MERAL Publications and Solutions Pvt. Ltd.

Original Article

Semangat: mobile application to improve medication adherence in people living with human immunodeficiency virus in Indonesia

Hesty Utami Ramadaniati[1*], Nurita Andayani[1], Agung Saputra[2], Rasta Naya Pratita[1]

[1]Faculty of Pharmacy, Universitas Pancasila, Jakarta, Indonesia. [2]Faculty of Engineering, Universitas Pancasila, Jakarta, Indonesia.

Correspondence: Hesty Utami Ramadaniati, Faculty of Pharmacy, Universitas Pancasila, Jakarta, Indonesia. Hesty.utami@univpancasila.ac.id

Received: 12 September 2025; **Revised:** 23 December 2025; **Accepted:** 11 January 2026

ABSTRACT

This study evaluated the effectiveness of the Semangat application in improving antiretroviral treatment (ART) adherence, eHealth literacy (EHL), and human immunodeficiency virus (HIV)-related knowledge among people living with HIV in Indonesia. A quasi-experimental study was conducted among 494 PLWH in 20 primary health centers in Jakarta, equally assigned to an intervention group (IG) and a control group (CG). The IG used the Semangat app for 4 weeks, while the CG received standard care. Outcomes were assessed before and after the intervention using self-administered questionnaires. Baseline characteristics and outcomes were comparable. After the intervention, high adherence increased to 70% in the IG, compared with just over 50% in the CG ($p < 0.001$). EHL improved markedly in the IG (22.77 to 24.79), with 61.1% achieving good EHL, compared with 30.8% in the CG. HIV knowledge gains were also significantly higher in the IG ($p < 0.001$). Nearly half rated the app's usability as good/very good, and 60% were satisfied. In conclusion, Semangat improves ART adherence, EHL, and HIV knowledge, supporting its value as a complement to standard HIV care.

Keywords: Electronic health literacy, HIV, Knowledge, Medication adherence

Introduction

Globally, approximately 40 million individuals are living with HIV, with 1.3 million new infections and 630,000 AIDS-related deaths reported in 2024 [1]. Despite major advances in antiretroviral therapy (ART), the epidemic continues to pose a substantial public health challenge across many regions of the world [1]. This global challenge is also reflected in Indonesia, where the HIV epidemic continues to grow in both scale and complexity. Indonesia -an archipelagic nation in Southeast Asia with an estimated population of 281 million in 2024 [2]- is experiencing a steady increase in the number of people living with HIV (PLWH). According to the 2024 Executive Report on the Development of HIV AIDS and Sexually Transmitted Infections by the Indonesian Ministry of Health, an estimated 503,261 individuals were living with HIV. Among them, around 70% were aware of their HIV status, 62% were receiving ART, and only 42% of those on ART had achieved viral suppression [3]. These indicators fall short of the UNAIDS "95–95–95" global targets, which aim for 95% of PLWH to know their status, 95% of those diagnosed to receive ART, and 95% of those on treatment to achieve viral suppression. In Indonesia, the highest burden of HIV cases has been observed in five provinces—East Java, West Java, Central Java, the Special Region of Jakarta, and North Sumatra—demonstrating the uneven geographic distribution of the epidemic [3].

Given the nature of HIV as a chronic condition that necessitates prolonged therapeutic interventions, adherence to ART is considered an essential determinant that enhances optimal clinical outcomes and, consequently, treatment efficacy. Adherence to antiretroviral therapy, evidenced by diminished

Access this article online	
Website: www.japer.in	**E-ISSN:** 2249-3379

How to cite this article: Ramadaniati HU, Andayani N, Saputra A, Pratita RN. Semangat: mobile application to improve medication adherence in people living with human immunodeficiency virus in Indonesia. J Adv Pharm Educ Res. 2026;16(1):51-62. https://doi.org/10.51847/O7DQ8smBkb

viral load, may also play a significant role in mitigating the transmission rate of HIV. Nevertheless, the evidence reveals that approximately 45% of PLWH exhibit poor adherence to antiretroviral therapy [4]. Non-adherence to ART carries serious individual and public-health consequences. At the individual level, missed doses can lead to incomplete viral suppression, resulting in virologic rebound, immune deterioration, and an increased risk of opportunistic infections and AIDS-related morbidity and mortality [5]. Persistent sub-optimal adherence also facilitates the emergence of drug-resistant HIV strains, which compromise future treatment options and increase healthcare costs [6]. Various research findings have indicated that adherence to antiretroviral medications is modulated by a multitude of factors, encompassing demographic variables, health literacy, accessibility to healthcare resources, economic conditions, and sociocultural influences [7-9]. One significant predictor of ART adherence is health literacy. Several studies have revealed the considerable impact of health literacy on the knowledge and treatment adherence of patients with HIV [10-12]. Health literacy is characterized as the extent to which a person possesses the capability to acquire, convey, process, and comprehend health-related information, enabling them to make informed health choices. Factors influencing health literacy include reading proficiency, numeracy skills, the capacity to understand health directives, and the ability to search for, evaluate, and utilise health information, including digital resources [12]. Low health literacy levels have been identified as a silent epidemic that hinders patients' capacity to effectively navigate the healthcare system [11].

A diverse array of strategies aimed at improving medication adherence among PLWH has been documented [13]. The rise of digital technology has enabled the emergence of mobile health as a significant tool for enhancing self-management, including treatment adherence among patients with chronic diseases. In 2023, approximately 69% of the global population owned smartphones, reflecting a 1.6 times increase in users since 2016 [14]. In the context of Indonesia, the number of smartphone users is projected to exceed 190 million (82%) in 2023. Presently, Indonesia ranks as the fourth-largest smartphone market globally, following China, India, and the United States [15]. As individuals increasingly view smartphones as essential items and utilise them regularly, mobile health technology presents an effective and efficient means to involve patients in their healthcare. Furthermore, the growing demand for mobile health technology may lead to the creation of mobile applications designed to assist self-management for patients with various conditions, including HIV. Mobile applications aimed at self-management have created opportunities for PLWH to access more integrated and convenient healthcare. Several mobile applications have been specifically tailored for PLWH or particular subgroups within this population (e.g., youth, transgender), such as Aysoo [16], Health Manager [17], Stop HIV, HIV Dating, and WYZ [18], as well as Excellent Self Supervised HIV Care/ESCC [19]. The features offered may vary from one application to another. However, these applications typically include functionalities for personal health status monitoring, reminders, communication with healthcare providers, connections to social networks, and health information. Research on HIV has revealed the beneficial effects of mobile applications that support self-management in enhancing symptom management, medication adherence, and engagement in HIV care [17, 20-22]. Furthermore, a systematic review has shown that mobile applications are being utilised more frequently to address behavioural and social challenges faced by PLWH [23]. Another review aimed at investigating the effectiveness and potential of mobile health (mHealth) technologies revealed that incorporating mHealth technologies into healthcare strategies can significantly enhance adherence to ART among PLWH [24].

It has been justified that digital and mobile interventions for antiretroviral adherence hold significant potential for cost-effective delivery. Although there is substantial evidence signifying the use of digital interventions for PLWH, there are only a limited number of mobile applications that have been specifically designed to meet the needs of PLWH within the Indonesian context. The Semangat application has been developed by the research team for PLWH in Indonesia to facilitate integrated HIV care. Semangat is an Android-based mobile application developed to improve self-management and ART adherence among PLWH in Indonesia (23). The application integrates educational, behavioral, and motivational elements. Its key features include HIV-related educational content in simple language, daily medication and clinic visit reminders, side-effect logging, and tools to strengthen users' capacity to access and evaluate digital health information.

Technically, Semangat was developed using Java for Android and operates through a local server with secure data transmission. User authentication is anonymous, ensuring privacy and confidentiality, and only non-identifiable data is stored. The word "semangat" is literally an acronym standing for "keep up your motivation to take antiretroviral medicines to control HIV". This term is occasionally used among Indonesians to motivate individuals when facing challenges. The development of Semangat has been described elsewhere [25]. This study aimed to evaluate the effectiveness of the Semangat application to improve ART adherence as the primary outcome and the secondary outcomes (eHealth literacy/EHL, HIV-related knowledge).

Materials and Methods

Study design and participant

A quasi-experimental study with a pre- and post-intervention design was conducted over three months (January–March 2025) in sub-district public health centers (PHCs) in Jakarta, Indonesia. Jakarta, the nation's capital, comprises five municipalities, each subdivided into several sub-districts. These PHCs serve as the primary points of HIV care delivery, where monthly ART and routine clinical consultations are provided free of charge through the national HIV program. From each municipality, four PHCs

reporting the highest number of people living with HIV (PLWH) were purposively selected, resulting in a total of 20 participating PHCs.

Participants were allocated using simple random sampling at the PHC level, consistent with a quasi-experimental design. A quasi-experimental design was selected because random assignment of individual participants was not feasible within the operational structure of PHCs. This design enables evaluation of intervention effects in real-world conditions while preserving internal validity through pre–post comparison [26]. Within each of Jakarta's five municipalities, two PHCs were randomly assigned to either the intervention group (IG) or the control group (CG). Individual-level randomization was not performed; instead, all eligible participants within each selected PHC were invited to participate according to their center's group assignment. The sample size of PLWH in each municipality was determined using the Slovin formula, while the number of participants recruited from each PHC was proportionally allocated based on the PLWH population distribution.

Eligible participants were adults aged 18 years or older who had received antiretroviral therapy (ART) for at least three months before data collection, were literate in mobile phone use, and owned an Android smartphone. Individuals who declined or later withdrew consent were excluded from the study. The research obtained approval from the District Health Office and received ethical authorization from an Institutional Ethics Committee (Approval No: 1061/UN2.F1/ETIK/PPM 00.02/2023). Consent was acquired from the participants, and their involvement was entirely voluntary.

Data collection

The researchers briefed the participants in IG on how to download and practice using Semangat. The Semangat was available from the Google Play Store®. Patients in IG were instructed to use the Semangat mobile application independently at home for a period of four weeks to support their self-management. The intervention was designed to be integrated into participants' daily lives, complementing standard care consisting of monthly consultations and free ART provision at primary health centers. Meanwhile, patients in CG received standard care.

Instruments and measures

Self-administered questionnaires were used as instruments to gather data from participants at the initiation and end of the study. No participant attrition occurred between pre- and post-assessments. The questionnaires were adopted from several studies to assess participants' medication adherence, EHL literacy, and HIV knowledge [27-30]. Additional questionnaires were given to patients in the IG to evaluate the usability of the Semangat and their satisfaction after using the application. The questionnaire was piloted among 30 PLWH in a non-study PHC before data collection to ensure its validity and reliability. Validity of the questionnaire was determined as valid, as shown by a validity coefficient value of 0.930, and test-retest reliability was considered adequate (Cronbach's alpha = 0.637). The moderate reliability of the questionnaire may have affected its internal consistency and should be considered when interpreting the results.

The questionnaires consisted of six parts. Parts 1-4 were distributed to all participants before and after intervention, whilst Parts 5-6 were given only to IG after intervention.

Data analysis

Data were analysed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA). A descriptive analysis was conducted to determine the demographic characteristics of PLWH, their patterns of seeking online health information, medication adherence, EHL, and knowledge regarding HIV/AIDS. The validity coefficient of the questionnaire was calculated using Pearson correlation. The Chi-square test was employed to compare the demographic characteristics and online information-seeking patterns between IG and CG. The Mann-Whitney test was applied to compare the primary outcome (medication adherence) and secondary outcomes (EHL and HIV knowledge) between the two groups. The Wilcoxon signed-rank test was performed to determine the within-group difference in the scores of medication adherence, EHL, and HIV knowledge before and after intervention. Data normality was tested using the Kolmogorov-Smirnov test before applying non-parametric analyses. Analyses were two-tailed with a significance level of $p < 0.05$. Further, we calculated Cohen's d to measure the effect size before and after intervention within each group for primary and secondary outcomes. Cohen classified effect size as small (d=0.2), medium (d = 0.5), and large (d≥0.8) [31]. Effect size quantifies the magnitude or practical importance of an observed difference or relationship, providing information beyond statistical significance [31].

Results and Discussion

A total of 494 PLWH participated in the study. As detailed in **Table 1**, overall, the distribution of socio-demographic characteristics indicates comparability between the intervention and control groups at baseline. The age distribution was comparable across groups, with the largest proportion of participants belonging to the 25–34 year category (49.4% in IG vs. 40.1% in CG), followed by those aged 35–44 years (27.1% vs. 36.8%, respectively). Gender composition was also similar, with males constituting the majority in both the intervention (80.6%) and control (78.5%) groups. Meanwhile, educational attainment showed a similar trend, with most participants having completed secondary education (62.3% in IG and 70.4% in CG). Employment status revealed that the majority of participants in both groups were employees, with a slightly higher proportion in IG (66.4%) compared to CG (58.7%). Conversely, self-employment and unemployment were marginally more prevalent in CG. With respect to the duration of HIV since

diagnosis, approximately half of the participants in both groups had been living with HIV for more than three years (48.3% in the intervention group and 48.9% in the control group), with smaller proportions reporting durations of less than one year or between one and three years.

Table 1. Baseline socio-demographic characteristics of study participants (N=494)

Characteristics	Intervention Group (N=247) No.(%)	Control Group (N=247) No.(%)	p-value*
Age (years)			
18 - 24	34 (13.8)	23 (9.3)	0.030
25 – 34	122 (49.4)	99 (40.1)	
35 – 44	67 (27.1)	91 (36.8)	
45-54	19 (7.7)	30 (12.3)	
>55	5 (2.0)	4 (1.6)	
Gender			
Male	199 (80.6)	194 (78.5)	0.655
Female	48 (19.4)	53 (21.5)	
Education level			
Primary	10 (4.1)	14 (5.7)	0.051
Secondary	154 (62.3)	174 (70.4)	
Tertiary	83 (33.6)	59 (23.9)	
Employment status			
Employee	164 (66.4)	145 (58.7)	0.187
Self-employed	39 (15.8)	52 (21.1)	
Unemployed	44 (17.8)	50 (20.2)	
Duration of HIV since diagnosis (years)			
<1	57 (23.1)	63 (25.5)	0.672
1-3	71 (28.7)	63 (25.5)	
>3	119 (48.3)	121 (48.9)	

*Statistical analysis was performed using the Chi-square test

Table 2 presents the profile of online HIV information-seeking behaviours among study participants in the intervention and control groups. A significant difference ($p<0.001$) was observed in the sources of online HIV-related information. Specifically, participants in the intervention group more frequently reported using health-related websites (19.0% vs. 15.4%) and social media (35.6% vs. 24.3%), whereas reliance on online encyclopedias and news websites (2.0% vs. 4.9%) and other media (2.0% vs. 8.9%) was more common in the control group. Search engine use was high in both groups (41.3% vs. 46.5%). Regarding motivations for seeking HIV-related information, no significant differences were found between groups ($p=0.722$). Across both groups, the vast majority of participants reported being primarily self-motivated (80.2% vs. 82.2%), with only small proportions citing family, friends, healthcare providers, or others as sources of motivation. Similarly, trusted sources of HIV information were comparable ($p=0.977$), with almost all participants in both groups identifying healthcare providers as their most trusted source (>95%). Very few participants cited the PLWH community, public figures, or social media.

Table 2. Profile of online HIV information-seeking by participants before intervention (N=494)

Variables	Intervention group (N=247) No.(%)	Control group (N=247 No.(%)	P-value*
Sources of HIV-related information			
Health-related websites	47 (19.0)	38 (15.4)	<0.001
Social media	88 (35.6)	60 (24.3)	
Search engine	102 (41.3)	115 (46.5)	
Online encyclopedia and news website	5 (2.0)	12 (4.9)	
Other media (e.g., TV, radio)	5 (2.0)	22 (8.9)	
Sources of motivation for HIV information seeking			
Themselves	198 (80.2)	203 (82.2)	0.722
Family	13 (5.3)	16 (6.5)	
Friends	21 (8.5)	19 (7.7)	
Healthcare providers	9 (3.6)	6 (2.4)	
Others	6 (2.4)	3 (1.2)	
Trusted sources of HIV information			
Healthcare providers	235 (95.1)	236 (95.6)	0.977
PLWH community	8 (3.2)	8 (3.2)	
Public figure	1 (0.4)	1 (0.4)	
Social media	3 (1.2)	2 (0.8)	

Devices used for searching HIV online information			
Handphone/tablet	240 (97.2)	238 (96.4)	0.799
Laptop/Personal computer	7 (2.8)	9 (3.6)	
Frequency of internet use for searching HIV information			
Every day	15 (6.1)	13 (5.3)	
3-6 times per week	7 (2.8)	3 (1.2)	
1-2 times per week	47 (19.0)	19 (7.7)	<0.001
Every 2 weeks	31 (12.6)	19 (7.7)	
Every 3 weeks	16 (6.5)	21 (8.5)	
Once per month	131 (53.0)	172 (69.6)	
Daily duration of internet use for searching HIV information			
<4 hours	241 (97.6)	241 (97.6)	
4-8 hours	6 (2.0)	4 (1.6)	0.694
9-12 hours	0	0	
>12 hours	1 (0.4)	2 (0.8)	

PLWH = people living with HIV

*Statistical analysis was performed using the Chi-square test

In terms of devices used for online searches, there were no significant differences (p=0.799), with almost all participants using handphones or tablets (>96%) and only a minority using laptops or personal computers. By contrast, a significant difference was observed in the frequency of internet use for HIV information (p<0.001). While the majority in both groups reported seeking information once per month (53.0% vs. 69.6%), participants in the intervention group were more likely to search weekly (e.g., 1–2 times per week: 19.0% vs. 7.7%). Meanwhile, the daily duration of internet use for HIV information did not differ significantly between groups (p=0.694). Most participants reported using the internet for less than four hours daily (>97%), with only a very small proportion reporting longer durations.

Table 3 depicts the scores of ART adherence, EHL, and HIV knowledge before and after intervention in both groups. The baseline mean adherence scores also showed no significant difference between groups, with 3.04 (SD = 1.15) in the intervention group and 3.24 (SD = 1.19) in the control group (p = 0.109). In terms of the ART adherence profile, at baseline, the distribution of ART adherence levels was similar between groups. In the intervention group, 9.3% of participants were classified as low adherent, 54.3% as moderate adherent, and 36.4% as high adherent. In the control group, 7.7% were low adherent, 47.4% moderate adherent, and 44.9% high adherent **(Figure 1)**. Following the intervention, substantial improvements were observed in the intervention group. The proportion of participants classified as high adherent increased markedly from 36.4% to 70.0%, while moderate adherence declined from 54.3% to 28.8% and low adherence dropped from 9.3% to only 1.2%. In contrast, the control group demonstrated only modest changes, with high adherence increasing slightly from 44.9% to 51.0%, moderate adherence decreasing from 47.4% to 42.1%, and low adherence remaining almost unchanged (7.7% to 6.9%). Consistent with these categorical findings, the mean adherence score in the intervention group increased significantly to 3.98 (SD = 0.904), representing a large improvement of +0.94 points (Cohen's d = 0.908). Meanwhile, the control group showed only a small increase in the adherence score with a mean change of 0.13 points (Cohen's d = 0.117). At the endpoint, between-group differences were statistically significant (p < 0.001) **(Table 3)**. Overall, both categorical and mean score analyses demonstrated that the intervention was highly effective in improving ART adherence, whereas the control group exhibited only minimal change.

Table 3. Score of Antiretroviral Treatment (ART) Adherence, E-Health Literacy, HIV Before and After Intervention

Variables	Intervention group (N=247)	Control group (N=247)	p-value[a]
Score of ART adherence			
Baseline, mean (SD)	3.04 (1.152)	3.24 (1.192)	0.109
Endpoint, mean (SD)	3.98 (0.904)[b]	3.38 (1.186)[c]	0.000
Difference within group, mean (SD)	+0.94 (1.102)	+0.13 (0.793)	0.000
E-Health literacy			
Baseline, mean (SD)	22.77 (4.042)	21.21 (4.382)	0.212
Endpoint, mean (SD)	24.79 (2.893)[b]	21.55 (4.309)[c]	0.030
Difference within group, mean (SD)	+2.02 (3.665)	+0.34 (2.732)	0.000
HIV knowledge			
Baseline, mean (SD)	3.49 (0.775)	3.57 (0.793)	0.077
Endpoint, mean (SD)	3.79 (0.484)[b]	3.63 (0.726)[c]	0.029
Difference within group, mean (SD)	+0.30 (0.591)	+0.06 (0.294)	0.000

SD = standard deviation

a =Difference between the two groups by using the Mann-Whitney test

b = Difference before-after within the intervention group was conducted using the Wilcoxon test, p-value = 0.000 (Cohen's d = 0.908) for ART adherence, p-value = 0.000 (Cohen's d = 0.575) for e-Health Literacy, p-value = 0.000 (Cohen's d = 0.464) for HIV knowledge

c = Difference before-after within the control group was conducted using the Wilcoxon test, p-value = 0.007 (Cohen's d = 0.118) for ART adherence, p-value = 0.001 (Cohen's d = 0.078) for e-Health literacy, p-value = 0.003 (Cohen's d = 0.079) for HIV knowledge

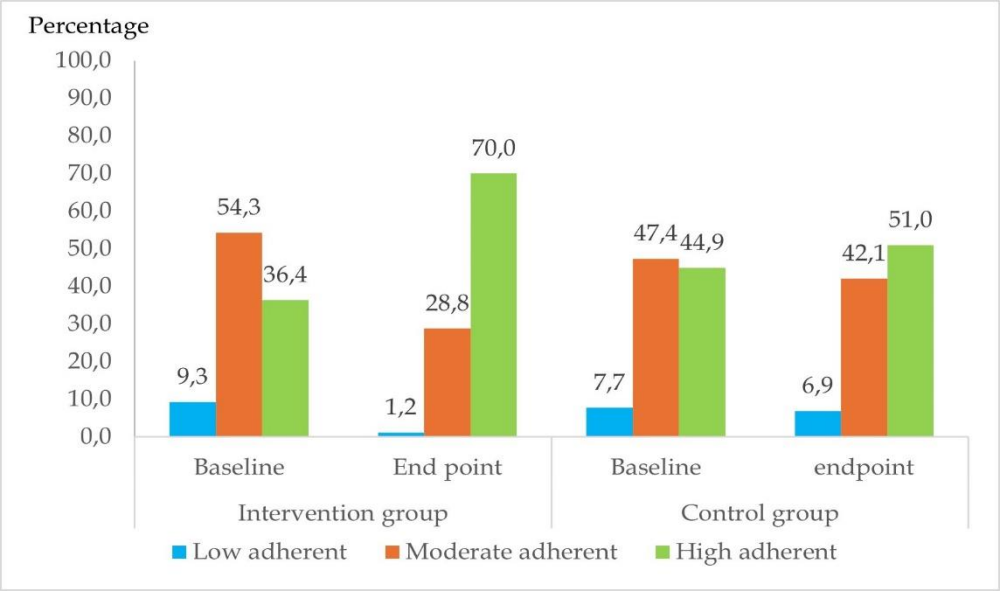

Figure 1. Level of Antiretroviral Treatment (ART) Adherence Before and After Intervention

Regarding EHL, at baseline, the distribution of EHL was comparable between the two groups. In the intervention group, 56.7% of participants had poor literacy and 43.3% had good literacy, while in the control group, 68.4% demonstrated poor literacy and 31.6% had good literacy **(Figure 2)**. The baseline mean EHL score was also similar between groups, with 22.77 (SD = 4.04) in the intervention group and 21.21 (SD = 4.38) in the control group, and the difference was not statistically significant ($p = 0.212$) **(Table 3)**.

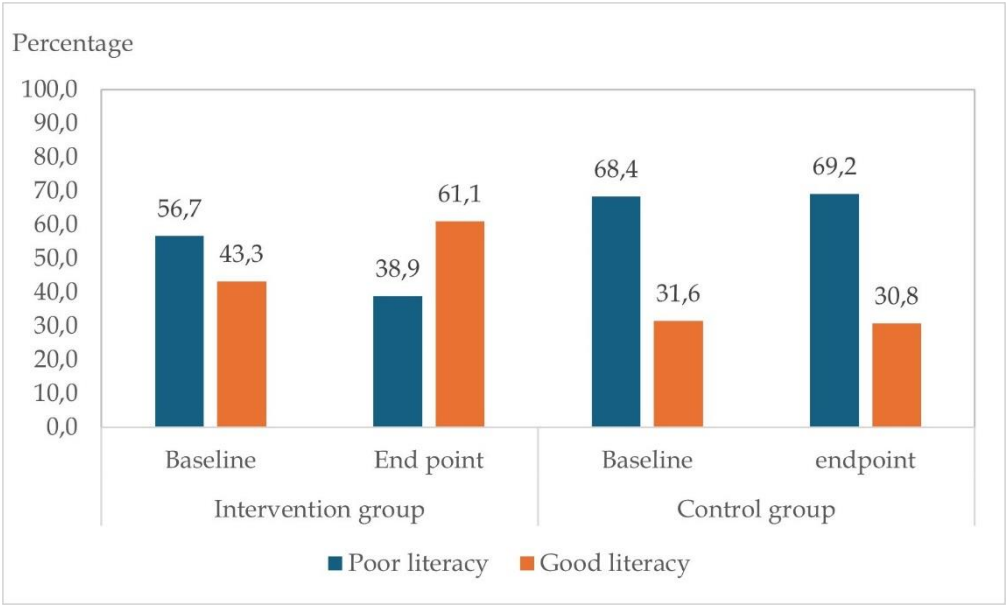

Figure 2. Level of e-Health Literacy Before and After Intervention

Following the intervention, a marked improvement was observed in the intervention group. The proportion of participants with good literacy increased to 61.1%, while poor literacy declined to 38.9% **(Figure 2)**. In contrast, the control group showed no meaningful change, with 69.2% classified as having poor literacy and 30.8% as having good literacy at endpoint. Consistent with these categorical findings, the mean literacy score in the intervention group increased significantly to 24.79 (SD = 2.89), representing a mean improvement of +2.02 points (SD = 3.67, $p < 0.001$, Cohen's d = 0.575). Meanwhile, the control group showed only a minimal increase to 21.55 (SD = 4.31), with a mean improvement of 0.34 points (Cohen's d = 0.078) **(Table 3)**. At the endpoint, the between-group difference in mean scores was statistically significant ($p = 0.030$). In general, these results demonstrated that the intervention was effective in significantly improving both the proportion of

participants with good EHL and the mean literacy scores, while no substantial improvement was observed in the control group.

The analysis of HIV knowledge demonstrated consistent improvements in the intervention group across both categorical knowledge levels and mean scores. At baseline, the majority of participants in both groups were classified as having good knowledge, with 64.0% in the intervention group and 72.1% in the control group, and no significant differences were observed between groups **(Figure 3)**. Mean baseline scores further confirmed this comparability, with the intervention group scoring 3.49 ± 0.775 and the control group 3.57 ± 0.793 (p = 0.077), **(Table 3)**.

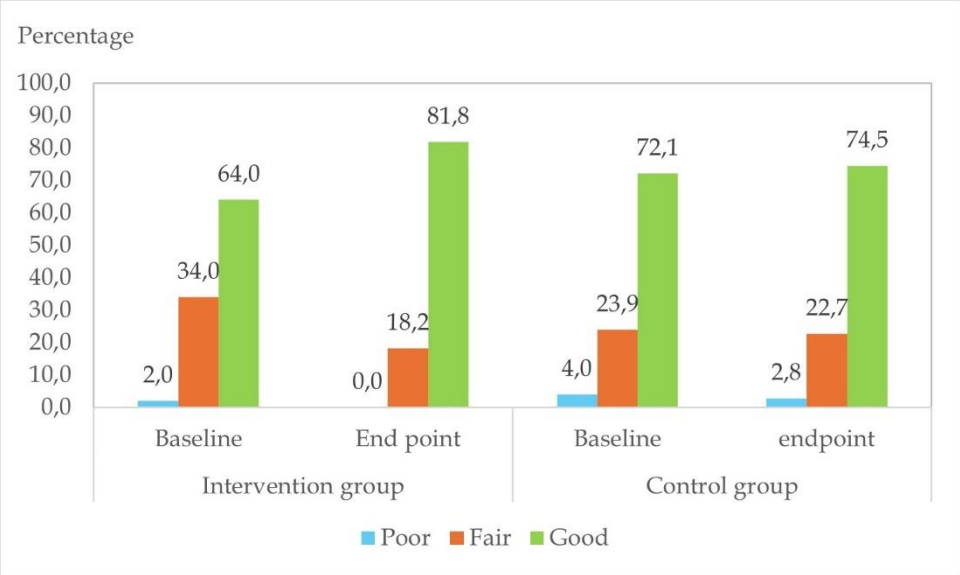

Figure 3. Level of HIV-related Knowledge Before and After Intervention

By the endpoint, marked improvements were observed in the intervention group. The proportion of participants classified as having good knowledge increased substantially from 64.0% to 81.8%, while no participants remained in the poor category. In contrast, only a modest increase was observed in the control group, with the proportion in the good category rising slightly from 72.1% to 74.5%, and 2.8% of participants continuing to demonstrate poor knowledge **(Figure 3)**. These categorical shifts were corroborated by the mean score analysis detailed in **Table 3**. The intervention group achieved a statistically significant increase in mean knowledge score (3.79 ± 0.484), compared to a smaller increase in the control group (3.63 ± 0.726), with the between-group difference at endpoint reaching statistical significance (p = 0.029). Further, the mean gain score was significantly higher (p < 0.001) in the intervention group (+0.30, Cohen's d = 0.464) relative to the control group (+0.06, Cohen's d = 0.079). These results confirm that the intervention had a strong positive impact on enhancing HIV knowledge relative to the control group.

Assessment of the Semangat application's usability **(Table 4)** showed a mixed distribution of responses among intervention participants. While 29.2% rated the application as "very good" and 20.2% rated it as "good," a notable proportion perceived it less favourably, with 29.2% rating usability as "poor" and 21.4% as "fair." This indicates that although more than half of the participants acknowledged the application as at least "good" or "very good," nearly half expressed reservations regarding its usability. In terms of user satisfaction toward Semangat, 38.1% of participants reported being "very satisfied," and 21.9% were "satisfied," leaving 40% of participants being "less satisfied". The findings suggested that while the application was positively received by a majority, there remains room for further improvement to optimise user experience and satisfaction.

Table 4. Assessment of Application Usability and User Satisfaction in the Intervention Group After Four-Week Use

Parameters	Intervention group (N=247) No.(%)
Level of Application Usability	
Poor	72 (29.2)
Fair	53 (21.4)
Good	50 (20.2)
Very Good	72 (29.2)
Level of Satisfaction	
Less Satisfied	99 (40.0)
Satisfied	54 (21.9)
Very Satisfied	94 (38.1)

This quasi-experimental study demonstrated that the Semangat mobile application was effective in improving ART adherence, EHL, and HIV-related knowledge among PLWH in Indonesia. Participants in the intervention group exhibited significantly greater improvements in both categorical and mean scores of adherence and literacy compared with the control group, while also showing marked gains in HIV knowledge. The application's features, particularly HIV-related information provision and medication reminders, have likely made a key contribution in enhancing digital literacy, patients' knowledge, and ultimately

medication adherence. The improvement in ART adherence among Semangat users can be attributed to this integration of educational, behavioural, and motivational features. The application not only provided reliable HIV-related information but also personalised medication reminders, addressing both knowledge and behavioural barriers to adherence. Its eHealth literacy component likely enhanced users' capacity to evaluate and apply health information, thereby improving understanding, communication, and confidence in self-management. Additionally, Semangat's culturally attuned messaging and user-friendly interface enhanced engagement, while recurring reminders reinforced medication-taking habits and self-regulation.

Maintaining adherence in chronic conditions such as HIV is influenced by a wide range of demographic, economic, and sociocultural factors. Among these, health literacy has consistently been identified as a critical determinant, as it affects patients' ability to understand treatment instructions, evaluate health information, and make informed decisions [5]. Previous research has consistently shown that patients with higher levels of health literacy are more likely to adhere to their medications [32-34]. Persell *et al*. for instance, demonstrated that health literacy was closely linked to patients' understanding of medication indications, dosing, and instructions, suggesting that limited literacy contributes to poor self-management [35]. Similarly, Lu and Zhang reported that eHealth literacy in online health communities was positively associated with treatment adherence [36-39]. They found this relationship was mediated by factors such as physician–patient communication, health information–seeking behaviours, and the perceived quality of online health information [40]. This evidence has reinforced our study results, where improved eHealth literacy among Semangat users may have facilitated better communication, more effective information use, and ultimately, higher ART adherence. This underscores the importance of integrating literacy-focused digital tools into HIV care to complement traditional clinical support [41-44].

Our findings also resonate with previous mHealth initiatives in Indonesia; however, the *Semangat* application offers distinctive advantages in terms of its integrated focus on eHealth literacy and broader usability among general PLWH populations. Similarly, Garg *et al*. developed "Rumah Sela", an application targeting key populations affected by HIV—such as men who have sex with men, transgender individuals, and people who use drugs [45-53]. The study reported improvements in HIV-related knowledge and behaviors, alongside high acceptability and increased service utilization (e.g., HIV testing). In contrast, Semangat was designed for the wider PLWH community, not restricted to key populations, thereby expanding its potential reach and impact on national adherence improvement efforts [54]. Another HIV application known as IMUT ARV, which stands for "Ingat Minum Obat ARV" (Remember to take antiretroviral therapy), offered similar features to Semangat, such as educational information, reminders for taking ART, and notifications for collecting ART from PHC. During the usability assessment of IMUT ARV, PLWH and healthcare providers indicated that IMUT ARV could potentially enhance medication compliance. Therefore, this application was highly recommended for wider use among PLWH. However, while IMUT ARV primarily focused on behavioural reminders, Semangat integrates an eHealth literacy enhancement component, aiming to strengthen users' abilities to access, understand, and apply HIV-related digital information, thereby fostering more sustainable adherence behaviours. Furthermore, findings on IMUT ARV's scalability and long-term outcomes remain limited [55]. Unlike Sobat Sehat, another Indonesian-based HIV application created by the Indonesian AIDS Coalition, Semangat goes beyond informational and locational support. Sobat Sehat provides general information on symptoms, prevention, and treatment using geo-location to identify nearby healthcare services, but lacks adherence reminders and literacy-based engagement tools. Semangat, conversely, combines educational, behavioural, and motivational elements through medication and visit reminders, interactive health information, and features that support users' comprehension and self-management capacity [56].

When compared with mHealth initiatives abroad, Semangat also demonstrates a more holistic approach. For example, South Korea's Excellent Self-Supervised HIV Care (ESCC) and Health Manager applications focus primarily on adherence reminders and patient–provider communication [17, 19], while Iran's Aysoo emphasizes self-care through diet and exercise monitoring [16]. Meanwhile, applications such as WYZ and LifeSkills in the United States were designed for specific subgroups (e.g., youth and transgender women) to enhance engagement and peer support [18, 28]. In contrast, Semangat was developed through participatory design tailored to Indonesia's cultural context, literacy levels, and healthcare infrastructure, making it more adaptable for large-scale implementation in low- and middle-income settings. Its dual emphasis on behavioral support and digital literacy empowerment differentiates it from most existing HIV mHealth interventions globally [57-61].

Despite the promising results, several limitations should be acknowledged. First, the intervention period was relatively short (four weeks), limiting the ability to assess the long-term sustainability of the observed improvements. Second, although allocation at the PHC level was randomised, individual randomisation was not conducted, which may have introduced selection bias and unmeasured differences between groups [62-71]. Third, adherence assessment relied on self-reported measures, which are susceptible to recall and social desirability bias and may have overestimated actual adherence levels. Fourth, approximately half of the participants rated the application's usability as "poor" or "fair," indicating the need for further refinement to enhance user experience and interface design. Finally, as Semangat was specifically developed within the Indonesian context, its generalisability to other settings may require cultural and contextual adaptation.

Conclusion

The Semangat mobile application significantly improved ART adherence, eHealth literacy, and HIV knowledge among PLWH in Indonesia compared to standard care alone. By combining reminder features with accessible health information, the application addressed both behavioural and educational barriers to adherence. While the short duration and limited usability highlight areas for further development, these findings support the integration of Semangat into Indonesia's Satu Sehat digital health ecosystem as a community-based HIV management tool. Future studies should evaluate long-term sustainability, user-centered refinements, and the impact on clinical outcomes such as viral suppression.

Acknowledgments: We would like to express our gratitude to all PLWH in the study primary health care centers and our research assistants (Alzeta, Alphadeo, Asti, Deswita, Wita) for their participation and support in this study. We also thank Universitas Pancasila through its "Hıbah Internal 2025 Scheme" for providing financial assistance to undertake this study.

Conflict of interest: None

Financial support: The study was supported by Universitas Pancasila research grant through "*Hibah Penelitian Internal 2025*".

Ethics statement: The study was granted two-year ethical clearance (2023-2025) from an Institutional Ethics Committee (1061/UN2.F1/ETIK/PPM 00.02/2023).

References

1. Joint United Nations Programme on HIV/AIDS. Fact sheet 2024. Joint United Nations Programme on HIV/AIDS; 2024.
2. BPS Statistics Indonesia. Statistical yearbook of Indonesia 2024. Jakarta: BPS Statistics Indonesia; 2024.
3. Kementerian Kesehatan Republik Indonesia. Laporan eksekutif perkembangan HIV AIDS dan penyakit infeksi menular seksual (PIMS) semester I tahun 2024. Jakarta: Kementerian Kesehatan Republik Indonesia; 2024.
4. Benson C, Wang X, Dunn KJ, Li N, Mesana L, Lai J, et al. Antiretroviral adherence, drug resistance, and the impact of social determinants of health in HIV-1 patients in the US. AIDS Behav. 2020;24(12):3562-73. doi:10.1007/s10461-020-02937-8
5. Reynolds R, Smoller S, Allen A, Nicholas PK. Health literacy and health outcomes in persons living with HIV disease: A systematic review. AIDS Behav. 2019;23(11):3024-43. doi:10.1007/s10461-019-02432-9
6. Ullah Nayan M, Sillman B, Hasan M, Deodhar S, Das S, Sultana A, et al. Advances in long-acting, slow-effective-release antiretroviral therapies for treatment and prevention of HIV infection. Adv Drug Deliv Rev. 2023;200:115009. doi:10.1016/j.addr.2023.115009
7. Gast A, Mathes T. Medication adherence influencing factors—an (updated) overview of systematic reviews. Syst Rev. 2019;8(1):112. doi:10.1186/s13643-019-1014-8
8. Atuhaire L, Shumba CS, Mapahla L, Maposa I, Nyasulu PS. Factors associated with adherence to HIV testing guidelines among HIV-negative female sex workers in Kampala, Uganda. IJID Reg. 2022;4:25-32. doi:10.1016/j.ijregi.2022.05.008
9. Isika AI, Shehu A, Dahiru T, Obi IF, Oku AO, Balogun MS, et al. Factors influencing adherence to antiretroviral therapy among HIV-infected adults in Cross River State, Nigeria: A cross-sectional study. Pan Afr Med J. 2022;43:187. doi:10.11604/pamj.2022.43.187.37172
10. Cunha GH, Galvão MT, Pinheiro PN, Vieira NF. Health literacy for people living with HIV/AIDS: An integrative review. Rev Bras Enferm. 2017;70(1):180-8. doi:10.1590/0034-7167-2015-0052
11. Mgbako O, Conard R, Mellins CA, Dacus J-D, Remien RH. A systematic review of factors critical for HIV health literacy, ART adherence, and retention in care in the U.S. for racial and ethnic minorities. AIDS Behav. 2022;26(11):3480-93. doi:10.1007/s10461-022-03680-y
12. Perazzo J, Reyes D, Webel A. A systematic review of health literacy interventions for people living with HIV. AIDS Behav. 2017;21(3):812-21. doi:10.1007/s10461-016-1329-6
13. Whiteley LB, Olsen EM, Haubrick KK, Odoom E, Tarantino N, Brown LK. A review of interventions to enhance HIV medication adherence. Curr HIV/AIDS Rep. 2021;18(5):443-57. doi:10.1007/s11904-021-00568-9
14. Laricchia F. Global smartphone penetration rate as share of population from 2016 to 2023 [Internet]. 2024 [cited 2024 Aug 16]. Available from: https://www.statista.com/statistics/203734/global-smartphone-penetration-per-capita-since-2005
15. Siahaan M. Number of smartphone users in Indonesia from 2018 to 2028 [Internet]. 2023 [cited 2024 Aug 16]. Available from: https://www.statista.com/forecasts/266729/smartphone-users-in-indonesia
16. Safdari R, SeyedAlinaghi S, Mohammadzadeh N, Noori T, Rahmati P, Qaderi K, et al. Developing Aysoo: A mobile-based self-management application for people living with HIV. HIV AIDS Rev. 2022;21(1):24-30. doi:10.5114/hivar.2022.113389
17. Shim MS, Kim S, Choi M, Choi JY, Park CG, Kim GS. Developing an app-based self-management program for people living with HIV: A randomized controlled pilot study during the COVID-19 pandemic. Sci Rep. 2022;12(1):19401. doi:10.1038/s41598-022-19238-w
18. Erguera XA, Johnson MO, Neilands TB, Ruel T, Berrean B, Thomas S, et al. WYZ: A pilot study protocol for designing and developing a mobile health application for engagement in HIV care and medication adherence in youth

and young adults living with HIV. BMJ Open. 2019;9(5):e030473. doi:10.1136/bmjopen-2019-030473
19. Kim GS, Kim L, Baek S, Shim MS, Lee S, Kim JM, et al. Three cycles of mobile app design to improve HIV self-management: A development and evaluation study. Digit Health. 2024;10:20552076241249294. doi:10.1177/20552076241249294
20. Dillingham R, Ingersoll K, Flickinger TE, Waldman AL, Grabowski M, Laurence C, et al. PositiveLinks: A mobile health intervention for retention in HIV care and clinical outcomes with 12-month follow-up. AIDS Patient Care STDS. 2018;32(6):241-50. doi:10.1089/apc.2017.0303
21. Perera AI, Thomas MG, Moore JO, Faasse K, Petrie KJ. Effect of a smartphone application incorporating personalized health-related imagery on adherence to antiretroviral therapy: A randomized clinical trial. AIDS Patient Care STDS. 2014;28(11):579-86. doi:10.1089/apc.2014.0156
22. Westergaard RP, Genz A, Panico K, Surkan PJ, Keruly J, Hutton HE, et al. Acceptability of a mobile health intervention to enhance HIV care coordination for patients with substance use disorders. Addict Sci Clin Pract. 2017;12(1):11. doi:10.1186/s13722-017-0076-y
23. Mehraeen E, SeyedAlinaghi S, Pashaei Z, Mirzapour P, Barzegary A, Vahedi F, et al. Mobile applications in HIV self-management: A systematic review of scientific literature. AIDS Rev. 2022;24(1):24-31. doi:10.24875/AIDSRev.21000025
24. Alandia A, Yona S. Mobile health technologies for adherence to antiretroviral therapy in HIV/AIDS: A systematic review. Indones J Glob Health Res. 2024;6(6):4035-46. doi:10.37287/ijghr.v6i6.3929
25. Ramadaniati HU, Andayani N, Saputra A, Pratita RN. Development of a mobile application prototype to support self-management among people living with HIV in Indonesia. HIV AIDS Rev. Forthcoming.
26. Harris AD, McGregor JC, Perencevich EN, Furuno JP, Zhu J, Peterson DE, et al. The use and interpretation of quasi-experimental studies in medical informatics. J Am Med Inform Assoc. 2006;13(1):16-23. doi:10.1197/jamia.M1749
27. Norman CD, Skinner HA. eHEALS: The eHealth literacy scale. J Med Internet Res. 2006;8(4):e27. doi:10.2196/jmir.8.4.e27
28. Schnall R, Cho H, Liu J. Health information technology usability evaluation scale (Health-ITUES) for usability assessment of mobile health technology: Validation study. JMIR Mhealth Uhealth. 2018;6(1):e4. doi:10.2196/mhealth.8851
29. Stoyanov SR, Hides L, Kavanagh DJ, Zelenko O, Tjondronegoro D, Mani M. Mobile app rating scale: A new tool for assessing the quality of health mobile apps. JMIR Mhealth Uhealth. 2015;3(1):e27. doi:10.2196/mhealth.3422
30. Saputra G. Gambaran pengetahuan, sikap dan perilaku terkait HIV/AIDS pada siswa kelas 3 SMK PGRI 1 Kota Bogor tahun 2008. Jakarta: Universitas Indonesia; 2008.
31. Sullivan GM, Feinn R. Using effect size—or why the P value is not enough. J Grad Med Educ. 2012;4(3):279-82. doi:10.4300/jgme-d-12-00156.1
32. Nandyala AS, Nelson LA, Lagotte AE, Osborn CY. An analysis of whether health literacy and numeracy are associated with diabetes medication adherence. Health Lit Res Pract. 2018;2(1):e15-e20. doi:10.3928/24748307-20171212-01
33. Lee YM, Yu HY, You MA, Son YJ. Impact of health literacy on medication adherence in older people with chronic diseases. Collegian. 2017;24(1):11-8. doi:10.1016/j.colegn.2015.08.003
34. Lor M, Koleck TA, Bakken S, Yoon S, Dunn Navarra AM. Association between health literacy and medication adherence among Hispanics with hypertension. J Racial Ethn Health Disparities. 2019;6(3):517-24. doi:10.1007/s40615-018-00550-z
35. Persell SD, Karmali KN, Lee JY, Lazar D, Brown T, Friesema EM, et al. Associations between health literacy and medication self-management among community health center patients with uncontrolled hypertension. Patient Prefer Adherence. 2020;14:87-95. doi:10.2147/PPA.S226619
36. Badrov M, Perisin AS. A web-based survey in Croatia on knowledge and attitude of non-orthodontic specialists toward orthodontic treatment. Asian J Periodontics Orthod. 2022;2:67-73. doi:10.51847/cCt4tZqiCt
37. Bona C, Owusu A. Assessment of periodontal outcomes in anterior teeth following intrasulcular restorations using the BAIR technique. Asian J Periodontics Orthod. 2022;2:74-82. doi:10.51847/ZuMxBVFttu
38. Poornachitra P, Maheswari U. Identifying non-specific symptoms in oral submucous fibrosis patients: A clinical perspective. Asian J Periodontics Orthod. 2023;3:18-24. doi:10.51847/xLpm4TfyCA
39. Belfiore CI, Manfredini M, Dipalma G. Longitudinal analysis of bacterial colonization on clear orthodontic retainers using 16S rRNA sequencing. Asian J Periodontics Orthod. 2023;3:35-43. doi:10.51847/01LDpzGEFa
40. Lu X, Zhang R. Association between eHealth literacy in online health communities and patient adherence: Cross-sectional questionnaire study. J Med Internet Res. 2021;23(9):e14908. doi:10.2196/14908
41. Welman A, Chima MD. Respecting autonomy in African communities: Traditional beliefs and challenges for informed consent in South Africa. Asian J Ethics Health Med. 2023;3:1-16. doi:10.51847/KmUs6uzoc1
42. Costa LA, Eiro N, Vaca A, Vizoso FJ. Advanced microscopy and cell culture techniques in regenerative endodontics. Asian J Periodontics Orthod. 2022;2:42-6. doi:10.51847/ExCWvexPbC

43. Ashokkumar P, Giri GVV, Pandya K. Parotid abscess-associated facial palsy in hemodialysis patients: Clinical and surgical considerations. Asian J Periodontics Orthod. 2022;2:47-50. doi:10.51847/naDu2XfBBQ
44. Mei L, Jiang L. Factors influencing post-treatment relapse in diastema closure. Asian J Periodontics Orthod. 2022;2:51-5. doi:10.51847/5BKHDdH8UU
45. Roger J, Dupuis C, Muller L. Understanding organizational citizenship behavior: The mediating role of impression management and the moderating role of power distance. Asian J Indiv Organ Behav. 2023;3:89-98. doi:10.51847/oNFM50mCjK
46. Jeung DY, Chang SJ. The role of emotional labor as a mediator in the relationship between organizational climate and employee burnout. Asian J Indiv Organ Behav. 2023;3:1-8. doi:10.51847/OQDl5r3KKA
47. Ernst P, Weber T. Impact of flexible work arrangements on the engagement levels of younger employees. Ann Organ Cult Leadersh Extern Engagem J. 2024;5:72-86. doi:10.51847/njhaTa39mx
48. Holmes R, Norris D. Empowering leadership and employee performance: The mediating role of work engagement in Ethio-Telecom. Ann Organ Cult Leadersh Extern Engagem J. 2024;5:147-58. doi:10.51847/R6TQ0Y2j4W
49. Szklener K, Nieoczym K, Niedziela K, Światłowski Ł, Mańdziuk S. Exceptional survival with lorlatinib in ALK-rearranged lung cancer: A case report. Asian J Curr Res Clin Cancer. 2023;3(1):1-5. doi:10.51847/DxGARc9jsQ
50. Jin LW, Tahir NAM, Islahudin F, Chuen LS. Exploring treatment adherence and quality of life among patients with transfusion-dependent thalassemia. Ann Pharm Pract Pharmacother. 2024;4:8-16. doi:10.51847/B8R85qakUv
51. Qiao J, Luo B, Ming J, Zhou S, Chen Y, Zhang X. Prevalence and implications of non-prescription antibiotic dispensing in Baghdad community pharmacies. Ann Pharm Pract Pharmacother. 2024;4:34-41. doi:10.51847/5SuGTfpren
52. Lv X, Yang L, Fan Z, Bao X. Synthesis and biological assessment of novel quinazolinone–piperazine hybrid derivatives as antimicrobial agents. Pharm Sci Drug Des. 2024;4:16-25. doi:10.51847/OCT1Q8Fm7d
53. Park K. Advances in controlled drug release systems: Current trends and future prospects. Pharm Sci Drug Des. 2024;4:26-34. doi:10.51847/m708A2Qw3b
54. Garg PR, Uppal L, Mehra S, Mehra D. Mobile health app for self-learning on HIV prevention knowledge and services among a young Indonesian key population: Cohort study. JMIR Mhealth Uhealth. 2020;8(9):e17646. doi:10.2196/17646
55. Fatimatuzahro F, Widjanarko B, Shaluhiyah Z. Model pengembangan aplikasi "Ingat Minum Obat ARV" berbasis Android sebagai pengingat minum obat pada ODHA. J Keperawatan Silampari. 2023;6:1479-91.
56. Indonesia AIDS Coalition. Sosialisasi Sobat Sehat Jakarta [Internet]. Jakarta: Indonesia AIDS Coalition; 2023 [cited 2024 Aug 16]. Available from: https://iac.or.id/id/sosialisasi-sobat-sehat-kota-bandung/
57. Awasthi A, Bigoniya P, Gupta B. Phytochemical characterization and pharmacological potential of *Moringa oleifera* extract. Spec J Pharmacogn Phytochem Biotechnol. 2024;4:1-8. doi:10.51847/VEJJO91vAT
58. Ganea M, Horvath T, Nagy C, Morna AA, Pasc P, Szilagyi A, et al. Rapid method for microencapsulation of *Magnolia officinalis* oil and its medical applications. Spec J Pharmacogn Phytochem Biotechnol. 2024;4:29-38. doi:10.51847/UllqQHbfeC
59. Syam S, Maheswari U. Incidental maxillary sinus findings in CBCT scans: A retrospective analysis. Interdiscip Res Med Sci Spec. 2023;3(2):25-30. doi:10.51847/EvXEF16qHk
60. Fritea L, Sipponen M, Antonescu A, Groza FM, Chirla R, Vesa C, et al. Impact of pre-existing conditions on inflammatory response in COVID-19 patients. Interdiscip Res Med Sci Spec. 2023;3(1):11-9. doi:10.51847/ylgQeUPVMb
61. Ku JK, Um IW, Jun MK, Kim IH. Clinical management of external apical root resorption using amnion membrane matrix and Biodentine. J Curr Res Oral Surg. 2023;3:1-5. doi:10.51847/lOSwt6Qzpv
62. Yang J, Tang Z, Shan Z, Leung YY. Integrating rapid maxillary expansion and Le Fort osteotomy for esthetic rehabilitation: A clinical case report. J Curr Res Oral Surg. 2023;3:22-6. doi:10.51847/E0OEwI52jo
63. Essah A, Igboemeka C, Hailemeskel B. Exploring gabapentin as a treatment for pruritus: A survey of student perspectives. Ann Pharm Educ Saf Public Health Advocacy. 2024;4:1-6. doi:10.51847/h8xgEJE3NE
64. Souza JS, Reis EA, Godman B, Campbell SM, Meyer JC, Sena LWP, et al. Designing a healthcare utilization index to enable worldwide patient comparisons: A cross-sectional study. Ann Pharm Educ Saf Public Health Advocacy. 2024;4:7-15. doi:10.51847/EeWKtBkVgK
65. Cinar F, Aslan FE. Impact of prolonged COVID-19 symptoms on patient quality of life. Int J Soc Psychol Asp Healthc. 2023;3:1-7. doi:10.51847/rYq0gZIX7G
66. Delcea C, Rad D, Gyorgy M, Runcan R, Breaz A, Gavrilă-Ardelean M, et al. Exploring Romanian resilience: A network analysis of coping mechanisms during the COVID-19 pandemic. Int J Soc Psychol Asp Healthc. 2023;3:13-20. doi:10.51847/HgPIOyOclr
67. Nebotova LV, Gasanov EAO, Makhsubova SH, Abdullayeva ZA, Shabaev SS, Kadiev IA. Current approaches and advances in the treatment of hemangiomas. J Med Sci Interdiscip Res. 2023;3(1):1-8. doi:10.51847/0kweYaHVIP
68. Guigoz Y, Vellas B. Nutritional status assessment in elderly using different screening tools. J Med Sci Interdiscip Res. 2023;3(1):9-19. doi:10.51847/JZjGw02xal
69. Tâlvan E, Budişan L, Mohor CI, Grecu V, Berindan-Neagoe I, Cristea V, et al. Interconnected dynamics among inflammation, immunity, and cancer—from tumor

suppression to tumor onset, promotion, and progression. Arch Int J Cancer Allied Sci. 2023;3(1):25-8. doi:10.51847/nbSWsJHJMZ

70. Kim S, Bae H, Kim H. A diagnostic and therapeutic dilemma: Giant multifocal retroperitoneal dedifferentiated liposarcoma with dual heterologous components. Arch Int J Cancer Allied Sci. 2024;4(2):1-5. doi:10.51847/5JnC3jAkZz
71. Su Z, Qin M, Hu D. Impact of lecture versus group discussion-based ethics training on nurses' moral reasoning, distress, and sensitivity: A randomized clinical trial. Asian J Ethics Health Med. 2024;4:81-96. doi:10.51847/iBvPMrJSLE