

The Effect of Information Digitization: The ENNOE Method on Knowledge and Adherence to Treatment in HIV People

Abstract

Aims: This study evaluated the effectiveness of information digitization using the ENNOE method in enhancing knowledge and treatment adherence among people living with HIV/AIDS (PLHIV).

Materials & Methods: This study employed a research and development (R & D) design, followed by a one-group pre-test-post-test approach with 30 randomly selected participants undergoing antiretroviral therapy (ART). The study was conducted in 2024 in Jambi City, Indonesia. The intervention was delivered through the ENNOE method, which encompasses Engagement, Education, Monitoring, and Adherence. Data were collected using structured questionnaires assessing knowledge and ART adherence before and after the intervention. Statistical analyses, including chi-square tests, paired t-tests, and Cohen's d effect size, were conducted to evaluate the intervention's effectiveness.

Findings: The findings indicated that baseline patient knowledge and adherence to ART were relatively low prior to the intervention. However, a significant improvement was observed following the intervention. The mean knowledge score increased from 43.0 ± 4.7 to 60.8 ± 6.9 ($p=0.001$, Cohen's $d=3.01$), while medication adherence improved from 57.7 ± 2.5 to 68.5 ± 5.1 ($p=0.001$, Cohen's $d=2.68$), demonstrating a substantial effect. Additionally, education level and marital status were identified as factors influencing ART adherence.

Conclusion: The implementation of the ENNOE method through digital health information delivery has been demonstrated to effectively enhance knowledge and adherence to ART among people living with HIV (PLHIV). This study has some limitations, including a small sample size of 30 participants, which may limit generalizability, suggesting the need for a larger sample in future research, and the lack of comparison between the digital method and traditional education.

Keywords

Health Literacy [<https://www.ncbi.nlm.nih.gov/mesh/68057220>];

Medication Adherence [<https://www.ncbi.nlm.nih.gov/mesh/68055118>];

HIV Infections [<https://www.ncbi.nlm.nih.gov/mesh/68015658>];

Patient Education as Topic [<https://www.ncbi.nlm.nih.gov/mesh/68010353>]

Introduction

HIV (Human Immunodeficiency Virus) is a pathogen that targets the human immune system and, if left untreated, can progress to Acquired Immunodeficiency Syndrome (AIDS) [1, 2]. The virus replicates by utilizing T cells as host cells, leading to a progressive decline in immune function. Due to its prolonged asymptomatic phase, which can last 5-10 years after initial exposure, early diagnosis remains a significant challenge in disease control efforts, underscoring the need for proactive screening and intervention strategies [3].

Globally, the number of individuals living with HIV continues to rise, with approximately 38.4 million people infected as of 2021, including 1.5 million new cases [4]. Epidemiological data indicate that HIV is predominantly concentrated among high-risk groups, such as men who have sex with men (MSM), people who inject drugs, and commercial sex workers [5, 6]. Additionally, geographical factors play a significant role in the spread of HIV, with certain countries and regions exhibiting higher prevalence rates than others [7].

In Indonesia, the number of HIV cases has risen significantly. As of June 2021, there were 303,993 reported HIV cases and 132,995 cases of AIDS. In Jambi Province, by September 2022, the number of HIV cases had reached 2,341, with 820 cases of AIDS [8]. However, the proportion of people living with HIV/AIDS (PLHIV) who remain on antiretroviral therapy (ART) is still relatively low, with only 26% of the total PLHIV actively undergoing treatment. This presents a significant challenge in improving patient adherence to therapy [9, 10].

One of the major barriers to effective HIV treatment is low patient adherence to ongoing antiretroviral therapy (ART). Several factors contribute to this issue, including social stigma, limited access to information, fear of drug side effects, and economic and geographical obstacles. Research indicates that many people living with HIV face significant challenges in accessing healthcare services due to stigma and discrimination from both the community and healthcare providers. This results in a negative impact on loss to follow-up (LTFU) rates, where patients discontinue their treatment prematurely.

Several previous studies have explored the use of digital technology in health education, including mobile applications and online platforms to improve ART adherence [11-13]. However, most existing digital interventions focus solely on delivering information without a comprehensive monitoring mechanism. Therefore, this study introduces the ENNOE method (*Engagement, Education, Monitoring, Adherence*), which integrates digital education with adherence monitoring to provide a more holistic approach to supporting people living with HIV/AIDS (PLHIV).

The ENNOE method differs from previous digital interventions by incorporating four key components: Engagement, to enhance patient involvement in the educational process; Education, as a needs-based information delivery tool; Monitoring, to track the progress of patient knowledge and behavior; And Adherence, which focuses on improving ART compliance. With this approach, ENNOE not only provides a digital education model that is adaptive and responsive to the needs of PLHIV but also contributes to more effective health behavior changes [14, 15].

Using an evidence-based approach, this study not only examines the feasibility and effectiveness of the ENNOE method but also seeks to provide practical solutions to support the HIV/AIDS elimination program by 2030, in line with national and global targets. Therefore, this study aimed to analyze the impact of information digitization through the ENNOE method on improving knowledge and treatment adherence among PLHIV.

Materials and Methods

Study design

The research method employed in this study is a Research and Development (R & D) design, which integrates both qualitative and quantitative approaches. This methodology was used to develop and assess the effectiveness of information digitization based on the ENNOE (Engagement, Education, Monitoring, Adherence) method in improving knowledge and treatment adherence among people living with HIV/AIDS (PLHIV). The model development follows the ADDIE (Analysis, Design, Develop, Implementation, and Evaluation) framework to ensure the intervention's effectiveness [16, 17]. During the media evaluation stage, a field trial was conducted using a One-Group Pre-test-Post-test Design approach.

Study setting

This study was conducted at four key health centers in Jambi City Rawasari Health Center, Simpang Kawat Health Center, Talang Bakung Health Center, and Putri Ayu Health Center between April and June 2024. These sites were strategically selected based on their central role in providing care and treatment services for individuals living with HIV (PLHIV) in the region.

Respondent

The study population consisted of all people living with HIV (PLHIV) undergoing antiretroviral therapy (ART) at the Jambi City Health Centers. A random sampling technique was used to select participants, with the sample size determined through power analysis to achieve a statistical power of 0.80 and an alpha level of 0.05, ensuring sufficient sensitivity to detect meaningful differences in knowledge and adherence levels. The inclusion criteria were PLHIV who had been undergoing ART for less than six months and were willing to participate. Exclusion criteria included PLHIV who declined to participate in the study. The field trial involved 30 respondents, who were proportionally selected from each health center in Jambi City. Participants were chosen until the total reached 30, ensuring an equal distribution across health centers to maintain the representativeness of the data.

Variables and instruments

The variables examined in this study include the independent variable, which is information digitization using the ENNOE method, and the dependent variables, which are increased knowledge and treatment adherence among people living with HIV (PLHIV). Additionally, control variables such as social stigma, family support, and access to health services may influence the study outcomes. The International Standardized Questionnaire on HIV and AIDS Knowledge (HIV-KQ-18) has demonstrated validity and reliability in assessing HIV/AIDS knowledge across various populations, including in Indonesia. Research conducted in Yogyakarta indicated that this instrument has a validity coefficient (r_{xy}) ranging from 0.177 to 0.564, exceeding the r -table value of 0.112, and high reliability, with a KR20 value of 0.763. Furthermore, the adaptation and validation of HIV-KQ-18 for the general Indonesian population showed Cronbach's alpha values ranging from 0.75 to 0.89, indicating good internal consistency^[18].

The Adherence to Refills and Medications Scale (ARMS) questionnaire has also proven valid and reliable for assessing patient adherence to medication, including in chronic disease contexts like HIV. Research has shown that the ARMS performs well, even among patients with low literacy levels^[19].

Data collection

The first step in this study was the validation of the Digital Educational Media by Prof. Drs. Damris Muhammad, M.Sc., Ph.D., CIQaR, a conceptual/design expert from the Faculty of Science and Technology at Jambi University. He served as a validator during the expert validation process, assessing the concepts (theory-intervention-impact) in the conceptual paper titled *Digitalization of Information to Increase Knowledge and Adherence to Treatment in People with HIV/AIDS (ODHIV)*. Following assessment and revisions, the digital educational media was deemed suitable for use.

Data collection was conducted using two primary approaches: Knowledge assessment and adherence monitoring. To evaluate the knowledge of people living with HIV/AIDS (PLHIV), the International Standardized Questionnaire on HIV and AIDS Knowledge (HIV-KQ-18) was used, an instrument with established validity and reliability. Knowledge data was gathered through pre- and post-intervention assessments, which aimed to measure changes in HIV/AIDS knowledge following the educational intervention.

Additionally, patient adherence to antiretroviral therapy (ART) was monitored using a combination of the Daily Check method and the Adherence to Refills and Medications Scale (ARMS). The Daily Check method records daily medication adherence, while the ARMS measures long-term adherence based on prescription refills and medication compliance. Adherence data was also collected at both pre-test and post-test intervals to assess any changes.

To handle missing data, a predefined protocol was established. If a participant missed a response in the questionnaire, multiple imputation was applied to estimate missing values based on the observed data. If a participant failed to complete more than 10% of the total questions, their data were excluded from the final analysis to maintain the validity of the results.

Data analysis

Data collected in this study were analyzed using IBM SPSS 23 software. Descriptive analysis was employed to characterize the respondents and assess their levels of knowledge and ART adherence before and after the intervention. Additionally, inferential statistical tests, including the chi-square test, were used to examine the association between risk factors and ART adherence, while paired t-tests were conducted to compare the levels of knowledge and adherence before and after the implementation of the ENNOE method. Cohen's d analysis was applied to determine the magnitude of the difference in mean knowledge and adherence levels. A p -value of less than 0.05 was considered statistically significant.

To ensure the validity of the statistical analysis, assumption testing was conducted before hypothesis testing. Data normality was assessed using the Shapiro-Wilk test, while homogeneity of variances was evaluated with Levene's test. Based on the normality assumption test, it was concluded that the data

followed a normal distribution and homogeneity was met, allowing the use of parametric tests for power analysis. Additionally, missing data were handled through multiple imputations to reduce potential biases, and outliers were examined to assess their impact on the overall findings.

Findings

Tables 1 and 2 present the responses from conceptual/design experts and public health experts, respectively. Table 3 illustrates the distribution of respondent characteristics, while Table 4 shows the relationship between risk factors and ART adherence. A significant increase in knowledge was observed between the pre-test and post-test, highlighting the substantial impact of the educational intervention on patients' understanding of HIV/AIDS. Additionally, patient adherence to ART medication also showed a marked improvement, indicating that the intervention not only enhanced knowledge but also motivated patients to adhere more consistently to their treatment, as shown in Table 5.

Table 1. Conceptual/design expert responses (theory-intervention-impact) on the information digitization conceptual paper

No. Question	Comments and suggestions for improvement
1 Are the narratives and constructs of the behavioral theories used in this study: Health belief model (HBM), Social Behaviour and Change Communication (SBCC), and Integrated Behaviour Model (IBM) and theoretical constructs used. Technology Acceptance Model (TAM) are true narratives and constructs?	Basically can be used, it's just too complicated, try to simplify it to make it easier to understand the theory.
2 Are the narrative and theoretical constructs of HBM, SBCC, IBM and TAM used in this research relevant to the purpose of the academic paper?	This theory can be used and is in line with the purpose of the academic paper.
3 Are the narratives and constructs of the stages of behavior change of patients with HIV actually contained in the narratives and constructs of HBM, SBCC, IBM and TAM used in this study?	Yes, there is a behavior change construct.
4 Does this academic paper contain stages of intervention that are in accordance with the theory of health promotion?	Yes, simplified stages can be used and include health promotion theory.
5 Does the intervention's behavior change component match the expected output?	The intervention can be expected to produce the desired behavior change.
- Validation results and suggestions	Improve the interconnectedness of the theoretical concepts used and simplify the interconnectedness of the theories used so that they are easy to understand.

Table 1 has been revised in accordance with expert suggestions. Improvements were made to simplify the linkage of theoretical concepts used to make it easier to understand. Thus, this table has been declared valid and can be used in research.

Table 2. Expert responses to public health conceptual (theory-intervention-impact) on the digitization conceptual paper

No. Question	Comments and suggestions for improvement
1 Does this intervention tool contain materials that meet the needs of an educational model intervention product to order of delivery need to be clarified to make it more increase knowledge and decision to seek treatment for systematic and easily understood by ODHIV?	The material presented is quite relevant, but the scope and needs of an educational model intervention product to order of delivery need to be clarified to make it more increase knowledge and decision to seek treatment for systematic and easily understood by ODHIV.
2 Is the delivery of material or messages in this educational model easy to understand?	Most of the materials are quite clear, but it is necessary to review the use of technical terms that may be difficult for ODHIV to understand. It is better to use simpler and more communicative language.
3 Is the educational model developed suitable for the characteristics of HIV patients?	This educational model is appropriate, but it is important to ensure a more inclusive approach that considers the psychosocial aspects of patients to be more effective in improving treatment adherence.
4 Does the developed educational model intervention tool contain the steps needed to improve knowledge and treatment adherence in PLHIV?	The existing stages are quite complete, but the evaluation stage could be clarified so that the effectiveness of the intervention can be better measured.
5 Are there any important steps missing in the educational model intervention tool to improve knowledge and treatment adherence among PLHIV?	It is recommended to add a feedback stage from PLHIV to determine the extent to which they understand the material presented and adjust the educational approach if necessary.
- Validation results and suggestions	It is important to ensure that the intervention tool covers all the necessary steps, including effectiveness evaluation and patient feedback. With these improvements, it is hoped that the education model can be optimized in improving knowledge and treatment adherence in PLHIV.

Table 2 has been revised based on expert suggestions to ensure that the intervention tool covers all necessary steps, including effectiveness evaluation and patient feedback. With these improvements, the educational model was declared valid and is expected to be more optimal in improving knowledge and

treatment adherence in PLHIV.

Table 3. Distribution of respondent characteristics

Characteristic	n (%)
Age	
Mean±SD	40.57±10.76
17-29	5 (16.7)
30-44	13 (43.3)
45-60	12 (40)
Gender	
Male	24 (80)
Female	6 (20)
Education level	
Elementary school	11 (36.7)
Junior high school	6 (20)
High school	8 (26.7)
Bachelor	5 (16.7)
Type of work	
Labo	11 (36.7)
Housewife	4 (13.3)
Civil servants	5 (16.7)
Private employee	1 (3.3)
Motorcycle taxi driver	9 (30)
Marital status	
Unmarried	15 (50)
Mating	15 (50)

Table 3 presents the respondents' demographics. Most are young to middle-aged males with primary or secondary education. The majority work as laborers or motorcycle taxi drivers, while fewer are civil/private employees or housewives. Marital status is fairly evenly split between married and unmarried individuals.

Table 4. Results of factor analysis of determinants of Antiretroviral Therapy (ART) adherence before the ENNOE method information digitization intervention

Variable	ATR compliance		p-value
	Non-compliant	Compliant	
Age			0.517
17-35 years old	4 (66.7)	2 (33.3)	
36-59 years	19 (79.2)	5 (20.8)	
Gender			0.084
Male	20 (83.3)	4 (16.7)	
Female	2 (50)	3 (50)	
Type of work			0.977
Not working	13 (76.5)	4 (23.5)	
Working	10 (76.9)	2 (23.1)	
Education level			0.031
Low	14 (93.3)	1 (6.7)	
High	9 (60)	6 (40)	
Marital status			0.002
Not yet	18 (94.7)	1 (5.3)	
Marriage	5 (45.5)	6 (54.5)	
Knowledge			0.050
Less	13 (92.9)	1 (7.1)	
Good	10 (72.5)	6 (37.5)	

Table 4 shows that age, gender, and occupation did not have a significant impact on ART adherence ($p>0.05$). However, education level emerged as an important factor, with individuals possessing lower education levels generally exhibiting lower adherence rates compared to those with higher education ($p<0.05$). Marital status also had a significant influence on adherence, with married individuals showing higher adherence rates ($p<0.05$). Furthermore, knowledge of ART was positively associated with adherence, as patients with a better understanding of the treatment were more likely to remain compliant ($p<0.05$).

Table 5. Mean knowledge and ART medication adherence after the ENNOE method information digitization intervention

Variable	N	Mean±SD	p-value	Cohen's d
Knowledge	30		0.001	3.01
Pre-test		43.0±4.7		
Post-test		60.8±6.9		

Medication adherence	30		0.001	2.68
Pre-test		57.7±2.5		
Post-test		68.5±5.1		

Table 5 presents a comparison of pre-test and post-test results for knowledge and medication adherence, along with the corresponding statistical analysis. For knowledge, there was a significant improvement between the pre-test and post-test scores, with the mean score increasing from 43 to 60.8. This improvement was statistically significant, as indicated by a p-value suggesting a highly meaningful difference, and a large effect size (Cohen's $d=3.01$), reflecting the strong impact of the intervention on enhancing knowledge. Similarly, for medication adherence, a significant improvement was observed, with the mean score rising from 57.7 to 68.5. This change was also statistically significant, with a p-value indicating a meaningful difference and a large effect size (Cohen's $d=2.68$), signifying a substantial increase in adherence following the intervention. In summary, both knowledge and adherence showed significant improvement, with the intervention producing strong positive effects on both outcomes.

Discussion

Analysis of the determinants of ART adherence before the intervention revealed that age, gender, and employment status did not significantly impact adherence. However, education level and marital status showed significant differences. Respondents with lower education levels were more likely to be non-adherent to therapy, with 93.3% not adhering to treatment, while those with higher education demonstrated higher adherence rates, with 40% adhering. This suggests that education may enhance awareness of the importance of medication adherence.

Marital status also played a significant role in ART adherence. Married respondents exhibited higher adherence rates, with 54.5% adhering to treatment, whereas unmarried individuals tended to be more non-adherent, with 94.7% not adhering. This indicates that social support, particularly from a spouse, may contribute to improved treatment adherence. Additionally, knowledge about ART was positively associated with adherence, as those with better knowledge were more likely to adhere to treatment. This underscores the importance of providing comprehensive information to patients to help them better understand and manage their treatment [20, 21].

One of the interesting findings in this study is the stronger influence of education on adherence compared to gender and employment status. One possible explanation is that individuals with higher levels of education may have better health literacy, enabling them to understand medical advice, recognize the risks of non-adherence, and manage their treatment more effectively. In contrast, gender and employment status do not show a significant relationship with adherence. This may be due to the fact that both male and female patients face similar adherence barriers, such as stigma, medication side effects, and forgetting to take their medication, regardless of their type of employment. Further studies are needed to explore whether job stability, income level, or work-related stress may have an indirect effect on ART adherence [22, 23].

In accordance to the study of Jin *et al.* [24], patient medication adherence is influenced by demographic factors such as higher education, marriage and adequate knowledge. Patient education plays a crucial role in improving medication adherence. Counseling on the importance of consistent medication is essential for enhancing patient compliance. Some patients may perceive the need for medication as intermittent, leading them to discontinue treatment in an attempt to assess whether it is still necessary. Another study reported that some patients lack understanding of their therapeutic role in treatment [25], lack of knowledge about the disease and the consequences of poor adherence [26, 27].

The effectiveness of the ENNOE information digitization intervention in improving patient knowledge and adherence can be attributed to several key factors. Firstly, digitized information allows for the widespread distribution of educational materials that are easily accessible to patients. In the context of antiretroviral therapy (ART), a thorough understanding of the medication's benefits, mode of action, and the importance of adherence is essential [28]. Through digital platforms, information can be delivered in diverse formats such as text, images, videos, and interactive animations, making it more engaging and easier to comprehend for patients with varying levels of education [29]. This approach helps address the limitations of traditional education methods, which often rely on verbal communication from health workers with limited time [30].

Secondly, the ENNOE method used in information digitization facilitates a more personalized and patient-centered educational experience. Digital technology enables the delivery of content tailored to the individual's health condition, level of understanding, and specific needs [31]. For instance, patients with limited knowledge of ART can be provided with simpler, more accessible materials, while those

with a higher level of understanding can receive more detailed information. This customization enhances patient engagement in the education process, leading to increased motivation and improved adherence to their treatment [32].

Moreover, digitizing information using the ENNOE method provides patients with the flexibility to access educational materials anytime and anywhere. This feature is particularly beneficial for individuals who face time constraints or challenges in attending in-person education sessions at health facilities [33]. With the ability to access content via electronic devices such as mobile phones or computers, patients can engage with the material at their own pace and convenience. This level of accessibility also addresses geographical barriers, particularly for patients residing in remote areas or those with limited mobility. By offering this ease of access, patients are more likely to stay engaged with their education and gain a deeper understanding of the importance of adhering to antiretroviral therapy (ART) [34, 35].

The ENNOE digital method further enhances patient engagement through interactive features such as quizzes, discussion forums, and virtual Q & A sessions with healthcare professionals. These interactive elements not only help patients better grasp the educational content but also offer an opportunity to clarify any confusion or misconceptions about ART. Such active participation aids in information retention and strengthens patient trust in their treatment. Additionally, digital reminders, such as notifications or alarms, can further support patients by helping them stay on track with their medication schedules, thereby improving adherence [36].

Finally, the effectiveness of the ENNOE-based digital intervention is also linked to an increase in patients' confidence and autonomy in managing their treatment. Access to accurate and easily comprehensible information empowers patients to make informed decisions about their health. Improved education also reduces the fear and stigma often associated with ART, motivating patients to remain consistent with their therapy. In this way, the ENNOE method not only enhances patient knowledge but also fosters positive behavioral changes that contribute to better ART adherence [11].

Although the findings of this study provide valuable insights, several limitations should be considered. First, the relatively small sample size may limit the generalizability of the results to a broader population. A larger sample in future studies would help confirm these findings and enhance the robustness of statistical analyses. Second, this study was conducted in a single urban setting, which may restrict its applicability to rural populations, where access to digital health interventions and healthcare facilities may differ. Further research should compare ART adherence patterns in urban and rural settings to identify unique barriers and opportunities for more effective interventions. Third, potential biases may affect the study results. Social desirability bias may lead participants to report higher adherence than in reality, while recall bias could impact the accuracy of self-reported knowledge levels. Using more objective adherence measurement methods, such as electronic medication monitoring, could improve data accuracy in future research.

Based on the findings of this study, the integration of the ENNOE method into the national digital health policy is recommended as a scalable and cost-effective solution to improve ART adherence and treatment outcomes for PLHIV, with its implementation through digital training for health educators to enhance patient understanding, funding allocation by policymakers to ensure the accessibility of digital health programs, and the use of ENNOE by patients for self-monitoring and more effective adherence tracking.

Conclusion

This study confirms that the ENNOE information digitization intervention is effective in enhancing patient knowledge and adherence to treatment. A digitized educational approach serves as a valuable strategy for improving patients' understanding of ART and promoting better adherence. This method provides accessible, engaging, and personalized educational content that supports patients in managing their treatment. Given its effectiveness, integrating similar digital interventions into healthcare services can contribute to better treatment outcomes and long-term therapeutic success for individuals living with HIV/AIDS.