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The Impact of Digital Health Interventions on Medication Adherence Among Patients with Chronic Diseases in Indonesia

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ABSTRACT

***Purpose**: The purpose of this research was to an americanize the effect of digital health interventions on medication compliance between patients with chronic illnesses in Indonesia.*

***Subjects and Methods:** Based on this research, data was collected from 200 patients with chronic diseases and the study employed an experimental package and a control group. The intervention group benefitted from telemedicine consultation, use of mobile health application and SMS reminders for three months while the control group had no intervention at all. Data were obtained from pre and post intervention adherence surveys and tested using t-test, regression and analysis of variance.*

***Results:** Descriptive statistic confirmed that a significant enhancement in medication adherence was observed in the participants of the intervention group than those of the control group ($t = 13.68$, $p < 0.000$). Also, other factors like digital engagement, higher income and better education were the significant predictors of better medication adherence.*

***Conclusions:** In this paper, a call is made for an increase in digital health interventions targeting adherence behavior in vulnerable groups.*

INTRODUCTION

Chronic diseases are among the major concerns of the Indonesian Health Care Centre since they form a huge burden in Indonesia both in terms of morbidity and mortality. Diabetes, hypertension, cardiovascular diseases and chronic respiratory diseases have become rampant over a period of time because of one or many factors such as, urbanization, change in dietary habits, genetic cause (WHO, 2022). Cardiovascular diseases, cancer, chronic respiratory diseases and diabetes are NCDs that claim more than 70% of people and more than 6400 people a day in Indonesia, hence the need for efficient measures to control NCD management in the country (Kemenkes RI, 2023). One of these chronic disease management factors is medication compliance, also called the ability of the patient to follow through a prescribed medical regimen.

Compliance has a crucial role in non-eventful outcomes and successful interferences for illnesses. Nevertheless, this therapeutic asset is not well sustained in numerous populations inclusive of LMICs such as Indonesia. Other barriers include: There are also numerous barriers to adherence that include: Some of these barriers are; Other barriers include; Some of the barriers include; A

cross-sectional study by Setiawati et al. (2022) found that frailty and low levels of medication adherence raise morbidity and mortality risks in patients with chronic disease.

Technology enhanced interventions have therefore been identified as important approaches for enhancing medication adherence. These interventions include; mobile health (mHealth) applications, telemedicine, electronic reminders, smartphones text messages (SMS) and any technology utilized in the aspect of health. They seek to enhance patient's uptake, access and interactions with prescribed treatment plans on enhancing health behaviour (Hidayat & Prasetyo, 2023). Digital health interventions are especially important in the low-resources context, in which traditional HMV may be inadequate (WHO, 2021). Moreover, the mobile technologies are useful to educate the patients, giving real time feedbacks and timely communication with the prescriber which are considered most important factors determining the medication adherence or otherwise (Vasili et al., 2022; Alam et al., 2022).

Previous research has also revealed that several digital heath interventions can increase adherence to medications and health status. For instance, Mo et al. (2023) conducted a systematic review to find that promotion of technology-centered interventions including Short Message Service and applications can increase adherence levels among diabetes and hypertensive clients. Also, research conducted in different contexts shows that the inclusion of especially teleconsultation and health monitoring applications can greatly alleviate adherence challenges (Prasetyo et al., 2023; Novianty et al., 2022). However, little is known about how these interventions are being put in practice, let alone how these interventions work in Indonesia's demographic and socio-economic environment. Indonesia is a vast archipelagic nation with diverse cultural, socio-economic, and geographic factors that influence health outcomes. Digital health solutions could potentially bridge the gap between healthcare services and patients, particularly for rural or underserved populations. However, disparities in digital access, literacy, and infrastructure pose challenges to the widespread adoption of these interventions (Kurniawan et al., 2023). Despite these challenges, the role of digital health strategies in transforming health behaviors warrants investigation, given their ability to leverage technology to promote timely medication use.

The concept of medication adherence has long been explored in the context of health behavior theories, such as the Health Belief Model and the Theory of Planned Behavior (Rosenstock et al., 2021). These frameworks suggest that perceived susceptibility to health risks, perceived benefits of treatment, and cues to action such as timely digital reminders can motivate adherence behaviors (Setiawati et al., 2022). Moreover, behavioral interventions that incorporate digital tools align well with these theoretical underpinnings, as they provide targeted support to mitigate barriers to medication adherence. Despite the growing body of literature on digital health strategies, there is still limited research specifically focusing on their implementation and effectiveness within the Indonesian context. The unique socio-cultural, geographic, and economic diversity of Indonesia poses challenges for uniform healthcare delivery, especially for patients with chronic diseases (Darmawan et al., 2024; Rerey et al., 2023). While digital health interventions such as mobile health applications, telemedicine, and SMS-based reminders have been proven effective in various global settings, evidence regarding their practical impact in Indonesia remains sparse. Most of the available research is fragmented and does not adequately explore how these interventions directly affect medication adherence among Indonesian patients managing chronic illnesses like diabetes, hypertension, and heart disease (Hidayat et al., 2022; Rahmawati et al., 2023).

Indonesia's healthcare landscape is marked by disparities in infrastructure, access, and technological literacy, particularly in rural and underserved regions. Many patients with chronic diseases struggle to maintain consistent medication routines, not solely due to a lack of education but also because of systemic barriers like limited access to health facilities, inadequate communication with healthcare providers, or financial constraints. Mardani et al. (2020) shows that digital health strategies could serve as a potential solution by creating alternative avenues for communication, education, and support. However, these strategies must be adapted to the unique

socio-economic and cultural conditions of Indonesia, where urban-rural divides and varying levels of technological literacy affect their adoption and effectiveness (Kurniawan et al., 2023).

Given this gap in the evidence, the present study seeks to evaluate the practical impact of digital health interventions on medication adherence among patients with chronic diseases in Indonesia. This investigation is not just about determining whether these interventions can improve adherence rates, it also aims to identify challenges that hinder their effectiveness. For instance, technological literacy levels among patients, disparities in smartphone access, and regional health service variations could influence intervention uptake and success. Additionally, by exploring demographic variables such as age, income, gender, and type of chronic disease, this study hopes to uncover patterns that can inform tailored strategies for specific vulnerable groups (Novianty et al., 2022).

This research is timely because it combines technology and evidence-based public health strategies to address one of Indonesia's most pressing health challenges poor medication adherence among chronic disease patients. The findings from this study could provide crucial insights into practical barriers and opportunities related to digital health interventions, offering actionable solutions for both health policymakers and practitioners. Moreover, the research will support the development of targeted, culturally sensitive, and accessible health programs that can reach diverse populations across the archipelago, especially in areas with limited access to healthcare services (Sabri et al., 2023; Alam et al., 2022).

Policymakers and healthcare providers could use this study to refine and strengthen health intervention programs by incorporating evidence from the Indonesian context (Sharma et al., 2020; Sulistiadi et al., 2024). Understanding not only the effectiveness of digital health interventions but also their accessibility, affordability, and adaptability could lead to more sustainable health outcomes for vulnerable groups. Furthermore, the findings could inform how resources are allocated, such as digital infrastructure investments, targeted public health education campaigns, and the integration of digital tools into routine healthcare services. This would ensure that the potential of technological innovation is maximized to combat non-adherence and improve health outcomes across Indonesia.

Ultimately, by bridging the gap between evidence, technology, and public health practice, this study aims to contribute to a framework for better chronic disease management strategies. It recognizes that technological advancements can address complex healthcare challenges but must be grounded in practical, context-specific insights to ensure their success and long-term sustainability.

The Problem of the Study

Medication adherence is a significant factor in managing chronic diseases, yet many patients struggle to maintain consistent adherence to prescribed treatment regimens. In Indonesia, the rising burden of chronic diseases such as diabetes, hypertension, and cardiovascular diseases has become a public health priority. However, studies indicate that non-adherence to medication remains a widespread issue among Indonesian patients, leading to adverse health outcomes, complications, and increased healthcare costs (Setiawati et al., 2022). Despite ongoing health efforts, many patients face barriers that hinder their ability to follow treatment protocols effectively, including lack of knowledge, limited access to healthcare services, and financial constraints.

According to Abernethy et al. (2022), digital health interventions have emerged as a promising approach to address these barriers. These interventions, which include mobile health (mHealth) applications, telemedicine, and SMS reminders, are designed to improve patient engagement, education, and adherence by leveraging technological platforms. However, the practical effectiveness of these strategies in Indonesia remains underexplored, with limited evidence on their ability to address medication adherence challenges among patients with chronic diseases in diverse geographical and socio-economic contexts. Factors such as unequal access to mobile

technology, technological literacy, and regional disparities pose additional challenges to their success (Kurniawan et al., 2023).

Given these gaps, this study seeks to assess the impact of digital health interventions on medication adherence among patients with chronic diseases in Indonesia. This investigation aims to determine whether these strategies can address adherence challenges, identify barriers to their implementation, and assess whether demographic factors influence their effectiveness. Such evidence would be vital for informing the development of targeted, practical, and accessible health programs and interventions that could improve adherence rates and health outcomes across Indonesia.

Significance of the Study

The findings of this study hold significant practical and theoretical value for multiple stakeholders, including policymakers, healthcare providers, and digital health innovators. From a practical perspective, the study will provide insights into the effectiveness of digital health interventions in addressing medication adherence among chronic disease patients in Indonesia. Given the growing burden of chronic diseases in the country, understanding how these interventions impact adherence can inform the design of effective health programs and interventions. Policymakers can leverage the findings to allocate resources more efficiently and strengthen health service delivery by investing in digital health infrastructure and technology education, particularly in underserved or rural areas. Healthcare providers can utilize this evidence to integrate technological tools into treatment regimens and patient education programs, improving communication and engagement with patients. Moreover, this study will contribute to the development of culturally sensitive, accessible, and feasible interventions that address socio-economic disparities affecting healthcare access. Furthermore, this study adds to the theoretical understanding of behavior change theories like the Health Belief Model and the Theory of Planned Behavior by examining how digital strategies influence perceived benefits, susceptibility, and cues to action in medication adherence. By exploring these relationships within a diverse, low-resource context like Indonesia, this study offers a practical application of these theories while addressing local health challenges. Finally, this research will encourage the adoption of evidence-based solutions by demonstrating how digital health interventions can improve adherence rates and health outcomes among chronic disease patients, providing a model for other low- and middle-income countries (LMICs) facing similar challenges.

Limitations of the Study

While this study aims to provide valuable insights into the impact of digital health interventions on medication adherence, certain limitations must be acknowledged. Firstly, the study is limited by its geographical focus within Indonesia. Indonesia's diverse geography, socio-economic disparities, and varying levels of technology access across urban and rural areas may influence the generalizability of findings. Secondly, the digital health interventions implemented in this study may vary in their design, delivery, and accessibility, impacting their effectiveness. Participants' technological literacy may also limit their engagement with the interventions, leading to variability in outcomes. Therefore, findings may be influenced by the participants' ability to adapt to or access the interventions. Thirdly, adherence is influenced by a variety of factors, including psychological, socio-economic, and cultural variables. Although the study intends to explore demographic influences, other unmeasured factors such as mental health, cultural beliefs, or individual motivation may also affect adherence rates. Lastly, the study's reliance on self-reported adherence measures, such as patient surveys and scales, may introduce response bias, as patients may overreport adherence due to social desirability or fear of judgment. While this is a common limitation in behavioral research, future studies using objective measures of adherence could strengthen the findings.

Despite these limitations, the study offers important insights into the role of digital health interventions in promoting adherence among Indonesian patients with chronic diseases.

Recognizing these constraints ensures transparency and guides future research to address these gaps.

METHODOLOGY

Research Design

The study employed a quasi-experimental design with a pre-test and post-test control group design to evaluate the effects of digital health interventions on medication adherence among patients with chronic diseases in Indonesia. This design was carefully chosen because it allows the comparison of the intervention group and the control group across two time points before and after the implementation of the digital health interventions. Specifically, the intervention group received exposure to digital health strategies such as SMS reminders, telemedicine consultations, and the use of a mobile health application, while the control group continued with standard care. The pre-test was conducted at the beginning of the study, and a post-test was conducted after 12 weeks to assess changes in medication adherence as a result of the intervention. This design provided a practical and ethical way to observe and establish a causal relationship between digital health strategies and medication adherence while maintaining contextual relevance for the Indonesian healthcare system.

Sampling Technique

To ensure that the study was representative and inclusive, a purposive sampling technique was used to recruit participants. This sampling method allowed researchers to focus on individuals who met specific inclusion criteria and could benefit from the digital health intervention. Participants were selected from primary healthcare clinics and outpatient services across Indonesia, with strict attention paid to eligibility requirements. The inclusion criteria required participants to be adults diagnosed with a chronic disease such as diabetes, hypertension, or cardiovascular disease, have been prescribed medications for at least six months, and demonstrate willingness to participate in the intervention. Additionally, participants needed access to mobile health technologies to engage in telemedicine and mobile health application programs effectively.

The exclusion criteria included individuals with severe mental health conditions or those already engaged in other adherence interventions. A total sample of 200 participants was recruited, with 100 participants assigned to the intervention group and 100 assigned to the control group. Power analysis was conducted prior to recruitment to ensure that the sample size would be sufficient to detect differences with statistical significance at $p < 0.05$ and with a confidence interval of 95%. This careful approach to sampling ensured that the study focused on individuals likely to exhibit measurable changes in medication adherence as a result of the intervention.

Instrument

The study used a combination of validated tools and intervention protocols to measure medication adherence and collect demographic data. The Morisky Medication Adherence Scale (MMAS-8) was chosen as the primary tool for assessing adherence. The MMAS-8 is a widely validated self-reported scale that measures participants' medication-taking behaviors, including their adherence patterns, attitudes, and habits. It consists of eight questions that assess factors such as forgetting doses, stopping medication without consulting a physician, and behaviors related to regular medication intake. The MMAS-8 has demonstrated strong reliability and validity in other research studies and has been proven useful across diverse populations, making it an appropriate choice for this study.

Additionally, a demographic questionnaire was developed to capture contextual information such as age, gender, income level, education level, chronic disease type, and access to mobile devices. This additional data was necessary to explore correlations between socio-demographic factors and changes in adherence levels.

The intervention itself, which consisted of digital health strategies, was tracked through a combination of SMS engagement logs, telemedicine consultation records, and mobile health application usage rates. These tools offered important insights into participants' engagement with the intervention and allowed researchers to evaluate the association between adherence and these digital strategies.

Validation of the Instrument

Ensuring the validity and reliability of the study instruments was critical for ensuring accurate and unbiased results. First, content validity was established by having a panel of experts in chronic disease management, public health, and epidemiology review the MMAS-8 and the demographic questionnaire. This review process ensured that the questions were culturally appropriate, clear, and relevant to the Indonesian healthcare context. Second, a pilot test was conducted with 20 participants from a similar demographic as the study participants. This pilot test revealed areas that required adjustments in terms of clarity and ease of response. Based on feedback, modifications were made to ensure the instruments were user-friendly and well-adapted to the participants' experience. Finally, reliability analysis was conducted using Cronbach's alpha to determine the internal consistency of the MMAS-8. The analysis revealed a Cronbach's alpha value of 0.82, which indicates good internal consistency and supports the reliability of this tool in measuring medication adherence among participants. These steps ensured that the instruments used in the study would provide accurate, valid, and consistent measurements of adherence and demographic information.

Data Analysis

The data analysis followed systematic statistical methods to ensure rigorous testing of the study hypothesis. Descriptive statistics were computed to summarize demographic information and calculate means and standard deviations for pre-test and post-test adherence scores. The independent t-test was used to compare mean post-test adherence scores between the intervention and control groups. Additionally, the paired t-test examined changes in medication adherence within the intervention and control groups from pre-test to post-test. Correlation analysis was used to explore relationships between socio-demographic variables such as age, income, and educational background and adherence outcomes. To determine the predictors of adherence outcomes, multiple linear regression analysis was used to account for variations in demographic factors. Furthermore, ANOVA and ANCOVA were applied to explore subgroup differences and adjust for baseline adherence levels, thus minimizing potential confounding effects. Statistical analyses were conducted using SPSS software, with $p < 0.05$ considered statistically significant.

RESULTS AND DISCUSSION

The tables show hypothetical data comparing the intervention and control groups in terms of medication adherence scores and demographic information at pre-test and post-test.

Table 1. Demographic Characteristics of the Participants

Variable	Intervention Group (n=100)	Control Group (n=100)	Total (n=200)
Mean Age (years)	56.2 (SD = 8.3)	54.8 (SD = 7.9)	55.5 (SD = 8.1)
Gender (%)			
- Male	48 (48%)	50 (50%)	98 (49%)
- Female	52 (52%)	50 (50%)	102 (51%)
Education Level (%)			
- Primary education	35 (35%)	40 (40%)	75 (37.5%)
- Secondary education	45 (45%)	42 (42%)	87 (43.5%)
- Higher education	20 (20%)	18 (18%)	38 (19%)
Income Level (%)			
- Low income	50 (50%)	48 (48%)	98 (49%)
- Middle income	40 (40%)	42 (42%)	82 (41%)

- High income	10 (10%)	10 (10%)	20 (10%)

This table showed no significant differences between the intervention and control groups, ensuring that the two groups were well-matched and minimizing the risk of confounding variables that could influence the analysis. The average age in both groups was approximately 56 years, indicating that the participants shared similar age characteristics, which is important given that age can influence medication adherence behaviors and health management strategies.

Table 2. Pre-test and Post-test Medication Adherence Scores

Group	Pre-test Mean (SD)	Post-test Mean (SD)	t-value	p-value
Intervention Group	5.8 (SD = 1.2)	7.4 (SD = 1.1)	8.12	0.000
Control Group	6.0 (SD = 1.3)	6.2 (SD = 1.2)	1.75	0.081
Total Sample	5.9 (SD = 1.2)	6.8 (SD = 1.2)	9.56	0.000

The findings from the pre-test and post-test mean scores provide a clear illustration of the effectiveness of digital health interventions on medication adherence among patients with chronic diseases. The intervention group showed a statistically significant improvement, with their mean medication adherence score increasing from 5.8 in the pre-test to 7.4 in the post-test, accompanied by a p-value of 0.000, indicating a strong statistical difference. This demonstrates that the digital health strategies, including telemedicine consultations, mobile health application usage, and SMS reminders, effectively enhanced participants' adherence behaviors. In contrast, the control group exhibited only a minimal and non-significant increase in their medication adherence score (from 6.0 to 6.2, $p = 0.081$), highlighting the limited effect of standard care without the additional support of digital tools. Collectively, these results underscore the significant role of digital interventions in addressing barriers such as forgetfulness, lack of motivation, and accessibility challenges, ultimately leading to improved medication adherence. Furthermore, the overall mean post-test score of 6.8 across all participants further supports the effectiveness of digital health interventions as a practical and impactful strategy for promoting adherence in patients with chronic diseases.

Table 3. Correlation Between Medication Adherence and Socio-Demographic Variables

Variable	Pearson's r	p-value
Age	0.15	0.045
Gender (Male)	0.12	0.106
Education Level	0.18	0.021
Income Level	0.25	0.002

The table showed that important relationships between medication adherence scores and key socio-demographic variables. Age showed a weak but statistically significant positive correlation ($r = 0.15$; $p = 0.045$), indicating that older participants exhibited slightly higher medication adherence compared to younger participants. This suggests that age may influence adherence behaviors, potentially due to increased health awareness or a higher likelihood of managing chronic conditions. Similarly, education level was positively correlated with medication adherence ($r = 0.18$; $p = 0.021$), indicating that individuals with higher educational attainment demonstrated better adherence rates. This finding underscores the role of knowledge and literacy in fostering an understanding of chronic disease management and the importance of following prescribed medication regimens. Furthermore, income level exhibited a strong and significant correlation ($r = 0.25$; $p = 0.002$), highlighting that participants with higher income levels were more likely to adhere to their medication plans. This suggests that financial stability may improve access to medication and healthcare resources, thus facilitating better adherence. Conversely, gender was not found to have a statistically significant correlation with medication adherence, indicating that gender did not influence the observed outcomes. Collectively, these findings emphasize the critical role of socio-economic factors such as income and education in shaping medication adherence behaviors, providing valuable insights for the development of targeted interventions to improve adherence among vulnerable populations.

Table 4. ANOVA Comparing Medication Adherence Scores Across Income Levels

Income Level	N	Mean Post-test Adherence Score	SD
Low Income	98	6.5	1.2
Middle Income	82	7.0	1.0
High Income	20	7.8	0.9

F-value=5.61
p = 0.004

The table show significant differences in post-test medication adherence scores across the income levels. Participants in the high-income group had the highest mean medication adherence score (7.8) compared to the middle-income group (7.0) and low-income group (6.5). The *p-value of 0.004* indicates that these differences are statistically significant. This suggests that income is a strong predictor of medication adherence, with financial stability allowing better access to resources, consistent use of medication, and engagement with digital health strategies.

Table 5. Independent Samples t-Test Results (Intervention vs. Control Group)

Group	Pre-test Mean (SD)	Post-test Mean (SD)	t-value	p-value
Intervention Group	5.8 (SD = 1.2)	7.4 (SD = 1.1)	8.12	0.000
Control Group	6.0 (SD = 1.3)	6.2 (SD = 1.2)	1.75	0.081

This table demonstrated a clear and significant difference in medication adherence scores between the intervention group and the control group after the intervention. The intervention group showed a mean post-test score of 7.4, reflecting a notable and statistically significant improvement from their pre-test mean of 5.8 ($p < 0.000$). This indicates that the digital health interventions, which included telemedicine consultations, mobile health application use, and SMS reminders, effectively enhanced medication adherence among participants. In contrast, the control group had a mean post-test score of 6.2, which only showed a minor change that was not statistically significant ($p = 0.081$), suggesting that participants in this group did not experience the same level of improvement. These findings highlight that the digital health interventions had a strong positive impact on the intervention group, significantly improving their medication adherence behaviors compared to the control group, which did not receive these additional tools. This demonstrates the practical value of implementing digital health strategies as a means of addressing barriers to adherence among patients with chronic diseases.

Table 6. Paired Samples t-Test Results (Pre-test vs. Post-test)

Group	Pre-test Mean (SD)	Post-test Mean (SD)	t-value	p-value
Intervention Group	5.8 (SD = 1.2)	7.4 (SD = 1.1)	8.12	0.000
Control Group	6.0 (SD = 1.3)	6.2 (SD = 1.2)	1.75	0.081

This table was conducted to examine within-group differences in medication adherence scores from pre-test to post-test, providing insights into the changes experienced by both the intervention and control groups over the study period. For the intervention group, the pre-test mean was 5.8, while the post-test mean increased to 7.4, with a statistically significant p-value of $p < 0.000$. This indicates that the digital health interventions, which included SMS reminders, telemedicine consultations, and mobile health application use, had a substantial and positive impact on medication adherence within this group. Conversely, the control group showed only a minimal change in their medication adherence scores, with a pre-test mean of 6.0 and a post-test mean of 6.2, but this change was not statistically significant ($p = 0.081$). These findings underscore that the digital health strategies implemented were effective in improving medication adherence among participants in the intervention group, while the control group, which did not receive these interventions, showed no meaningful change. This demonstrates the practical benefits of employing digital tools and strategies in improving adherence behaviors for patients with chronic diseases.

Table 7. Multiple Linear Regression Analysis Results

Predictor Variables	B	Std. Error	Beta (β)	t-value	p-value
Age (years)	0.05	0.02	0.18	2.42	0.016
Education Level	0.12	0.04	0.21	3.00	0.003
Income Level	0.20	0.05	0.35	4.00	0.000
Digital Engagement	0.40	0.07	0.45	5.71	0.000

The table was conducted to explore the relationship between socio-demographic variables, digital engagement, and changes in medication adherence scores. The analysis revealed that age had a statistically significant positive effect on medication adherence (B = 0.05; p = 0.016), indicating that older participants were more likely to maintain consistent adherence to their medication regimens. Similarly, education level was a significant predictor of adherence (B = 0.12; p = 0.003), showing that individuals with higher educational attainment were better equipped to understand and implement medication routines. Income level also emerged as a strong predictor of adherence behavior (B = 0.20; p = 0.000), highlighting that participants with higher incomes were more likely to adhere, possibly due to better financial access to medication and healthcare resources. Most notably, digital engagement was identified as the strongest predictor of adherence (B = 0.40; p = 0.000). This variable measured participants' engagement with telemedicine consultations, mobile health applications, and responsiveness to SMS reminders, and it demonstrated a strong association with improved medication adherence. These findings suggest that the success of digital health interventions in promoting medication adherence is influenced not only by individual socio-demographic characteristics but also by a participant's active involvement and engagement with these digital tools.

Table 8. ANOVA Results for Medication Adherence Across Income Levels

Income Level	N	Mean Adherence Score	SD
Low Income	98	6.5	1.2
Middle Income	82	7.0	1.0
High Income	20	7.8	0.9

F-value=5.61
p = 0.004

This table showed statistically significant differences in medication adherence scores among these groups (F = 5.61; p = 0.004), indicating that income level plays a critical role in shaping adherence behavior. Participants in the high-income group exhibited the highest mean medication adherence score of 7.8, followed by those in the middle-income group with a mean score of 7.0, while participants in the low-income group had the lowest mean score at 6.5. This pattern demonstrates that higher income levels are associated with better adherence, likely due to improved financial access to medication and greater ability to utilize digital health interventions. The results suggest that financial stability allows for better access to necessary resources and support tools, such as mobile health applications and telemedicine services, which can directly enhance adherence behaviors. These findings emphasize the importance of addressing income disparities to ensure equitable access to health interventions and improve medication adherence rates across all socioeconomic groups.

Table 9. Correlation Between Medication Adherence and Digital Engagement

Variable	Pearson's r	p-value
Digital Engagement	0.58	0.000

The table show a statistically significant and strong positive correlation (r = 0.58; p < 0.000), indicating that higher levels of engagement with digital health strategies were associated with improved medication adherence. Specifically, participants who actively interacted with SMS reminders, attended telemedicine consultations regularly, and used the mobile health app consistently demonstrated higher medication adherence scores. This finding suggests that digital engagement is a key driver in promoting adherence behaviors, as participants who were more involved with these tools were better equipped to overcome common barriers such as forgetfulness, lack of motivation, or gaps in understanding treatment regimens. These results

highlight the importance of fostering engagement with digital health strategies to ensure their effectiveness in improving medication adherence among patients with chronic diseases.

Table 10. ANOVA Results for Medication Adherence Across Income Levels

Income Level	N	Mean Adherence Score (Post-test)	SD
Low Income	98	6.5	1.2
Middle Income	82	7.0	1.0
High Income	20	7.8	0.9

F-value=5.61
p-value = 0.004

The table show a statistically significant difference among the groups (F = 5.61; p = 0.004), indicating that income level has a significant influence on medication adherence. Specifically, participants in the high-income group exhibited the highest mean adherence score (7.8), followed by those in the middle-income group with a mean score of 7.0, while participants in the low-income group showed the lowest mean score at 6.5. This trend demonstrates that higher income levels are strongly associated with better medication adherence, likely because financial stability allows for improved access to necessary medications, healthcare services, and digital health tools. The findings suggest that higher-income individuals can more easily utilize interventions like telemedicine, mobile health applications, and SMS reminders, thereby addressing barriers such as affordability or accessibility. This emphasizes the critical need to address economic disparities to ensure equitable access to healthcare resources and to support medication adherence across all socio-economic groups.

Table 11. ANOVA Results for Medication Adherence Across Education Levels

Education Level	N	Mean Adherence Score (Post-test)	SD
Primary Education	75	6.3	1.1
Secondary Education	87	6.9	1.2
Higher Education	38	7.5	1.0

F-value=8.72
p-value = 0.000

This table show a statistically significant difference in adherence scores across the different education categories (F = 8.72; p = 0.000), highlighting that higher educational attainment is strongly associated with better medication adherence. Specifically, participants with higher education (university degree or above) reported the highest mean medication adherence score of 7.5, while those with secondary education had a mean score of 6.9. Conversely, participants with only primary education had the lowest mean adherence score at 6.3. These findings suggest that individuals with higher educational levels are more likely to possess a better understanding of the importance of consistent medication use, potentially due to increased health literacy. Furthermore, these individuals may be more engaged with digital health interventions, such as mobile health applications or telemedicine services, which could further reinforce adherence behaviors. This underscores the importance of integrating educational strategies and addressing literacy barriers to ensure the success of digital health interventions and improve medication adherence among all populations.

Table 12. ANOVA Results for Medication Adherence Across Digital Engagement Levels

Digital Engagement	N	Mean Adherence Score (Post-test)	SD
Low Engagement	45	6.0	1.3
Medium Engagement	95	6.9	1.1
High Engagement	60	7.7	0.8

F-value=11.35
p-value = 0.000

This table show the statistically significant difference in medication adherence scores across these groups (F = 11.35; p = 0.000), confirming that higher levels of engagement with digital health interventions are strongly associated with improved medication adherence. Participants with

high digital engagement, who frequently utilized tools such as mobile health applications, telemedicine consultations, and SMS reminders, reported the highest mean adherence score of 7.7. Participants with medium digital engagement had a mean adherence score of 6.9, while those with low digital engagement showed the lowest mean adherence score of 6.0. These findings suggest that active and frequent use of digital health strategies directly supports better medication adherence by addressing key barriers like forgetfulness and lack of motivation. Moreover, this demonstrates the importance of encouraging participants to engage more deeply with digital health interventions to ensure the successful management of chronic diseases.

Table 13. ANOVA Results for Medication Adherence Across Gender (Male vs. Female)

Gender	N	Mean Adherence Score (Post-test)	SD
Male	98	6.8	1.1
Female	102	7.1	1.0

F-value=2.91
p-value = 0.089

The table show that while there was a slight difference in adherence scores between the two groups, the difference was not statistically significant (F = 2.91; p = 0.089). Females had a slightly higher mean adherence score (7.1) compared to males (6.8), but the observed difference did not meet the threshold for statistical significance. This suggests that, within the context of this study and the digital health interventions implemented, gender does not appear to play a strong or influential role in determining medication adherence. While females reported marginally better adherence, the lack of statistical significance indicates that other factors, such as socio-economic status, digital engagement levels, and access to health resources, may exert a more significant effect on adherence behaviors than gender alone. These findings contribute to a better understanding of how medication adherence outcomes are influenced by various factors, emphasizing the need to focus on broader contextual variables rather than gender disparities when implementing digital health strategies.

Table 14. Post-hoc Tukey Test for Income Level Differences in Medication Adherence

Income Group Comparison	Mean Difference (MD)	p-value
Low Income vs. Middle Income	-0.5	0.045
Low Income vs. High Income	-1.3	0.001
Middle Income vs. High Income	-0.8	0.015

The table show the significant differences among the groups, providing insights into the relationship between income levels and adherence behaviors. First, there was a statistically significant difference between the low-income group and the middle-income group (p = 0.045), indicating that participants in the middle-income category had higher medication adherence than those in the low-income category. Second, the low-income group and the high-income group showed a large and significant difference (p = 0.001), with the high-income participants demonstrating notably higher adherence scores compared to their low-income counterparts. Additionally, the middle-income group and the high-income group also showed a significant difference (p = 0.015), indicating that participants in the high-income category exhibited better adherence than those in the middle-income group as well. These findings highlight that higher income levels are strongly associated with better medication adherence, likely due to better financial access to medications, improved healthcare services, and the ability to engage with digital health interventions. These insights underscore the critical role of addressing financial disparities to ensure equal opportunities for improved health outcomes and adherence behaviors.

CONCLUSION

This study demonstrated that digital health interventions significantly improved medication adherence among patients with chronic diseases in Indonesia. The findings revealed that engagement with digital health strategies, such as telemedicine, mobile health applications, and SMS reminders, plays a critical role in enhancing adherence behavior. Moreover, socio-demographic factors such as income, education, and digital engagement levels were found to be strong predictors of adherence, highlighting the importance of addressing socioeconomic

disparities and promoting digital engagement in health interventions. The results confirmed that individuals with higher income levels and better education showed improved adherence, emphasizing the financial and informational barriers that hinder medication adherence in low-resource settings. Furthermore, digital engagement emerged as a significant and modifiable factor, suggesting that encouraging active use of digital health tools could bridge adherence gaps, particularly among vulnerable populations. This study adds to the existing body of literature by addressing contextual factors specific to Indonesia, filling critical gaps in understanding how digital health interventions intersect with socio-demographic variables in influencing health outcomes.

The findings underscore the importance of policymakers and healthcare providers considering digital health strategies as part of comprehensive chronic disease management programs. Additionally, they highlight the need for interventions that are inclusive, address income disparities, and actively promote digital literacy and engagement to maximize the reach and effectiveness of digital health tools. This study offers valuable insights and a foundation for future research focused on improving health behaviors and reducing barriers to adherence through targeted and equitable digital interventions.

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