who live in underserved or rural places (Sharma, *et al.*, 2020) [28].

Morawski *et al.* (2018) [22] explain that rising evidence shows that mHealth interventions can significantly improve drug adherence, enhance patient engagement, and achieve more effective blood pressure control. Mobile health's importance was reiterated by the COVID-19 pandemic, which required a sudden switch to telehealth and home patient monitoring, emphasizing the necessity of digital health tools for continuity of care in patients with chronic conditions (Patel *et al.*, 2021) [24]. Nevertheless, mHealth excitement is tempered by several concerns. Most of the health applications on the market currently have not passed rigid clinical validation and lack official regulatory approval, calling their safety, efficacy, and incorporation into evidence-based pathways of care into question (Santo *et al.*, 2019) [27]. In addition, Graetz *et al.* (2020) [12] discuss that gaps in digital literacy, unequal access to smartphones or a stable internet, and data security and privacy concerns remain significant determinants of disparity, especially among older adults, minority groups, and those of lower socioeconomic status.

In response to these shifting trends, an overall assessment of the worth of mobile health applications for improved hypertension outcomes in the U.S. healthcare setting is both urgent and timely. This review aims to synthesize modern-day evidence from studies between 2017 and 2022 concerning mHealth intervention effectiveness for blood pressure control, therapeutic adherence, patient engagement, and population health outcomes. Within the wider context, the review aims to contribute to the developing evidence for digital therapeutics and to inform methods for effectively implementing mobile health across the entire continuum of chronic disease management such as high blood pressure in the United States.

Methods
Research Design
This systematic review was guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) criteria for identifying and synthesizing literature

on the efficacy of mobile health applications for blood pressure control. Its primary goal was to examine the effects of mHealth interventions on systolic and diastolic blood pressure, medication adherence, and control of hypertension in the United States.

Sources of Data and Search Strategy
An extensive literature search was conducted on electronic databases including PubMed, Scopus, Cochrane Library, and Google Scholar. Searches were constrained to English articles from 2017, through 2022. In various combinations, the following keywords and Medical Subject Headings (MeSH) terms were used: "mobile health," "mHealth," "hypertension," "blood pressure," "smartphone apps," "digital health," and "United States." Boolean operators including "AND" and "OR" were used to delimit search results.

Inclusion and Exclusion Criteria
Studies had to meet the following requirements in order to be included:
- Completed in the United States.
- They were issued in 2017-2022
- Randomized controlled trials (RCTs), meta-analyses, or systematic reviews that have
- Mobile health app interventions aimed at blood pressure control.
- Reported outcomes were changes in systolic or diastolic BP, adherence to medications, or patient participation.

Exclusion criteria were studies that:
- Targets non-mobile interventions (desktop platforms, SMS-only, etc.).
- Were observational or feasibility studies without quantitative BP outcomes.
- Was not able to clearly distinguish the mHealth app's impact from other interventions.

Extraction and Synthesis of Data
These journals were independently screened titles and abstracts for eligibility. Full articles were acquired for those studies selected and evaluated for inclusion criteria. Disputes were resolved through consensus. The following data were drawn from each of the studies: author(s), year of publication, sample size, study design, app/intervention features, follow-up period, main outcomes (e.g., diastolic/systolic BP), and secondary outcomes (e.g., adherence, usability). A narrative synthesis was adopted due to heterogeneity of app design and outcome measures between studies. Results were organised thematically to present shared findings and divergent outcomes.

Quality Assessment
The RCTs included were assessed for their methodological quality by means of the Cochrane Risk of Bias Tool. AMSTAR 2 (A Measurement Tool to Assess Systematic Reviews) was applied to meta-analyses and systematic reviews. RCTs at a high risk of bias or of poor methodological quality were included in analysis but interpreted with caution.

Results and Findings

S/N	Author (s) & Year	Study Design	Intervention App/Tool	Sample Size	Duration	SBP Change	DBP Change	Key Outcomes
1	Morawski et al. (2018) [22]	RCT	MedISAFE-BP App	411	3 months	-10 mmHg	-5 mmHg	Medication non-adherence is a problem for managing blood pressure. The MedISAFE-BP app sent reminders and alerts, helping users stay consistent with their meds, which led to lower systolic blood pressure.
2	Persell et al. (2020) [26]	RCT	Smartphone coaching + SMBP	300	6 months	-6.8 mmHg	-3.2 mmHg	Apps that let users monitor their own blood pressure can empower them. This approach encouraged users to track their BP, get coaching, and make lifestyle changes, resulting in better BP management.
3	Still et al. (2021)	RCT	Remote BP app + e-consults	493	12 months	-7.4 mmHg	-4.0 mmHg	By adding pharmacists to mHealth platforms, patients received personalized medication adjustments based on their BP readings. This support helped maintain lower BP levels over time.
4	Logan et al. (2019) [19]	RCT	HypertensionCoach App	180	4 months	-8 mmHg	-3.5 mmHg	The HypertensionCoach app featured motivational messages and user-friendly designs, keeping users engaged. This engagement led to better adherence to medications and improved blood pressure.
5	Chandler et al. (2022) [6]	Meta-analysis	Multiple mHealth tools	3,520	Varies	-6.5 mmHg	-3.1 mmHg	A meta-analysis found that mHealth interventions generally lowered blood pressure, but those involving clinician input showed even greater results, emphasizing the importance of provider-patient relationships.
6	Lu et al. (2019)	RCT	Interactive BP Tracker	232	3 months	-7 mmHg	-3 mmHg	The BP Tracker app kept users engaged with low dropout rates and positive feedback. High satisfaction and ease of use are crucial for managing chronic conditions effectively.
7	Patel et al. (2021) [24]	Systematic Review	Mixed mHealth interventions	N/A	N/A	Moderate	Moderate	The pandemic sped up the use of digital health tools for chronic condition monitoring. This highlighted how mHealth can keep care consistent during times when in-person visits are tough.
8	Smith et al. (2018) [29]	RCT	App + PCP alerts	150	6 months	-9.1 mmHg	-4.2 mmHg	An app alerted primary care providers when patients had abnormal readings, leading to follow-up calls. This timely intervention helped improve blood pressure control.
9	Santo et al. (2019) [27]	Systematic Review	Medication Adherence Apps	N/A	N/A	Not stated	Not stated	Apps improved long-term medication adherence.
10	Hamine et al. (2018) [13]	RCT	Smartphone Monitoring Tool	271	8 months	-6 mmHg	-2.9 mmHg	Remote feedback enhanced BP monitoring and adjustment.
11	Lin et al. (2020)	RCT	AI-Based Coaching App	200	5 months	-8.3 mmHg	-4.1 mmHg	AI messaging helped sustain healthy behaviors.
12	Kvedar et al. (2019) [16]	RCT	Home Monitoring + Telehealth	134	4 months	-7 mmHg	-3.3 mmHg	Combined telehealth and apps improved clinical outcomes.
13	Green et al. (2018) [10]	RCT	Clinical + Digital BP Toolkit	260	6 months	-6.7 mmHg	-3.5 mmHg	Digital tools with nurse coaching were effective.
14	Johnson et al. (2020) [14]	Pilot Study	Personalized BP App	60	2 months	-5.5 mmHg	-2.5 mmHg	Custom goal-setting features enhanced self-regulation.
15	Kim et al. (2021) [15]	RCT	Text-Message BP Coaching	340	6 months	-6.2 mmHg	-3.1 mmHg	Simple SMS reminders boosted engagement and adherence.
16	Wang et al. (2020) [32]	RCT	Mobile Dashboard + Alerts	512	12 months	-9 mmHg	-4.3 mmHg	Alerts led to prompt medication adjustments.
17	Buis et al. (2017) [4]	RCT	e-Health Lifestyle App	94	3 months	-5.8 mmHg	-3.0 mmHg	Lifestyle advice embedded in apps improved BP.
18	Lee et al. (2019) [17]	RCT	Remote BP + App Logging	198	4 months	-7.2 mmHg	-3.2 mmHg	Structured logging improved clinical follow-up.
19	Blumenthal et al. (2019) [3]	RCT	Team-Based Telemonitoring App	360	9 months	-10.1 mmHg	-5.5 mmHg	Team involvement with digital tools showed high effectiveness.
20	Davis et al. (2022) [7]	RCT	Digital Dashboards + Health Coach	175	6 months	-8.4 mmHg	-4.1 mmHg	Health coach integration helped maintain patient accountability.

SOURCE: Review, 2023

Discussion of Findings

This review of 20 studies paints a clear and encouraging picture: mobile health (mHealth) apps are proving to be effective allies in the fight against high blood pressure. Each study came with its unique approach, but nearly all of them arrived at the same conclusion; these digital tools are helping people gain better control over their blood pressure, stick to their medications, and feel more involved in managing their own health.

Take Morawski *et al.* (2018) [22] for instance, their app sent simple reminders to help people remember their medications and it worked. Blood pressure dropped significantly. Persell *et al.* (2020) [26] added coaching to the mix, and participants not only tracked their blood pressure more regularly but saw healthier numbers too. Still *et al.* (2021) took it further by involving pharmacists directly through virtual consults, helping patients fine-tune their treatments in real time.

It is not just about the clinical outcomes, it is also about how people interact with these tools. Logan *et al.* (2019) [19] and Lu *et al.* (2019) found that people are more likely to keep using apps that are designed well and offer encouragement. Lin *et al.* (2020) studied AI-based coaching, while Davis *et al.* (2022) [7] worked on dashboards paired with health coaches. Both approaches kept people motivated and made it easier to stick with healthy habits.

Smith *et al.* (2018) [29] and Blumenthal *et al.* (2019) [3] showed how apps that alert doctors to unusual readings led to faster interventions and better outcomes. Wang *et al.* (2020) [32] saw similar results when automated alerts helped prompt medication adjustments at just the right time.

Chandler *et al.* (2022) [6] reminded us that when mHealth tools include clinicians, the results tend to be stronger across the board. Patel *et al.* (2021) [24] emphasized how vital these tools became during the pandemic, helping people keep up with care when face-to-face visits were not possible. Reviews by Santo *et al.* (2019) [27] and Hamine *et al.* (2018) [13] added further weight to the evidence, mHealth helps people stay on their meds, which is key to long-term success.

Some studies added a personal touch. Johnson *et al.* (2020) [14] explored how setting individual health goals through an app helped people take ownership of their progress. Kim *et al.* (2021) [15] showed that even simple text message reminders made a big difference. Green *et al.* (2018) [10] and Kvedar *et al.* (2019) [16] blended traditional care with mHealth, proving that tech does not replace providers, it supports them.

Finally, Buis *et al.* (2017) [4] and Lee *et al.* (2019) [17] looked at lifestyle tracking and remote logging. These tools helped users build consistent habits and strengthened follow-up care. Altogether, these studies offer more than just data, they tell a hopeful story. When thoughtfully designed and supported by clinical teams, mHealth apps do more than record numbers. They empower people, make care more accessible, and offer real potential to transform how hypertension is managed in everyday life.

Public Health Implications

Using mobile health (mHealth) apps for managing hypertension could really change things for public health in the U.S. Since high blood pressure is a major cause of health problems and deaths, getting more people to use these digital tools can help improve health across the board, lower costs, and support fairness in health care.

1. **Better Access to Care:** One of the biggest benefits of mHealth apps is that they can help more people access care, especially in areas that do not get enough medical services. Folks in rural or low-income communities often struggle to find doctors, get transportation, or deal with high costs. Mobile health apps help break down those barriers by allowing patients to check their blood pressure, stick to treatment plans, and learn about their health from home. This is a game changer for managing hypertension, reaching those who might not get to regular doctor visits (Kruse *et al.*, 2017).

2. **Savings and Efficiency:** Beyond just improving access, these apps can save money for healthcare systems. They encourage people to monitor their health and stick to their medications, which can lower the chances of serious health issues like strokes or hospital visits. Apps that allow for real-time tracking can help prevent these big, costly problems. Plus, by handling some of the education and monitoring tasks digitally, these tools can help doctors focus more on patients with complex needs (Gomez *et al.*, 2019) [11].

3. **Empowering Patients:** mHealth apps are all about putting patients in control of their health. They provide immediate feedback, help users set personal goals, and offer info to boost health understanding and promote positive changes. This is super important for managing chronic conditions like hypertension, where daily choices about food, exercise, and meds can really make a difference. When patients feel more capable and confident thanks to these apps, it can lead to better health habits and increased satisfaction with their care (Orsama *et al.*, 2013) [23].

4. **Tackling Health Disparities:** High blood pressure hits African American and Hispanic communities harder, and these groups often have less access to technology and health services. Well-designed mHealth tools that take cultural needs into account, are multilingual, and can work on affordable devices can help address these issues. Bringing in community health workers or peer support through digital platforms has shown to be effective in helping more people engage. Making sure everyone can access these tools means investing in better digital services, offering financial help, and reaching out to the community (Veinot *et al.*, 2018) [30].

5. **Connecting with Public Health Efforts:** Public health agencies can use mHealth technology for larger initiatives to control blood pressure among populations. These apps could fit into broader efforts for preventing chronic diseases or Medicaid programs targeted at high-risk groups. Collaborations with app makers, telecom companies, and local organizations can help spread these tools further and make them last. Plus, the data collected from these apps can give insights for tracking health trends, better resource distribution, and shaping health policies (Free *et al.*, 2013) [8].

6. **Challenges to Consider:** Even with all this potential, there are challenges to making sure mHealth apps are effective for managing hypertension. Some of these according t Giansanti (2021) include:
   - Keeping patient data safe and private
   - Testing the apps for accuracy and effectiveness
   - Figuring out regulations for digital treatments
   - Connecting apps with electronic health records

- Getting Medicare and Medicaid to cover these digital tools

Hence, mobile health apps for managing high blood pressure have a lot of potential for public health. If done right, they can improve blood pressure management, reduce health disparities, cut costs, and empower patients. Future success will depend on coordinated efforts across healthcare, tech, and policy to ensure these tools are accessible, safe, and backed by solid evidence.

Conclusion
This systematic review of eight U.S.-based studies conducted between 2017 and 2022 confirms that mobile health (mHealth) applications can make a real and positive difference in managing high blood pressure. The studies examined, ranging from randomized controlled trials to meta-analyses, consistently showed that using these apps helps lower systolic blood pressure by an average of 5 to 10 mmHg. This is not just a number; it represents a meaningful improvement in heart health and a reduction in the risk of serious complications like stroke or heart disease.

Using mHealth for blood pressure control supports broader public health goals, like lowering heart disease rates, improving health equality, and updating how chronic diseases are handled. But to make the most of these tools, there is a need to tackle some serious issues, like concerns about data safety, gaps in digital skills, trouble integrating them with current health systems, and issues with how they're paid for.

While early results are good, there is need for deeper studies to understand how well mHealth helps with blood pressure control over time and how it affects serious outcomes like hospital stays and death. Culturally sensitive interventions need to be developed so everyone can access and use these tools effectively.

This review sets out to understand whether mobile apps can truly help people manage their blood pressure, and the answer is a clear yes. By carefully reviewing eight strong studies, it is seen as solid evidence that these tools are not just convenient, but effective. It also identified the key elements that make them work and the barriers that still need to be addressed, like data security, access for underserved communities, and integration into healthcare systems. Therefore, this review reveals that mHealth apps are a valuable addition to hypertension care in the United States. With thoughtful design, support from healthcare teams, and smart policies, these tools can help more people take control of their health.

Recommendations
Drawing from the findings of this review, the following recommendations are proposed to help ensure mobile health (mHealth) apps can be successfully and fairly used to help people manage high blood pressure across the U.SA.:

1. **Support for Healthcare Policies:** Policymakers and insurance providers should develop clear and accessible ways to cover the cost of using mHealth tools through Medicare, Medicaid, and private insurance. These financial pathways are essential to making sure that both patients and clinics can adopt and use these technologies without unnecessary barriers.

2. **Work with Clinical Teams:** Healthcare systems and the companies that build electronic health records (EHRs) should make it easier for mHealth apps to connect with existing digital tools doctors already use. This would allow patient data from apps to show up in a doctor's regular workflow, encouraging real-time communication and more personalized care.

3. **Digital Health Education:** Public health educators and community organizations should launch local programs to help people, especially older adults and those in underserved areas, learn how to use health apps. Simple, hands-on training can go a long way in building confidence and helping people make the most of these tools.

4. **App Certification and Quality Control:** Agencies like the FDA and ONC should set up guidelines to evaluate and approve mHealth apps. People need to know that the tools they're using are safe, reliable, and actually help improve health outcomes. A clear certification system will help users and clinicians make smart choices.

5. **Design for Everyone:** Developers and tech companies should make sure their apps are built for everyone, not just the tech-savvy. That means easy-to-read screens, voice instructions, translation options, and content that reflects the values and language of the people using it. Inclusive design will help reach more people and close the digital divide.

6. **Funding for Research:** Research groups and funding bodies should continue to invest in studies that track the long-term effects of using mHealth apps to manage blood pressure. These studies should look at both medical outcomes and how people from different communities use and benefit from these tools over time.

7. **Collaboration Between Sectors:** To make the most of mHealth, there is a need for collaboration. Tech developers, doctors, schools, community groups, and government agencies should work together to build and scale solutions that really work in the real world. Sharing resources and expertise will help speed up progress.

8. **Privacy and Security Measures:** Legal and data privacy experts must ensure that every mHealth app keeps user information safe and respects personal boundaries. Clear, easy-to-read privacy policies and strong security checks are essential to maintaining trust and protecting people's sensitive health data.

By acting on these recommendations together, an environment can be created where mobile health apps are not just available, but truly accessible, trustworthy, and impactful for everyone managing high blood pressure.

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