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Effectiveness of Hybrid Digital Learning for Hypertension Self-Management Education among Hypertensive Patients

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Abstract: Hypertension remains a major global health problem associated with poor medication adherence, inadequate self-management behavior, and uncontrolled blood pressure among patients in primary healthcare settings. This study aimed to analyze the effectiveness of Hybrid Digital Learning for Hypertension Self-Management Education in improving medication adherence and blood pressure control among hypertensive patients. This study employed a quasi-experimental pretest-posttest control group design conducted at Klinik Pratama Jatipuro Muhammadiyah Karanganyar, Central Java, Indonesia, from January to March 2026. A total of 62 participants were recruited using purposive sampling and equally divided into intervention and control groups. The intervention group received hybrid digital learning interventions consisting of face-to-face educational sessions, digital pocketbook-based learning media, and weekly monitoring for eight weeks, while the control group received standard educational services. Medication adherence was measured using the Morisky Medication Adherence Scale (MMAS-8), while blood pressure was assessed using a calibrated digital sphygmomanometer. Data were analyzed using SPSS version 26 using descriptive and inferential statistical tests. The findings demonstrated significant improvements in medication adherence scores from 5.21 ± 1.12 to 7.43 ± 0.88, reductions in systolic blood pressure from 154.61 ± 10.43 mmHg to 132.48 ± 8.71 mmHg, and reductions in diastolic blood pressure from 96.32 ± 7.14 mmHg to 84.51 ± 6.27 mmHg among participants receiving the hybrid digital learning intervention ($p < 0.001$). The study concludes that Hybrid Digital Learning for Hypertension Self-Management Education is effective in improving medication adherence and blood pressure control among hypertensive patients. The findings support the integration of hybrid digital learning models into primary healthcare education programs to strengthen long-term hypertension self-management and technology-assisted patient education.

Keyword : Hybrid Digital Learning; Digital Health Education; Self-Management Education; Digital Pocketbook; Health Literacy

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Introduction

Hypertension remains one of the most significant global public health challenges and continues to contribute substantially to cardiovascular morbidity and mortality worldwide. The World Health Organization reported that more than 1.28 billion adults globally are affected by hypertension, yet a large proportion of patients still fail to achieve optimal blood pressure control due to poor adherence to treatment and inadequate self-management behaviors (World Health Organization, 2024). In Indonesia, hypertension prevalence among adults continues to increase and has become a major burden for primary healthcare services, particularly in relation to long-term disease management and prevention of cardiovascular complications. Recent evidence also demonstrates that low health literacy, limited patient engagement, and insufficient educational support are among the major barriers affecting hypertension self-management and medication adherence (Anh Hien et al., 2025). Hypertension is also associated with increased healthcare expenditure, decreased quality of life, and higher risks of stroke, heart failure, and kidney disease, particularly among populations with limited access to sustainable health education and self-management support (Prima Trisna Aji; Yunie Armiyati; Elinda Rizkasari, 2026).

The rapid development of digital technology has encouraged innovation in educational approaches, including the implementation of hybrid digital learning models in healthcare education. Hybrid digital learning combines face-to-face educational interaction with digital learning media to improve accessibility, flexibility, and learner engagement. Several studies have shown that digital learning interventions can improve knowledge acquisition, self-care behavior, and treatment adherence among patients with chronic diseases (Kappes et al., 2023). Furthermore, digital educational media such as mobile health applications, electronic pocketbooks, and telehealth-based learning systems have demonstrated positive effects on behavioral modification and long-term disease management (Zhang et al., 2024). These findings indicate that digital learning approaches have strong potential to support sustainable health education, especially in primary healthcare settings. From an educational perspective, hybrid digital learning promotes learner-centered education by integrating flexible technology-assisted learning with direct instructional interaction, thereby enhancing participant engagement, accessibility, and independent learning experiences (Yardley;, 2020).

In the context of hypertension management, self-management education plays a critical role in improving patients' ability to monitor symptoms, adhere to medication, regulate diet, maintain physical activity, and control blood pressure independently. Previous studies have emphasized that nurse-led educational interventions significantly improve medication adherence and blood pressure outcomes among hypertensive patients (Bulto et al., 2024). However, most previous interventions primarily focused on conventional face-to-face education without

integrating interactive digital learning support. Several digital health interventions have also been implemented separately through telemonitoring or mobile applications, but many studies reported limitations regarding patient engagement, continuity of learning, and accessibility for older adults in primary healthcare services (Aji, Kuan, et al., 2026). Therefore, there remains a need for an innovative educational model that combines direct educational interaction with accessible digital learning media to strengthen self-management learning outcomes among hypertensive patients.

Current conditions in primary healthcare services indicate that conventional educational approaches are often insufficient to maintain long-term behavioral change among patients with hypertension (Za'im et al., 2024). Preliminary observations conducted at Klinik Pratama Jatipuro Muhammadiyah Karanganyar revealed that many hypertensive patients experienced difficulties in maintaining regular medication adherence and independent blood pressure monitoring due to limited educational reinforcement and low access to continuous learning resources (Khasanah et al., 2024). Although educational counseling has been routinely conducted, the absence of interactive digital learning support limits patients' opportunities to revisit educational materials independently after face-to-face sessions. This condition creates a significant gap between the increasing demand for technology-assisted learning innovation and the continued reliance on traditional educational approaches in primary healthcare settings (Liu et al., 2025).

Several previous studies have investigated digital health education and nurse-led interventions for hypertension management; however, research specifically examining the integration of hybrid digital learning through face-to-face education combined with digital pocketbook media remains limited, particularly in Indonesian primary healthcare contexts. Most studies focused only on telehealth monitoring, mobile applications, or standard counseling without developing a structured hybrid learning model that integrates educational interaction, digital literacy support, and continuous learning reinforcement simultaneously (Widyastuti et al., 2025). Despite the growing implementation of digital health education, limited studies have specifically explored hybrid digital learning integrating face-to-face education and digital pocketbook-based reinforcement within primary healthcare settings in Indonesia. In addition, limited evidence is available regarding how hybrid digital learning can support sustainable learner engagement and independent self-management learning among adult participants in community healthcare education (Aji, Tania, et al., 2026). Therefore, this study introduces a hybrid digital learning approach for hypertension self-management education that integrates face-to-face learning sessions, digital pocketbook-based educational media, and continuous monitoring support within primary healthcare services.

Several previous studies have explored digital health education and nurse-led interventions for hypertension management in primary healthcare settings. A study conducted by (Widyastuti et al., 2025) examined telehealth-based hypertension monitoring and demonstrated improvements in blood pressure control; however, the study primarily focused on remote monitoring without integrating structured educational interaction or digital learning reinforcement. Another study by (Phn et al., 2024) investigated mobile application-based hypertension education and reported increased medication adherence, but the intervention relied mainly on application usage and did not combine face-to-face learning with continuous educational support. In addition, research conducted by (Blodgett et al., 2025) evaluated conventional counseling interventions for hypertension self-management and found moderate improvements in patient knowledge; nevertheless, the intervention lacked technology-assisted educational media and sustainable learner engagement strategies. Furthermore, (Aji, Tania, et al., 2026) explored digital health literacy interventions among hypertensive patients, but the study did not specifically develop a hybrid digital learning model integrating face-to-face education, digital pocketbook-based learning, and continuous monitoring simultaneously within primary healthcare services. Therefore, this study addresses these gaps by developing and evaluating a Hybrid Digital Learning for Hypertension Self-Management Education model that integrates face-to-face educational sessions, digital pocketbook-based learning media, and continuous learning reinforcement to improve medication adherence and blood pressure control among hypertensive patients in Indonesian primary healthcare settings (Prima Trisna Aji, Marta Tania GCC, 2026).

This study is important because it contributes to the development of educational innovation in health learning by integrating digital technology into patient self-management education. The novelty of this study lies in the implementation of a hybrid digital learning model that combines direct educational interaction and digital pocketbook-based learning media to improve self-management learning outcomes among hypertensive patients in primary healthcare settings. Unlike previous studies that primarily focused on telemonitoring or mobile applications separately, this study developed an integrated hybrid educational approach emphasizing continuous learning reinforcement, digital accessibility, and participant-centered self-management learning simultaneously. This study also contributes to the advancement of digital health education by providing evidence regarding the effectiveness of technology-assisted learning innovation in supporting behavioral modification and independent learning among adult learners in healthcare settings (Gordon et al., 2023). Therefore, this study aimed to evaluate the effectiveness of Hybrid Digital Learning for Hypertension Self-Management Education as a technology-assisted educational innovation in improving medication adherence, blood pressure control, and self-

management learning outcomes among hypertensive patients in primary healthcare settings.

Methodology

Research Model

This study employed a quasi-experimental research design using a pretest-posttest control group approach to evaluate the effectiveness of Hybrid Digital Learning for Hypertension Self-Management Education among hypertensive patients in primary healthcare settings. The overall research procedure implemented in this study is illustrated in Figure 1.

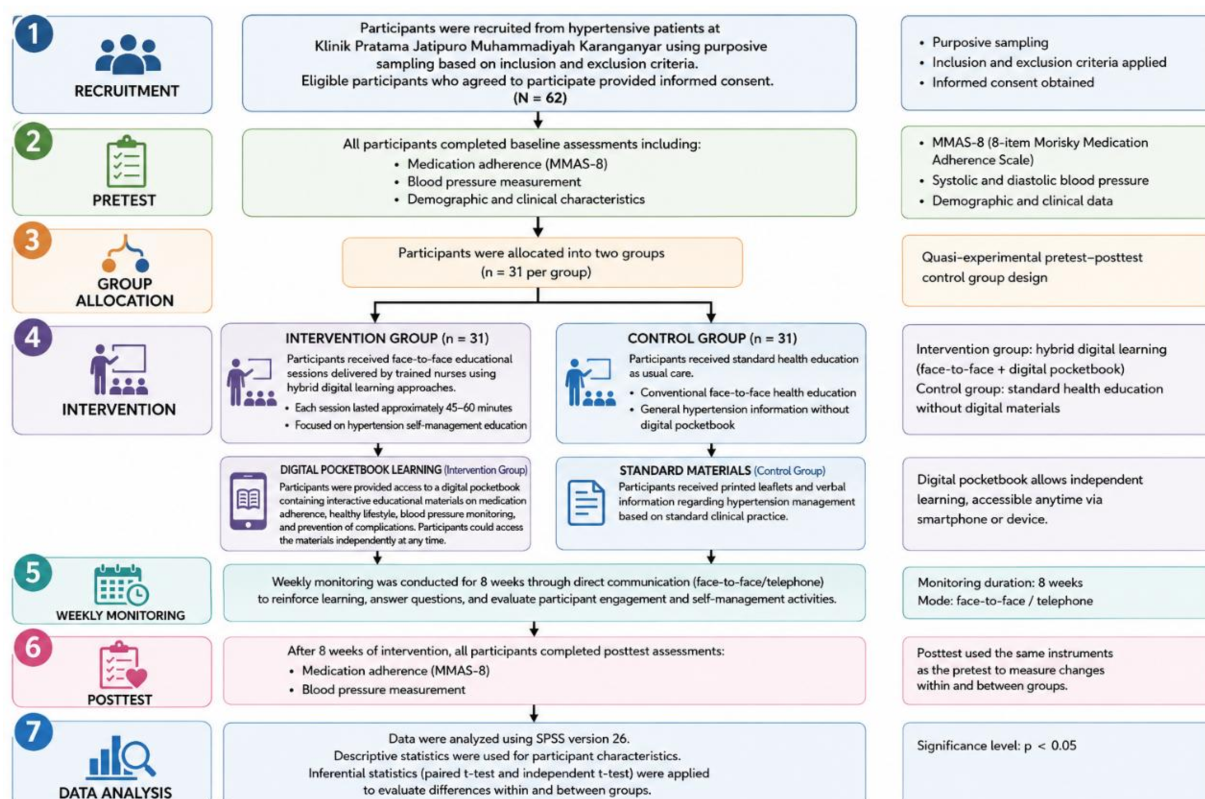


Figure 1. Flowchart of Hybrid Digital Learning Intervention Procedures
Source: Developed by the researchers (2026).

This design was considered appropriate for evaluating changes in learning outcomes and behavioral modification before and after the intervention. The study focused on the implementation of a hybrid educational intervention integrating face-to-face learning sessions with digital learning media through a digital pocketbook. This approach was selected because hybrid digital learning has been recognized as an innovative educational strategy that combines direct instructional interaction and technology-assisted learning to improve learner engagement, accessibility, and behavioral outcomes (Anderson, K., & Williams, 2021). The intervention also

emphasized participant-centered learning experiences and independent self-management learning development through technology-assisted educational reinforcement.

The intervention emphasized self-management learning activities designed to improve participants' understanding of hypertension management, medication adherence, healthy lifestyle modification, and independent blood pressure monitoring. The hybrid learning model in this study integrated educational reinforcement through weekly monitoring and digital educational access to support continuous learning processes. The study was conducted from January to March 2026 at Klinik Pratama Jatipuro Muhammadiyah Karanganyar, Central Java, Indonesia. The setting was selected because it routinely provides hypertension management services and supports community-based health education activities.

Partcipant

The population of this study consisted of hypertensive patients who routinely attended primary healthcare services at Klinik Pratama Jatipuro Muhammadiyah Karanganyar. Participants were selected using purposive sampling techniques based on predetermined inclusion criteria. Purposive sampling was selected to ensure that participants met the specific educational and clinical characteristics required for the intervention process. The inclusion criteria included: (1) diagnosed with hypertension by healthcare professionals, (2) aged over 18 years, (3) undergoing routine antihypertensive treatment, (4) able to communicate effectively, and (5) willing to participate throughout the study period. Meanwhile, patients with severe complications or cognitive impairment were excluded from the study.

A total of 62 participants were recruited and allocated into intervention and control groups, consisting of 31 participants in each group. Randomization was not applied because this study used a quasi-experimental design conducted within a real-world primary healthcare setting, where participant allocation needed to follow service schedules and practical clinical considerations. Participants attending healthcare services during the first recruitment period were assigned to the intervention group, while participants recruited during the subsequent period were assigned to the control group to minimize contamination between groups. To reduce selection bias, the researchers applied identical inclusion and exclusion criteria for both groups and compared baseline demographic and clinical characteristics prior to the intervention to ensure group comparability.

Data Collection Tools

Several instruments and educational media were utilized in this study. Medication adherence was measured using the Morisky Medication Adherence Scale (MMAS-8), which has been widely used in hypertension-related adherence studies

and demonstrated good validity and reliability in measuring self-management behavior (Heidari;, 2020). Previous studies reported Cronbach's alpha values above 0.70, indicating acceptable internal consistency of the instrument. Blood pressure measurements were conducted using a calibrated digital sphygmomanometer following standardized measurement procedures to ensure consistency and accuracy.

The primary educational media used in the intervention group was a digital pocketbook designed specifically for hypertension self-management learning. The digital pocketbook contained interactive educational materials related to medication adherence, dietary management, physical activity, stress management, blood pressure monitoring, and prevention of hypertension complications. Educational materials were developed using simple language and visual learning approaches to improve participant understanding and accessibility, particularly for adult learners in primary healthcare settings. In addition, weekly monitoring sheets were used to evaluate participant engagement and continuity during the intervention process.

Data Collection Process

The data collection process was conducted in several stages. Initially, all participants underwent pretest assessments to measure baseline medication adherence and blood pressure levels before the intervention. After the baseline assessment, participants in the intervention group received face-to-face educational sessions delivered by trained nurses using hybrid digital learning approaches. Each educational session was conducted for approximately 45-60 minutes and followed standardized educational materials and learning guidelines. All intervention sessions followed identical learning procedures and educational content to maintain intervention standardization across participants. Educational sessions focused on improving hypertension self-management understanding, medication adherence behavior, and independent lifestyle modification.

Following the face-to-face educational sessions, participants were provided with access to the digital pocketbook as an independent learning medium that could be accessed repeatedly throughout the intervention period. Weekly monitoring was conducted for eight weeks through direct communication and educational reinforcement to support participant engagement and learning continuity. Meanwhile, the control group received standard educational services without additional digital learning support.

At the end of the intervention period, posttest assessments were conducted to evaluate changes in medication adherence scores and blood pressure outcomes among participants. Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics were used to describe participant characteristics, while inferential statistical tests were applied to analyze differences before and after the intervention and between groups. The statistical analysis aimed to

evaluate differences in learning outcomes and behavioral changes before and after the intervention. The Shapiro–Wilk test was conducted to assess data normality. Data with normal distribution were analyzed using paired sample t-tests and independent sample t-tests, while non-parametric alternatives were applied for non-normally distributed data. Statistical significance was determined at $p < 0.05$ (Politi et al., 2021).

To ensure intervention consistency, all educational sessions, digital learning activities, and monitoring procedures were conducted using standardized educational guidelines and intervention protocols. The digital pocketbook content was reviewed and validated by two experts in nursing education and hypertension management before implementation. The educational content was evaluated for relevance, clarity, and learning suitability prior to implementation. A limited pilot evaluation was also conducted to assess participant readability and usability of the digital pocketbook before the main intervention. All educational interventions and monitoring activities were delivered by trained healthcare educators to ensure intervention standardization throughout the study period. Regular monitoring and supervision were conducted to maintain intervention fidelity throughout the implementation process (Yao et al., 2026).

The study focused on a single primary healthcare setting to support standardized intervention implementation. The quasi-experimental approach was selected to facilitate practical implementation within real-world primary healthcare settings while maintaining intervention feasibility and participant accessibility. Ethical principles including confidentiality, voluntary participation, and informed consent were maintained throughout the study process. All participants provided informed consent prior to data collection, and the study procedures were conducted in accordance with institutional research ethics standards and the Declaration of Helsinki. Participant anonymity and data confidentiality were ensured throughout the research process. All collected data were securely stored and used exclusively for research purposes.

Result and Discussion

Result

1. Normality Test Results

Prior to inferential statistical analysis, data normality was evaluated using the Shapiro–Wilk test because the sample size in each group was less than 50 participants. The results demonstrated that all outcome variables had p-values greater than 0.05,indicating normal data distribution. Therefore, parametric statistical tests, including paired t-test and independent t-test, were considered appropriate for further analysis.

Table 2. Shapiro–Wilk Normality Test Results

Variable	Group	Statistic	p-value	Distribution
Medication Adherence Pretest	Intervention	0.967	0.421	Normal
Medication Adherence Posttest	Intervention	0.973	0.587	Normal
Medication Adherence Pretest	Control	0.961	0.318	Normal
Medication Adherence Posttest	Control	0.969	0.463	Normal
Systolic Blood Pressure Pretest	Intervention	0.958	0.276	Normal
Systolic Blood Pressure Posttest	Intervention	0.965	0.398	Normal
Systolic Blood Pressure Pretest	Control	0.331	0.331	Normal
Systolic Blood Pressure Posttest	Control	0.959	0.289	Normal

Since all variables were normally distributed ($p > 0.05$), parametric statistical analyses using paired t-test and independent t-test were applied.

2. Participant Characteristics

A total of 62 participants were involved in this study, consisting of 31 participants in the intervention group and 31 participants in the control group. Based on demographic characteristics, most participants were aged between 45–60 years, indicating that hypertension was predominantly experienced among middle-aged and older adults. Female participants were more dominant in both groups, reflecting the common epidemiological characteristics of hypertension patients in primary healthcare settings. Most participants had experienced hypertension for more than one

year and routinely received antihypertensive medication therapy. The distribution of participant characteristics is presented in Table 1.

Table 1. Participant Characteristics

Characteristics	Intervention Group (n=31)	Control Group (n=31)
Age (Mean ± SD)	54.6 ± 7.2	53.9 ± 6.8
Female, n (%)	19 (61.3%)	18 (58.1%)
Male, n (%)	12 (38.7%)	13 (41.9%)
Hypertension duration >1 year	23 (74.2%)	21 (67.7%)
Routine medication therapy	31 (100%)	31 (100%)

Based on Table 1, both groups demonstrated relatively similar baseline demographic characteristics, indicating that the participants had comparable conditions before the intervention was conducted. No statistically significant differences were identified between groups during baseline assessment, indicating comparable initial participant characteristics.

3. Medication Adherence Outcomes

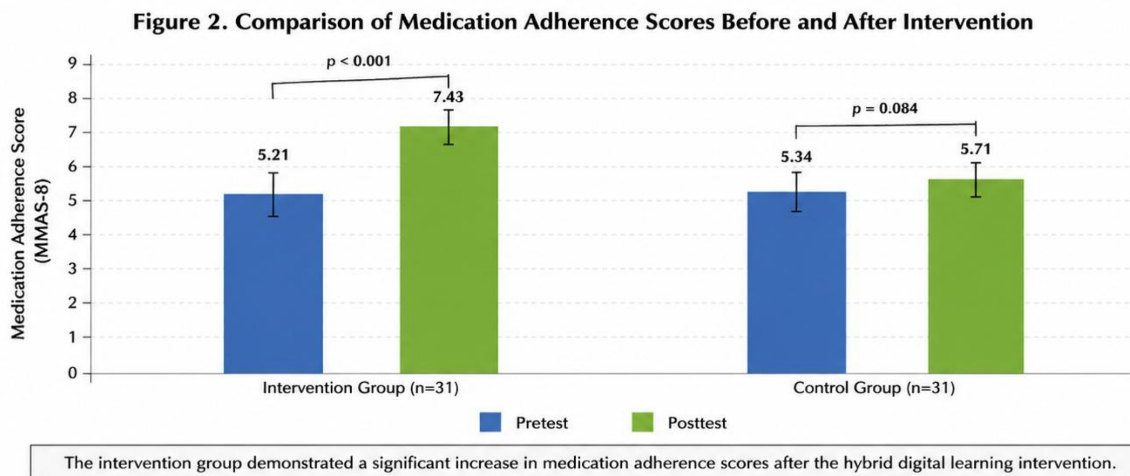
The results showed that participants in the intervention group experienced a significant improvement in medication adherence after receiving Hybrid Digital Learning for Hypertension Self-Management Education. The intervention integrated face-to-face learning sessions, digital pocketbook-based learning media, and continuous educational monitoring for eight weeks.

Table 2 presents the comparison of medication adherence scores before and after the intervention.

Table 2. Comparison of Medication Adherence Scores

Group	Pretest Mean ± SD	Posttest Mean ± SD	p-value
Intervention	5.21 ± 1.12	7.43 ± 0.88	<0.001
Control	5.34 ± 1.08	5.71 ± 1.01	0.084

The comparison of medication adherence scores before and after the intervention is presented in Figure 2.



Based on Figure 2, participants in the intervention group demonstrated a greater increase in medication adherence scores compared with the control group following the hybrid digital learning intervention.

Based on Table 2, the intervention group demonstrated a statistically significant increase in medication adherence scores after the intervention ($p < 0.001$). The intervention group demonstrated a mean increase of 2.22 points in medication adherence scores, indicating substantial improvement in self-management learning outcomes after participating in the hybrid digital learning intervention. Meanwhile, the control group showed only a slight improvement without significant statistical difference. These results indicate that the hybrid digital learning intervention produced significantly greater improvements compared with routine educational approaches. These findings indicate that the hybrid digital learning intervention effectively strengthened participants' self-management learning and medication adherence behavior. In addition to medication adherence outcomes, the study also evaluated the effectiveness of the intervention in improving blood pressure control among participants.

4. Blood Pressure Outcomes

The study also demonstrated significant improvements in blood pressure control among participants receiving the hybrid digital learning intervention.

Participants in the intervention group demonstrated more substantial improvements in systolic and diastolic blood pressure compared with the control group.

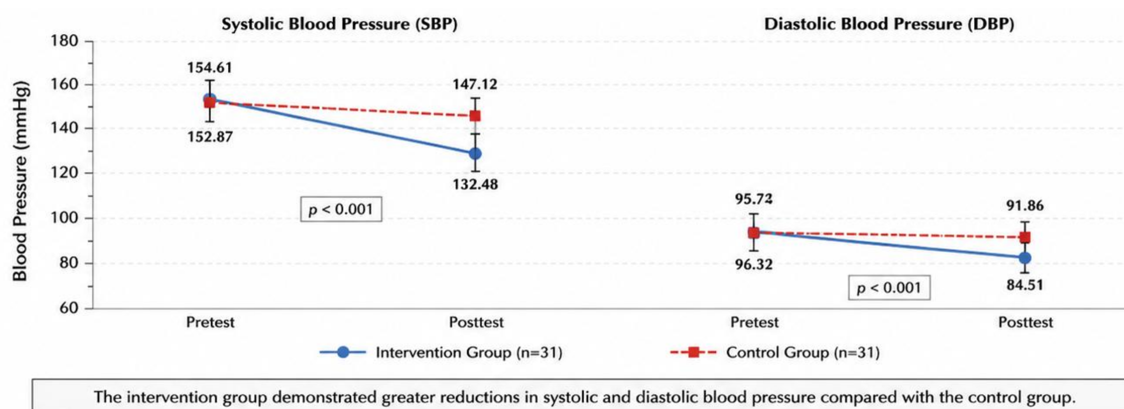
Table 3 presents the comparison of blood pressure outcomes between groups.

Table 3. Comparison of Blood Pressure Outcomes

Variable	Intervention Group	Control Group	p-value
Systolic BP Pretest	154.61 ± 10.43	152.87 ± 9.98	0.512
Systolic BP Posttest	132.48 ± 8.71	147.12 ± 10.02	<0.001
Diastolic BP Pretest	96.32 ± 7.15	95.74 ± 6.88	0.621
Diastolic BP Posttest	84.51 ± 5.94	91.86 ± 6.37	<0.001

Discussion

Figure 3 illustrates the changes in systolic and diastolic blood pressure before and after the intervention.



Based on Figure 3, the intervention group demonstrated greater reductions in systolic and diastolic blood pressure compared with the control group after the intervention period.

Based on Table 3, participants in the intervention group experienced a greater reduction in both systolic and diastolic blood pressure after participating in the hybrid digital learning program. The findings indicate that continuous educational reinforcement through digital learning media contributed positively to self-management behavior and blood pressure control. The intervention group demonstrated a mean reduction of 22.13 mmHg in systolic blood pressure and 11.81 mmHg in diastolic blood pressure after the intervention period. The posttest differences between groups were statistically significant, indicating that the hybrid

digital learning intervention was more effective than routine educational approaches in improving blood pressure control.

1. Hybrid Digital Learning Engagement

During the intervention process, participants in the intervention group demonstrated high engagement in digital learning activities. Most participants actively accessed the digital pocketbook repeatedly throughout the intervention period and participated consistently in weekly monitoring sessions. Participants reported that the digital pocketbook provided flexible learning opportunities, improved understanding of hypertension management, and supported independent learning activities at home. Participants also demonstrated improved self-directed learning behavior and greater engagement in technology-assisted educational activities throughout the intervention period (Brown et al., 2023).

The integration of face-to-face education and digital learning media also improved participant motivation and facilitated continuous educational reinforcement. These findings suggest that hybrid digital learning can increase participant engagement and strengthen self-management learning experiences in primary healthcare education settings (Zhang et al., 2024). Participants also demonstrated increased confidence and independent learning behavior in managing hypertension-related self-care activities during the intervention process. Overall, the findings demonstrated that Hybrid Digital Learning for Hypertension Self-Management Education effectively improved medication adherence, blood pressure control, participant engagement, and self-management learning outcomes among hypertensive patients. The integration of face-to-face learning, digital pocketbook-based education, and continuous monitoring also contributed positively to independent learning behavior and technology-assisted health education experiences in primary healthcare settings.

This study demonstrated that Hybrid Digital Learning for Hypertension Self-Management Education significantly improved medication adherence and blood pressure control among hypertensive patients in primary healthcare settings. The integration of face-to-face learning sessions with digital pocketbook-based learning media provided continuous educational reinforcement that enhanced participant engagement and supported independent self-management learning. These findings suggest that technology-assisted hybrid learning can serve as an effective educational strategy for promoting sustainable behavioral modification and independent self-management learning among individuals with chronic diseases (Prima Trisna Aji, Marta Tania GCC, 2026).

The significant improvement in medication adherence observed in this study is consistent with previous studies highlighting the effectiveness of digital learning interventions in strengthening self-management behavior and treatment adherence.

Recent evidence suggests that technology-assisted learning approaches increase participant accessibility to educational materials and encourage continuous learning engagement outside conventional educational sessions (Aji & Lazuardi, 2025). In this study, the availability of digital pocketbook-based learning media allowed participants to repeatedly access educational content, which contributed to improved understanding and long-term adherence behavior. From a learning theory perspective, the findings support learner-centered and self-directed learning principles, where repeated access to educational materials and continuous reinforcement facilitate active participant engagement and independent learning behavior. These findings are also consistent with behavioral learning principles suggesting that repeated reinforcement and accessible learning resources may strengthen long-term behavioral adaptation and self-management practices.

The findings also support previous studies emphasizing the important role of hybrid educational approaches in chronic disease management. Hybrid digital learning enables participants to receive direct interaction during face-to-face educational sessions while simultaneously benefiting from flexible and accessible digital learning support. According to Lazuardi et al. (2025), digital health education integrated with continuous reinforcement significantly improves self-care behavior and blood pressure outcomes among hypertensive patients. Similarly, Bulto et al. (2024) reported that nurse-led educational interventions positively affect medication adherence and cardiovascular risk management in primary healthcare services. However, several previous studies reported lower participant engagement in fully digital health interventions due to technological barriers and limited digital literacy among older adults. In contrast, the hybrid learning model implemented in this study combined direct educational interaction and simple digital learning support, which may explain the higher participant engagement observed during the intervention process.

Another important finding of this study was the significant reduction in systolic and diastolic blood pressure among participants receiving the intervention. These findings indicate that improved educational engagement and self-management learning contribute not only to behavioral outcomes but also to measurable clinical improvements. This finding indicates that effective educational engagement may indirectly influence physiological health outcomes through improved adherence and sustainable lifestyle modification behaviors. Educational reinforcement through weekly monitoring and digital learning activities likely increased participant awareness regarding medication routines, dietary modification, physical activity, and independent blood pressure monitoring. This result aligns with previous studies

reporting that continuous self-management education significantly improves hypertension control and long-term lifestyle modification (Pujiyanto, 2021).

From an educational perspective, this study contributes to the growing body of evidence regarding the implementation of digital learning innovation in health education. The novelty of this study lies in the integration of face-to-face educational interaction, digital pocketbook-based learning media, and continuous monitoring support within a structured hybrid digital learning model (Aji, Rizkasari, et al., 2026). Unlike previous studies that focused primarily on telehealth or mobile application monitoring separately, this study developed a more comprehensive educational learning approach emphasizing participant engagement, accessibility, and sustainable learning reinforcement simultaneously (Aji & Sani, 2021).

The findings also highlight the importance of digital literacy support in primary healthcare education. Although several participants initially experienced limitations in digital learning accessibility, continuous guidance and simple educational media design improved participant adaptability and learning participation. This finding suggests that digital educational innovation should consider learner characteristics, accessibility, and ease of use to maximize learning effectiveness among adult participants in community healthcare settings (Ben Yehuda et al., 2024). Practically, the findings suggest that primary healthcare educators and nurses can utilize hybrid digital learning approaches as accessible educational strategies to strengthen participant engagement and support sustainable self-management education programs. The findings of this study may also support the development of digital health education policies emphasizing technology-assisted learning innovation within community-based healthcare services (Yakavets et al., 2023). Nevertheless, variations in participant digital literacy and technology accessibility remained important challenges during the implementation process, particularly among older adult participants unfamiliar with digital learning media. The study also contributes to community-based health education practices by demonstrating how hybrid learning strategies can support flexible and sustainable adult learning in primary healthcare environments.

2. Instructional Design Implications for Adult Learning in Primary Healthcare

This study has several limitations. The intervention was conducted in a single primary healthcare setting with a relatively limited number of participants, which may affect the generalizability of the findings. In addition, the intervention duration was limited to eight weeks, so long-term sustainability of behavioral changes could not be fully evaluated (Gordon et al., 2023). Future studies are recommended to involve larger multicenter populations and longer intervention periods to evaluate the long-term effectiveness of hybrid digital learning interventions in chronic disease management and digital health education. Further research may also explore the integration of

mobile health applications, interactive multimedia learning, and artificial intelligence-assisted educational support to strengthen participant engagement and self-management learning outcomes.

Overall, Hybrid Digital Learning for Hypertension Self-Management Education demonstrated strong effectiveness in improving self-management learning outcomes among hypertensive patients. The findings support the implementation of technology-assisted educational innovation as an effective and sustainable strategy for strengthening participant-centered learning, digital health literacy, and chronic disease self-management education in primary healthcare services (Ormes et al., 2025). Furthermore, the hybrid learning model developed in this study has strong potential to be adapted across broader healthcare education contexts to support sustainable health learning, independent self-management behavior, and technology-assisted educational transformation in chronic disease management.

Conclusion

Hybrid Digital Learning for Hypertension Self-Management Education demonstrated significant effectiveness in improving medication adherence and blood pressure control among hypertensive patients in primary healthcare settings. The implementation of a structured hybrid digital learning approach contributed positively to participant engagement, independent learning behavior, and sustainable self-management education outcomes. The findings indicate that technology-assisted educational innovation has strong potential to enhance digital health literacy and sustainable self-management learning in primary healthcare services. The study also highlights the importance of integrating technology-assisted learning innovation into community-based health education to support flexible and learner-centered educational experiences. Primary healthcare educators and healthcare professionals are encouraged to adopt hybrid digital learning strategies to strengthen participant engagement and improve long-term chronic disease self-management education. Furthermore, the hybrid digital learning model developed in this study has strong potential to be implemented across broader healthcare education contexts as a sustainable strategy for strengthening digital health literacy, participant-centered learning, and technology-assisted chronic disease education. This study was limited by the relatively small sample size and short intervention duration conducted within a single primary healthcare setting, which may limit the generalizability of the findings.

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