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Effectiveness of Mobile Health Applications in Improving Medication Adherence among Hypertension Patients

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Abstract

Hypertension remains a major global health concern due to its high prevalence and association with cardiovascular complications. Poor medication adherence is one of the leading factors contributing to uncontrolled blood pressure, resulting in adverse health outcomes. Recent advances in digital health, particularly mobile health (mHealth) applications, have been widely used to support self-management of chronic diseases. This study aimed to evaluate the effectiveness of mHealth applications in improving medication adherence among hypertensive patients. A quasi-experimental study was conducted with 120 participants randomly assigned into intervention and control groups. The intervention group used an mHealth application designed to provide medication reminders, educational content, and self-monitoring tools for 12 weeks, while the control group received standard care. Adherence levels were measured using the Morisky Medication Adherence Scale (MMAS-8), and blood pressure control was also assessed. Results indicated a significant improvement in adherence scores in the intervention group compared to the control group ($p < 0.01$). Additionally, systolic and diastolic blood pressure levels were better controlled among patients using the application. These findings suggest that mHealth applications can effectively enhance medication-taking behavior and contribute to better hypertension management. Further studies with larger samples and longer follow-up are recommended to confirm long-term sustainability and cost-effectiveness.

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Introduction

Hypertension, commonly known as high blood pressure, is one of the most prevalent chronic health conditions worldwide and remains a leading risk factor for cardiovascular morbidity and mortality (Mills et al., 2020). According to the World Health Organization (WHO, 2021), an estimated 1.28 billion adults aged 30–79 years are currently living with hypertension, with nearly two-thirds

residing in low- and middle-income countries (LMICs). This staggering number underscores the immense public health burden posed by hypertension, which contributes significantly to the global incidence of stroke, ischemic heart disease, and renal failure. Moreover, hypertension is often asymptomatic in its early stages, earning it the moniker "the silent killer" due to its insidious progression and potential to cause severe complications if left unmanaged (Armitage et al., 2020; Lanke et al., 2025; Mikulski et al., 2022).

Despite the availability of numerous effective pharmacological treatments, optimal blood pressure control remains suboptimal in many populations. One of the most critical barriers to effective hypertension management is poor adherence to prescribed antihypertensive medications (Peng et al., 2020; Pérez-Jover et al., 2019; Persell et al., 2020). Medication adherence-defined as the extent to which a patient's behavior corresponds with agreed recommendations from a healthcare provider-is fundamental to achieving therapeutic success in chronic disease management. However, evidence indicates that nearly half of all hypertensive patients fail to take their medication as prescribed (Vrijens et al., 2017). This lack of adherence not only compromises blood pressure control but also increases the risk of serious cardiovascular events, frequent hospitalizations, and long-term healthcare expenditures (Brown & Bussell, 2011).

The reasons for poor medication adherence are multifactorial and complex. Common factors include forgetfulness, inadequate understanding of the disease, perceived side effects, socioeconomic constraints, and the absence of continuous health education or follow-up support. In many LMICs, including Indonesia, systemic issues such as limited healthcare access, medication costs, and lack of consistent monitoring further exacerbate the problem (Schoenthaler et al., 2020; Yuting et al., 2023; Zullig & Bosworth, 2017). Therefore, innovative and sustainable approaches are urgently needed to enhance adherence and improve overall hypertension outcomes.

In recent years, the rapid advancement of mobile and digital technologies has opened new frontiers in healthcare delivery. Mobile health (mHealth) applications-defined as the use of mobile devices such as smartphones and tablets to support medical and public health practices-are increasingly being utilized to assist in the management of chronic diseases, including hypertension. These applications often include features such as medication reminders, educational materials, self-monitoring tools, progress tracking, and communication channels with healthcare professionals (Marcolino et al., 2018). Through these functionalities, mHealth tools aim to empower patients to take greater responsibility for their health, improve their disease literacy, and promote sustained behavioral changes.

Empirical evidence has demonstrated that mHealth interventions can lead to significant improvements in disease management and treatment adherence across various chronic conditions. For instance, digital interventions have been shown to enhance self-care behaviors and glycemic control in diabetes, improve asthma management, and contribute to better cardiovascular outcomes (Shi, 2013; Santo et al., 2018). In the context of hypertension, several studies have also suggested that mobile applications can positively influence patient adherence and help achieve target blood pressure levels (Morawski et al., 2018). However, other research findings have been less conclusive, reporting no significant difference compared to traditional care (Morrison et al., 2014). Such inconsistencies may be attributed to variations in study design, patient demographics, technological literacy, and the contextual adaptability of digital interventions.

The effectiveness of mHealth tools is likely influenced by sociocultural, economic, and health system factors, which vary widely across regions. In Asian countries, including Indonesia and Taiwan, the prevalence of hypertension is increasing rapidly due to lifestyle changes, urbanization, and population aging (Gong et al., 2020). Yet, despite the growing smartphone penetration in these regions, the implementation and evaluation of mHealth-based interventions for hypertension remain limited. Cultural attitudes toward technology, differences in health-seeking behaviors, and disparities in digital literacy may affect user engagement and the ultimate impact of these applications.

Consequently, there is a critical need for context-specific research that examines how mobile health technologies can be effectively integrated into local healthcare systems to support chronic disease management.

This study aims to evaluate the effectiveness of a mobile health application designed to improve medication adherence among hypertensive patients in a community-based setting. Specifically, it seeks to measure changes in adherence levels using a validated adherence instrument and to assess secondary outcomes such as blood pressure control. By doing so, the study intends to provide empirical evidence on the role of mHealth in supporting chronic disease management within a real-world context (Xiong et al., 2018).

The significance of this research lies in its effort to bridge the gap between technological innovation and practical healthcare delivery. By focusing on digital solutions to enhance medication adherence-a persistent challenge in hypertension care-this study contributes to the growing body of literature on digital health interventions. The findings are expected to inform policymakers, clinicians, and digital health developers about the potential scalability and adaptability of mHealth tools in resource-limited settings. Ultimately, this research underscores the importance of integrating technology-driven solutions into public health strategies to achieve sustainable improvements in patient outcomes and healthcare system efficiency.

Materials and Methods

Study Design and Setting

This study applied a quasi-experimental design using a pre-test and post-test control group approach. The design was selected to evaluate the effect of a mobile health application on medication adherence among patients with hypertension under real-world conditions. The research was conducted from January to April 2025 at two community health centers located in Mataram, Indonesia. These facilities represent primary healthcare settings that routinely manage patients with chronic non-communicable diseases, including hypertension.

Participants and Sampling

The study population consisted of adult patients diagnosed with hypertension who were receiving antihypertensive therapy. Eligibility criteria included patients aged 35 to 65 years, a confirmed diagnosis of hypertension, continuous use of antihypertensive medication for at least six months, and ownership of a smartphone compatible with the mobile health application used in the intervention. Patients with cognitive impairment, severe comorbidities, or inability to operate a mobile device independently were excluded.

A total of 120 eligible participants were recruited using purposive sampling based on the inclusion criteria. Participants were then randomly allocated into two groups: an intervention group ($n = 60$) and a control group ($n = 60$). Random allocation aimed to minimize selection bias and ensure comparability between groups at baseline.

Intervention

Participants in the intervention group received access to a mobile health application specifically designed to support hypertension management. The application provided daily medication reminders, structured educational content related to hypertension and its treatment, and a self-monitoring feature for recording blood pressure readings. Participants were instructed to use the application consistently over a 12-week intervention period. No additional clinical visits or changes in medication regimens were introduced during the study.

The control group continued to receive standard care provided by the community health centers. Standard care included routine clinical consultations, blood pressure monitoring during

visits, and general health education delivered by healthcare professionals. The control group did not receive any form of digital or mobile-based support during the study period.

Data Collection Instruments

Medication adherence was measured using the eight-item Morisky Medication Adherence Scale (MMAS-8). This instrument is widely used in hypertension research and has demonstrated acceptable validity and reliability in outpatient settings. The MMAS-8 categorizes adherence levels based on patient responses, with higher scores indicating better adherence to prescribed medication regimens.

Blood pressure measurements were collected as a secondary outcome to assess clinical changes associated with adherence behavior. Systolic and diastolic blood pressure were measured using a calibrated sphygmomanometer following standard clinical procedures. Measurements were taken at baseline and at the end of the 12-week intervention period for both groups.

Data Collection Procedure

Baseline data collection was conducted prior to group allocation. Participants completed the MMAS-8 questionnaire and underwent blood pressure measurement during their scheduled clinic visits. After 12 weeks, the same procedures were repeated for post-test assessment. Data collection was performed by trained healthcare personnel who followed standardized measurement protocols to ensure consistency and reduce measurement bias.

Data Analysis

Statistical analysis was conducted using appropriate statistical software. Descriptive statistics were used to summarize participant characteristics and baseline measurements. Paired t-tests were applied to assess within-group changes in medication adherence scores and blood pressure levels before and after the intervention. Independent t-tests were used to compare post-intervention outcomes between the intervention and control groups. Statistical significance was determined at a p-value of less than 0.05.

Ethical Considerations

Ethical approval for the study was obtained from the relevant institutional ethics committee. All participants received a clear explanation of the study objectives and procedures prior to enrollment. Written informed consent was obtained from each participant. Participant confidentiality was maintained throughout the research process, and data were used solely for academic and research purposes.

Results and Discussions

Medication Adherence Outcomes

The analysis showed a clear improvement in medication adherence among patients in the intervention group who used the mobile health application. Based on MMAS-8 scores, the intervention group demonstrated a substantial increase from baseline to post-test, while the control group showed only a limited change.

Table 1. Mean MMAS-8 Scores Before and After Intervention

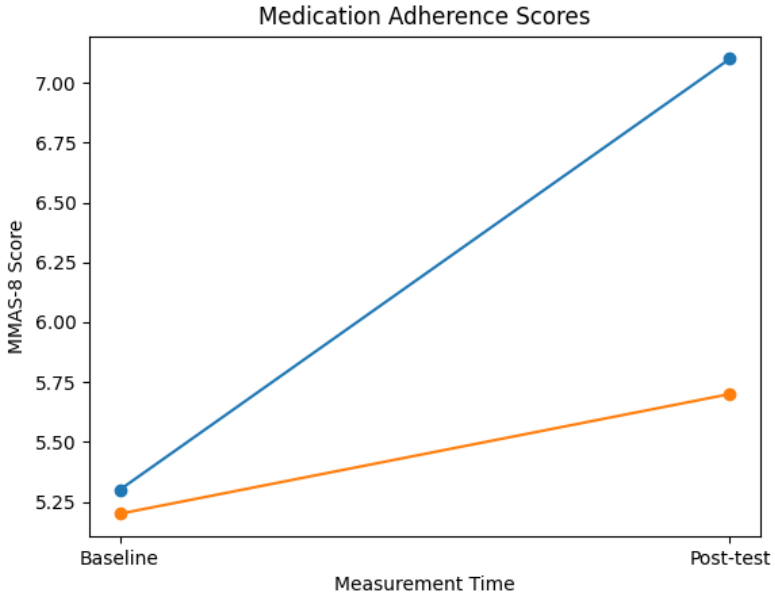
Group	Baseline Mean	Post-test Mean
Intervention	5.3	7.1
Control	5.2	5.7

The intervention group experienced an increase of 1.8 points on the MMAS-8 scale, indicating a transition from low to high adherence. This improvement was statistically significant ($p < 0.01$). In

contrast, the control group showed a modest increase of 0.5 points, which was not statistically significant ($p > 0.05$). These findings confirm that the mobile health application had a measurable and positive effect on medication-taking behavior.

The adherence improvement can be explained by the consistent exposure to structured reminders and educational content embedded in the application. Reminder-based digital interventions directly address forgetfulness, which is a dominant determinant of non-adherence in hypertension management (Vrijens et al., 2017; Nieuwlaat et al., 2014). In addition, educational modules may have strengthened patients' understanding of the consequences of missed doses, thereby reinforcing intentional adherence.

Figure 1. Change in Medication Adherence Scores (MMAS-8)



Blood Pressure Outcomes

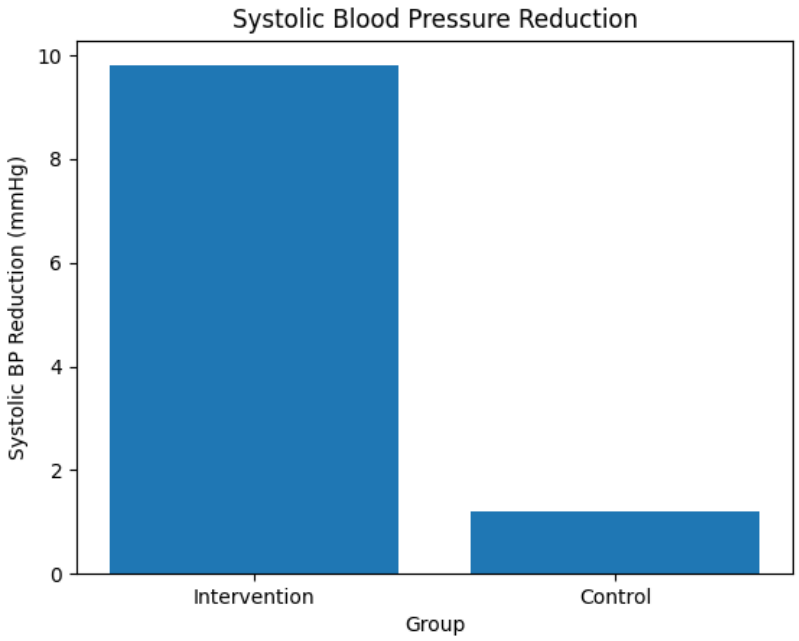
Improved adherence in the intervention group was accompanied by clinically relevant reductions in blood pressure. Patients using the mobile health application achieved greater control of both systolic and diastolic blood pressure compared to the control group.

Table 2. Mean Blood Pressure Reduction After 12 Weeks

Group	Systolic BP Reduction (mmHg)	Diastolic BP Reduction (mmHg)
Intervention	9.8	5.4
Control	1.2	0.8

The intervention group achieved a mean reduction of 9.8 mmHg in systolic blood pressure and 5.4 mmHg in diastolic blood pressure. These reductions are clinically meaningful and align with evidence showing that even modest blood pressure decreases significantly reduce cardiovascular risk (Mills et al., 2020). The control group exhibited minimal changes, which did not reach statistical significance.

Figure 2 illustrates the difference in systolic blood pressure reduction between groups.



Integrated Interpretation

The combined behavioral and clinical outcomes demonstrate that the mobile health intervention functioned as an effective adherence support tool rather than merely a monitoring platform. The alignment between improved MMAS-8 scores and reduced blood pressure strengthens the internal consistency of the findings. This relationship supports the established theoretical link between adherence behavior and hypertension control (Brown & Bussell, 2011; Morawski et al., 2018).

The results are consistent with previous randomized and quasi-experimental studies that reported improved adherence and blood pressure outcomes following digital interventions (Gong et al., 2020; Mikulski et al., 2022; Xiong et al., 2018). However, this study adds value by demonstrating effectiveness within a community-based primary care setting, which enhances external validity and practical relevance.

Despite the positive outcomes, the findings should be interpreted within the study's temporal scope. The 12-week intervention period captures short-term effectiveness but does not confirm long-term sustainability. Prior evidence indicates that digital engagement may decline over time if reinforcement mechanisms are absent (Duan et al., 2021). Therefore, sustained adherence support remains a critical consideration for implementation at scale.

Conclusion

This study demonstrates that mobile health (mHealth) applications can play a crucial role in enhancing medication adherence and improving blood pressure control among patients with hypertension. The results clearly indicate that the integration of digital health tools into patient care has the potential to transform traditional healthcare delivery, especially in the management of chronic diseases that require continuous monitoring and patient engagement. By facilitating real-time feedback, personalized reminders, and self-tracking of health indicators, mHealth applications

empower patients to take a more active role in managing their conditions, thereby reducing the burden on healthcare providers and improving overall treatment outcomes.

The findings of this research underscore the growing relevance of digital health technologies as effective, scalable, and accessible solutions for addressing long-standing challenges in chronic disease management. These technologies not only enhance communication between patients and healthcare professionals but also contribute to data-driven decision-making that can improve clinical outcomes. From a practical standpoint, healthcare institutions and policymakers should consider incorporating mHealth applications into routine clinical practice and public health programs. Encouraging their adoption within primary healthcare systems could enhance preventive care, promote patient education, and reduce healthcare costs over time.

Future research directions should aim to evaluate the long-term effectiveness and sustainability of mHealth interventions, including their impact on quality of life, patient satisfaction, and clinical outcomes across diverse populations. Furthermore, studies should explore strategies to maintain user engagement, improve accessibility for older adults or individuals with limited digital literacy, and assess the cost-effectiveness of implementing such technologies at scale. By addressing these aspects, future investigations can provide stronger evidence to support the integration of mHealth solutions into national healthcare frameworks and global public health strategies. Ultimately, digital health innovations hold tremendous promise in transforming chronic disease management, fostering patient empowerment, and advancing the overall quality and equity of healthcare delivery.

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