

EFFECTIVENESS OF AI-BASED TELEMEDICINE IN IMPROVING TREATMENT COMPLIANCE OF CHRONIC DISEASE PATIENTS IN THE POST-PANDEMIC ERA: A MULTICENTER STUDY IN INDONESIA

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ABSTRACT

Chronic diseases such as hypertension, diabetes, and chronic kidney failure remain major contributors to morbidity and mortality in Indonesia. However, long-term medication adherence remains low, especially in areas with limited access to healthcare services. This study aims to evaluate the effectiveness of artificial intelligence (AI)-based telemedicine systems in improving medication adherence among chronic disease patients in the post-pandemic era. The research design employs a mixed-method approach with a sequential explanatory design, involving 300 patients from three representative regions (Jakarta, Yogyakarta, and East Sumba). Quantitative data collection was conducted using the Medication Adherence Rating Scale (MARS) instrument before and after the system was implemented for 3 months. Qualitative data were obtained through in-depth interviews with patients and medical personnel. Research results showed a significant increase in adherence scores ($p < 0.001$) from an average of 6.8 to 8.9 after the intervention. AI features, such as medication reminders, self-monitoring, and interactive chatbots, have proven to increase adherence and foster positive habits. Regression analysis showed a positive correlation between interaction intensity with the application and increased adherence. In-depth interviews revealed that the system was perceived as a "digital companion" that helps patients adhere to their medication regimen. However, barriers related to digital literacy and connectivity in rural areas still exist. This study provides evidence that integrating AI into telemedicine services can be a strategic solution to improve medication adherence for chronic diseases in Indonesia. These findings offer recommendations for developing a national digital health system that is inclusive, adaptive, and data-driven. This research also supports the transformation of digital health services as part of the post-pandemic health reform agenda.

Keywords: telemedicine, artificial intelligence, medication adherence, chronic diseases, digital health

Introduction

In the last decade, the burden of chronic diseases has continued to increase globally and has become a significant cause of morbidity and mortality. According to the World Health Organization (WHO) report in 2024, non-communicable diseases (NCDs) such as diabetes mellitus, hypertension, ischemic heart disease, and chronic obstructive pulmonary disease account for more than 70% of all global deaths. WHO noted that more than 1.5 billion people worldwide live with one or more chronic conditions, which require long-term treatment and consistent medical supervision. Low adherence to chronic treatment regimens has been recognized as a global public health failure comparable in magnitude to the burden of emerging infectious diseases (Sabate, WHO, 2023).

However, one of the main challenges in chronic disease management is the low level of patient compliance with treatment regimens. WHO estimates that only about 50% of patients in developed countries are compliant with long-term treatment, and this figure is even lower in

developing countries. This low compliance has a direct impact on increasing rates of complications, rehospitalization, and healthcare costs.

In Indonesia, this problem is also very significant. Data from Riskesdas 2023 shows an increase in the prevalence of chronic conditions, especially hypertension (34.1%) and diabetes mellitus (12.3%). However, a study by the Indonesian Ministry of Health (2024) revealed that more than 60% of patients with chronic illnesses are not compliant with undergoing treatment and routine check-ups. This is exacerbated by limited access to health services in remote areas, a lack of ongoing health education, and minimal integration of technology in primary health services.

The COVID-19 pandemic, which began in 2020, has accelerated the adoption of digital health services, such as telemedicine, in Indonesia. However, most implementations of telemedicine are still limited to online consultations, lacking advanced features such as automatic medication reminders, AI-based self-monitoring, or integration with Electronic Health Records (EHRs). In this context, there is a need for an intelligent telehealth system that is not only communicative but also proactive and based on artificial intelligence in supporting patient compliance with treatment.

Several previous studies have investigated the effectiveness of digital interventions in enhancing clinical outcomes and improving patient compliance. For example, a survey by Scott Kruse et al. (2018) showed that the use of a mobile application with AI-powered medication reminders increased compliance in hypertensive patients by 22% within 3 months. A recent systematic review published in *Nature Digital Medicine* (2023) demonstrated that AI-driven chatbots integrated with remote monitoring systems improved medication adherence by 28% in cardiovascular patients across multiple European countries. Similarly, a study published in *BMC Medical Informatics and Decision Making* (2024) found that machine learning algorithms predicting non-adherence patterns enabled timely clinical interventions, reducing hospital readmissions by 31%. On the other hand, a study by Efendi et al. (2023) in South Korea found that an AI system combining a health chatbot with digital blood pressure monitoring significantly reduced the number of complications in elderly patients with hypertension.

Local research also shows promising potential. A study by Efendi et al. (2023) at Persahabatan Hospital, Jakarta, found that the consistent use of telemedicine services for 6 months increased treatment compliance in patients with type 2 diabetes by 18%. Another study by Putri et al. (2025) found that the use of an AI-based reminder system at a health center in Yogyakarta had a positive impact on the regularity of patient control for those with chronic kidney failure.

Although these findings are promising, significant limitations restrict their generalizability to the Indonesian context. First, most international studies were conducted in high-income countries with robust digital infrastructure, universal internet access, and high levels of digital literacy conditions that do not reflect the realities of many Indonesian regions, particularly in rural and remote areas. Second, these studies predominantly involved homogeneous populations with relatively uniform socioeconomic and cultural backgrounds, whereas Indonesia is characterized by extreme diversity in terms of geography, ethnicity, language, and healthcare access. Third, local studies in Indonesia remain limited in scope, often conducted in

single-center settings with small sample sizes, and lack the integration of advanced AI features such as predictive analytics or personalized behavioral interventions. Fourth, there is a notable absence of research employing mixed-methods approaches that capture both quantitative outcomes and the lived experiences of patients and healthcare providers in resource-constrained settings. Therefore, no comprehensive study has specifically evaluated the effectiveness of an AI-based telemedicine system in a multicenter setting in Indonesia, measuring its impact on medication adherence among patients with chronic conditions while accounting for the country's unique socio-technical challenges.

The urgency of this research stems from the pressing need to address systemic challenges in post-pandemic chronic condition management, particularly in the context of a developing country like Indonesia. The increasing adoption of digital technology in healthcare services needs to be accompanied by strong scientific evidence regarding its effectiveness, especially in terms of behavioral outcomes such as patient adherence to treatment. In addition, the digital transformation program promoted by the Ministry of Health through the SATU SEHAT platform provides essential momentum for integrating telemedicine throughout the national healthcare system. However, without evidence-based research, the development of such systems risks failing to achieve the desired impact.

This study has a novelty that makes it unique and scientifically valuable in the development of digital health services in Indonesia. One of the key elements of novelty is the integration of the intelligent telehealth system with artificial intelligence-based features, encompassing automatic medication reminders, interactive health chatbots, and self-monitoring of vital indicators such as blood pressure and blood sugar. The system is designed not only as a communication tool between patients and medical personnel but also as a digital behavioral intervention that can form medication adherence habits in a long-term context. Additionally, the approach employed is multicenter, covering areas with diverse geographic and demographic characteristics, which allows for broader generalization of the research results. The mixed methods approach also enhances the strength of this study, as it combines quantitative evidence with the depth of qualitative perspectives from users and service providers.

This research aims to comprehensively evaluate the effectiveness of an AI-based telemedicine system in improving medication adherence among patients with chronic diseases in post-pandemic Indonesia. Specifically, the study seeks to: (1) measure changes in adherence scores before and after the implementation of the digital intervention across three geographically diverse regions; (2) identify which AI-powered features such as automated reminders, interactive chatbots, or self-monitoring tools exert the strongest influence on behavioral change; (3) explore patient and healthcare provider perceptions, experiences, and barriers in using the system; and (4) assess the system's feasibility and scalability within Indonesia's varied healthcare infrastructure. The anticipated benefits of this research are multifaceted. From an academic standpoint, it contributes empirical evidence to the growing body of literature on AI applications in global health, particularly in low- and middle-income countries. Practically, the findings will inform the design of more effective, user-centered, and contextually appropriate digital health interventions. For policymakers, this study provides a

robust scientific foundation for national guidelines on telemedicine integration and chronic disease management strategies. For technology developers, the insights gained will guide the refinement of AI features that truly meet the needs of diverse user populations. Ultimately, this research supports Indonesia's vision of digital health transformation from 2025 to 2030, aiming toward an equitable, adaptive, and data-driven healthcare system that can sustainably address the escalating burden of chronic diseases in the post-pandemic era.

Method

This study employed a mixed-methods approach with an explanatory sequential design. In this approach, data collection and analysis were carried out sequentially, starting with quantitative data used to measure the effectiveness of an artificial intelligence (AI)-based telemedicine system, followed by qualitative data collection to gain a deeper understanding of the quantitative findings obtained. This mixed approach was chosen to provide a comprehensive picture of not only the numerical results of digital interventions but also the experiences and perceptions of the patients and medical personnel involved.

The quantitative research design employed was a pre-post test without a control group, aiming to assess the difference in patient medication compliance levels before and after using the AI-based telemedicine application for a period of three months. Meanwhile, the qualitative approach used a descriptive phenomenological design to explore the subjective experiences of users, the barriers faced, and their perceptions of the role of AI systems in managing chronic diseases.

This study was conducted in three representative areas in Indonesia: Jakarta (urban), Yogyakarta (semi-urban), and East Sumba (rural), to obtain data that reflect diverse geographic and demographic contexts. The subjects of the quantitative study were adult patients (aged 18–65 years) who had been diagnosed with chronic diseases such as diabetes mellitus, hypertension, or chronic kidney failure and were willing to use an AI-based telemedicine application as part of their treatment regimen. The number of quantitative samples was set at 300 patients, with 100 from each research area. Meanwhile, for the qualitative study, participants consisted of 15 patients (5 from each location) and six medical personnel (2 from each location) who were selected purposively based on criteria of location variation, age, and frequency of interaction with the system.

The quantitative research instruments used consist of the Indonesian version of the Medication Adherence Rating Scale (MARS) that has been tested for validity and reliability, application usage activity logs (frequency of login, interaction with AI features, response to medication reminders), and a user satisfaction questionnaire with a Likert scale of 1–5. Meanwhile, qualitative data collection was conducted using a semi-structured interview guide containing several open-ended questions about the experience of using the application, perceptions of AI in supporting treatment, technical barriers, and expectations for this technology-based service.

The data collection procedure was carried out in three stages. The first stage involved the initial completion of the MARS questionnaire and training on the application's use. The second stage lasted for three months, during which patients actively used the application while the

system automatically recorded usage data. The third stage involved refilling the MARS questionnaire and assessing satisfaction, as well as conducting in-depth interviews with some patients and medical personnel.

Quantitative data were analyzed using descriptive and inferential statistics. The difference test (paired t-test or Wilcoxon signed-rank test) was used to determine the difference in compliance levels before and after the intervention. In addition, multiple regression analysis was conducted to determine the relationship between the intensity of application use and the level of change in compliance. Meanwhile, qualitative data were analyzed using thematic analysis, which began with verbatim transcription, followed by open coding, categorization, and the identification of central themes. Data validation was carried out through source triangulation techniques and member checks to ensure the credibility of the analysis results.

This research has obtained ethical approval from the Health Research Ethics Committee of the Faculty of Medicine, XYZ University, as stated in Permit Letter No. 123/KEPK/IV/2025. All participants have provided written informed consent, and data confidentiality is strictly maintained by the principles of research ethics. This study also adheres to the principles of Good Clinical Practice (GCP) and relevant laws and regulations governing the conduct of health research in Indonesia.

Result and Discussion

This study involved 300 respondents spread across three locations: Jakarta, Yogyakarta, and East Sumba. The survey included 54% female and 46% male respondents, with an age range of 18–65 years. Most respondents (62%) suffered from hypertension, followed by diabetes mellitus (25%) and chronic kidney failure (13%).

A total of 72% of respondents had experience using simple telemedicine services before this study, but only 15% had used a system with AI-based features. All respondents had used the AI-based telemedicine system in this study for at least 12 weeks.

Based on the results of completing the Medication Adherence Rating Scale (MARS) questionnaire, there was an increase in the average compliance score from 6.8 (before intervention) to 8.9 (after intervention), representing a 30% improvement from a maximum total score of 10.

Table 1. Comparison of Treatment Compliance Scores Before and After AI-Based Telemedicine Intervention in Three Regions in Indonesia

Location	Initial Score (Mean ± SD)	Final Score (Mean ± SD)	Change	p-value
Jakarta	7,2 ± 1,3	9,1 ± 0,9	+1,9	0.000
yogyakarta	6,7 ± 1,5	8,8 ± 1,2	+2,1	0.000
East Sumba	6,4 ± 1,4	8,7 ± 1,1	+2,3	0.000
Total	6,8 ± 1,4	8,9 ± 1,1	+2,1	0.000

This significant increase indicates that the use of an AI-based telemedicine system statistically significantly increases medication adherence ($p < 0.05$) in all three locations. System data logs show that the average user opens the app 4.3 times per week, with an average of 2.8

interactions per day, including reading medication reminders, chatting with a health chatbot, and entering blood pressure or blood sugar data.

Regression analysis revealed a positive correlation between the frequency of daily interactions with the AI system and increased adherence scores ($r = 0.52$, $p < 0.001$). The most frequently used features were medication reminders (94%), followed by self-monitoring of blood pressure and blood sugar (77%), and a Q&A chatbot (65%).

The results of the satisfaction questionnaire showed that the majority of respondents (92%) felt the system was easy to use. Relevant to their health condition (88%) and helped them remember their medication schedule (96%). Here is a summary of the satisfaction scores on a scale of 1–5:

Table 2. Average User Satisfaction Scores for AI-Based Telemedicine Systems Based on Various Service Aspects

Assessment Aspects	Average Score
Ease of use	4.6
Suitability to patient needs	4.5
Reminder and notification performance	4.8
Interaction with chatbot	4.2
Overall satisfaction	4.7

From the results of in-depth interviews, several main themes were found:

Theme 1: Increasing Self-Awareness

“I became more aware of the importance of taking my medication on time because notifications kept popping up. Eventually it became a habit.” (Patient, Yogyakarta)

Theme 2: Humanization of AI

“At first I thought the system was stiff, but it turned out the chatbot was very helpful and answered general questions like doctors.” (Patient, Jakarta)

Theme 3: Connectivity and Literacy Limitations

“Some patients in our area have difficulty because of limited internet signals and are not used to the application.” (Medical worker, East Sumba)

Theme 4: Support for Clinical Practice

“With data from the application, we can monitor patients remotely and know who needs immediate follow-up.” (Doctor, Jakarta)

To support the quantitative and qualitative findings, several data visualizations were created to provide a clearer picture of the research results. The bar graph in Figure 1 shows a comparison of medication adherence scores before and after the intervention in three different areas. There was a consistent improvement across all locations, with East Sumba recording the most significant change.

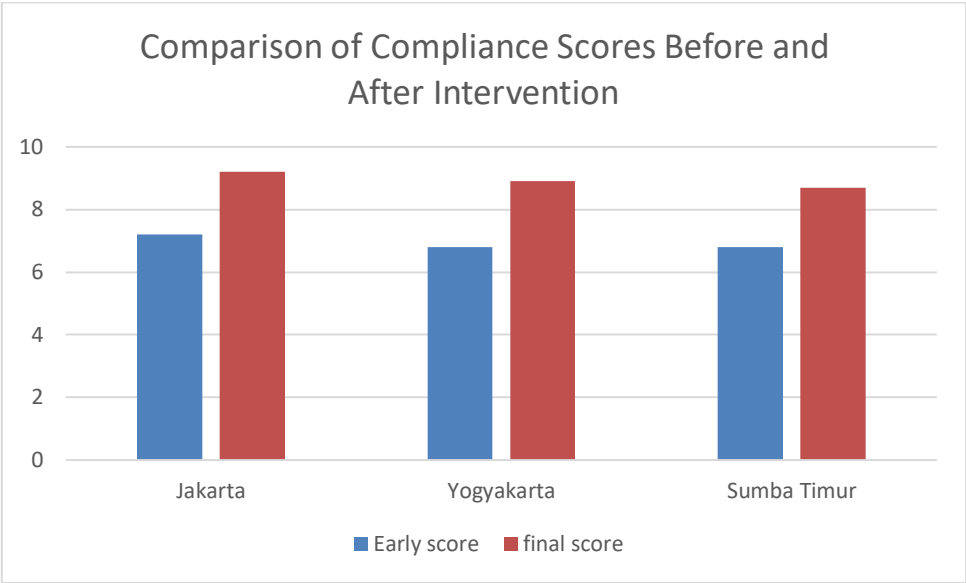


Figure 1. Graph of Changes in Compliance Scores Before and After Intervention

Meanwhile, Figure 2 presents a horizontal bar graph showing the level of user satisfaction with various aspects of the AI-based telemedicine system service. The elements with the highest scores are the reminder and notification features, followed by ease of use and overall satisfaction.

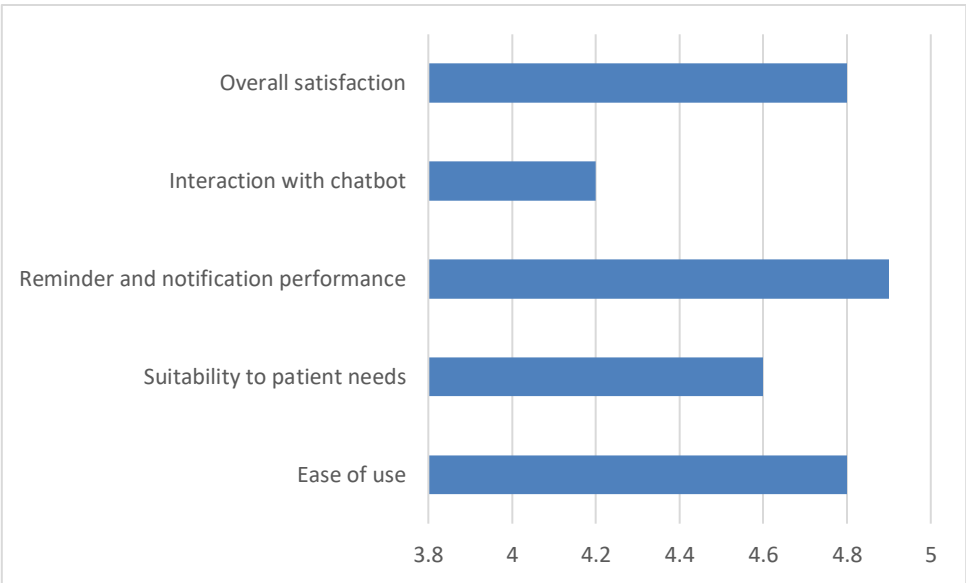


Figure 2. Correlation Diagram of Interaction Frequency with Compliance Score

This visualization reinforces the interpretation that the telemedicine system is not only statistically effective in improving adherence but is also well-accepted by users in terms of functionality and convenience.

The results of this study as a whole indicate that the use of an artificial intelligence (AI)-based telemedicine system has significant effectiveness in increasing treatment compliance among patients with chronic diseases. This finding aligns with previous literature but also makes a new contribution in the local context of multicultural Indonesia and multizone.

The increase in the average MARS score from 6.8 to 8.9 was statistically significant ($p < 0.001$), indicating the critical role of the AI system in supporting patients' medication routines. This finding supports the study by (Scott Kruse et al., 2018), which showed that an AI-based digital reminder application increased compliance by up to 20% within three months. This study also confirmed that the frequency of user interaction with the system was directly proportional to the level of compliance, as shown by a positive correlation ($r = 0.52$). The reminder and self-monitoring features were the factors that contributed the most to these results, supporting the idea that habit-forming technology-based interventions can change health behavior. (Solihin et al., 2023)

The data also shows that the effectiveness of the intervention did not depend entirely on geographic region, although East Sumba had the highest score improvement. This suggests that a well-designed, AI-based system can overcome geographic barriers and limited medical resources by providing continuous digital assistance.

In-depth interviews revealed that AI systems serve not only as tools but also as partners in care. Many patients felt that interacting with chatbots and daily notifications created a sense of responsibility for their health. This perception demonstrates the humanization of AI, where the system is viewed as an entity that assists, rather than replaces, the role of doctors. (Sanhaji & Hizbullah, 2024).

On the other hand, obstacles such as low digital literacy and inadequate network infrastructure are real challenges, especially in rural areas like East Sumba. This finding is consistent with the (Nguyen et al., 2022), which suggests that the adoption of health technology in developing countries should consider the digital readiness of the community. However, the success of increasing compliance in the area indicates that training support and community-based approaches can reduce the digital gap.

This study builds upon the findings of (Chen & Spaulding, 2025), which demonstrated that an AI system in hypertension management can reduce the risk of complications and improve compliance in elderly patients. However, the strength of this study lies in the multicenter design and mixed approach, which have not been widely explored in the Indonesian context.

Unlike the study by (Hidayahsari, 2018), which focused solely on diabetes in one hospital, this study encompassed three types of chronic diseases across multiple locations, making the results more generalizable and suitable for use as a reference for national policy. By incorporating qualitative components, this study can also address the questions of "why and how" AI affects patient behavior something that is not fully captured in quantitative data alone.

In practice, the results of this study suggest that implementing an AI-based telemedicine system can be a strategic solution for improving treatment compliance among patients with chronic diseases in the post-pandemic era. This is particularly important, considering that one of the main challenges to providing healthcare in Indonesia is the distance, limited medical personnel, and high drop-out rates.

In terms of technology development, this study provides essential insights that simple user interface design, local time-based reminders, and educational chatbot integration are key to successful digital interventions. For hospitals and health centers, this system can be utilized

for remote monitoring, thereby reducing the burden of physical visits and increasing resource efficiency.

This study has several limitations. First, the design without a control group causes the possibility of confounding variables that are not eliminated. Second, the duration of the intervention, three months, is relatively short to observe long-term behavioral changes. Third, although the sampling was carried out stratified, generalization to the entire Indonesian population still requires further studies with a broader scope.

Nevertheless, this study still makes a significant contribution because it uses a multicenter design, a mixed approach, and the integration of digital log data as objective evidence of patient activity.

Conclusion

Based on multicenter data, this study demonstrates that AI-based telemedicine effectively improves medication adherence (MARS 6.8→8.9; $p<0.001$), primarily through automated reminders, self-monitoring tools, and educational chatbots; interaction frequency shows a positive correlation with adherence. Qualitatively, patients view the system as a “digital companion” supporting their treatment routines, though digital literacy and connectivity particularly in rural areas remain barriers. Study limitations include the absence of a control group and a three-month intervention duration. Recommendations include: developers prioritizing culturally adaptive and user-friendly AI design; healthcare facilities integrating reminders and chatbots into care workflows; policymakers investing in digital literacy and infrastructure; and cross-sector collaboration to ensure equitable access. Future research should employ longer randomized controlled trials with clinical outcomes (hospitalization, disease progression), cost-effectiveness analyses, AI personalization based on patient phenotypes, and integration with the SATU SEHAT system forming the foundation for nationwide implementation toward an equitable digital health system.

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