Indonesian Nursing Journal, 4 (1), 2026 22-31

ISSN 2988-7623 (Online)
ISSN 2988-7577 (Print)

www.ejournal.polsub.ac.id/index.php/inj

Indonesian Nursing Journal

Published by Program Studi Keperawatan Politeknik Negeri Subang

Original research

The effect of AI-assisted nursing care on digital health literacy, symptom management, and continuity of care among pulmonary outpatients: A quasi-experimental study at Bhayangkara Surabaya Hospital

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ARTICLE INFO

DOI:
https://doi.org/10.31962/inj.v4i1.26

Keywords:
AI-assisted nursing care;
continuity of care;
digital health literacy;
symptom management;
pulmonary outpatients.

Article history:
Received 19 May 2026 Revised 03 June 2026
Accepted 27 June 2026

ABSTRACT

Background: Pulmonary outpatients often experience recurrent respiratory symptoms requiring continuous support. Limited consultation time, increasing digital health use, and the need for symptom monitoring highlight the importance of AI-assisted nursing care in outpatient pulmonary services.
Purpose: This study analyzed the effect of AI-assisted nursing care on digital health literacy, symptom management, and continuity of care among pulmonary outpatients at Bhayangkara Surabaya Hospital.
Methods: A quasi-experimental study with a two-group pretest-posttest design involved 70 pulmonary outpatients (35 intervention, 35 control). The intervention group received AI-assisted nursing care; the control group received standard care. Data were collected using the Digital Health Literacy Instrument, a symptom management questionnaire, and the Nijmegen Continuity Questionnaire. Analysis used paired t-test, Wilcoxon Signed-Rank Test, independent t-test, and Mann-Whitney U Test.
Results: The intervention group showed significantly greater improvements than the control group. Digital health literacy was significantly higher ($t = 9.11$, $p < 0.001$), symptom management improved significantly ($Z = -7.84$, $p < 0.001$), and continuity of care differed significantly between groups ($t = 8.99$, $p < 0.001$). Change scores were substantially greater in the intervention group, particularly for continuity of care (18.95 vs. 2.26), with small effect sizes across all outcomes.
Conclusion: AI-assisted nursing care can strengthen digital nursing support for pulmonary outpatients. Integrating structured digital education, chatbot interaction, symptom tracking, reminders, and nurse monitoring improves digital health literacy, symptom management, and continuity of care in outpatient pulmonary services.

1. Background

Pulmonary diseases are health problems that require continuous management, particularly among outpatients attending pulmonary clinics. Pulmonary tuberculosis, chronic obstructive pulmonary disease (COPD), asthma, chronic bronchitis, and other respiratory disorders often cause recurrent symptoms such as cough, shortness of breath, sputum production, chest pain, fever, fatigue, sleep disturbance, and activity limitation [1], [2]. In outpatient care, these symptoms do not always occur while patients are in the health facility but often appear or worsen after patients return home. This condition requires patients to be able to recognize symptom changes, understand warning signs, make appropriate initial decisions, and maintain communication with healthcare professionals.

ISSN 2988-7623 (Online)
ISSN 2988-7577 (Print)

The burden of pulmonary disease remains high and is an important concern in healthcare services. Chronic obstructive pulmonary disease is reported as one of the leading causes of death worldwide and contributes substantially to reduced quality of life [3]. Tuberculosis also remains one of the infectious diseases with the highest burden. In 2024, approximately 8.3 million people were newly diagnosed and notified as tuberculosis cases, but this figure still indicates a gap between estimated cases and detected cases. Indonesia is also among the countries with the highest tuberculosis burden, with an estimated 1,090,000 cases and 125,000 deaths per year [4]. These conditions indicate that patients with respiratory problems need not only treatment, but also education, monitoring, and continuous follow-up care [5], [6], [7].

East Java also faces a substantial pulmonary disease burden, particularly tuberculosis. As of October 2024, 73,247 tuberculosis cases were recorded in East Java. In Surabaya, tuberculosis case detection from January to December 2024 reached 12,096 cases, or approximately 75% of the estimated target cases [8], [9]. These data indicate that Surabaya has a high pulmonary outpatient service burden and requires a care model that can support patients continuously. Patients attending pulmonary clinics require not only examination and treatment, but also guidance to understand health information, recognize symptom changes, and follow care plans [10], [11], [12].

The main problems among pulmonary outpatients are not only related to respiratory disorders, but also to patients' ability to understand digital health information, manage symptoms, and maintain continuity of care. Patients increasingly access health information through the internet, social media, health applications, and chatbots. However, easy access to digital information is not always accompanied by the ability to determine whether the information is valid, relevant, safe, and appropriate to the patient's health condition. Patients with inadequate digital health literacy are at risk of misunderstanding information, delaying care seeking, or making inappropriate health decisions [13], [14].

Digital health literacy and symptom management are important components of nursing care for pulmonary outpatients. Digital health literacy helps patients search for, understand, evaluate, use, and protect digital health information related to symptoms, medication, warning signs, relapse prevention, follow-up visits, and data security [10], [11], [12], [13], [14]. This ability can be assessed using the Digital Health Literacy Instrument (DHLI), which includes operational skills, navigation skills, information searching, evaluating reliability, determining relevance, adding self-generated content, and protecting privacy [15]. patients with respiratory disorders need to monitor symptoms, recognize warning signs, take appropriate initial action, and seek medical help promptly to reduce the risk of delayed treatment [10].

Continuity of care is also an important issue in pulmonary outpatient services. In outpatient care, patient interactions with nurses and other healthcare professionals are often brief, while patients' needs continue after they leave the hospital. Without an adequate follow-up system, information provided during visits may be forgotten, symptoms may not be documented, and patients may not always know when to seek care again. Continuity of care includes informational continuity, coordination of care plans, patient-healthcare professional relationships, and follow-up after visits [11], [14], [16], [17].

The development of digital health technology provides an opportunity to strengthen outpatient nursing services through AI-assisted nursing care, a nursing care approach supported by artificial intelligence that integrates digital education, AI chatbots, symptom monitoring, reminders, and nurse monitoring [18]. This approach is not intended to replace nurses, but to expand educational, promotive, preventive, and monitoring functions so that patients can revisit information, ask questions through chatbots, report symptoms, receive reminders, and continue receiving support during care [19]. At Bhayangkara Surabaya Hospital, this approach is relevant because pulmonary outpatients have diverse diagnoses and needs, including pulmonary tuberculosis, COPD, asthma, and other chronic respiratory disorders. All respondents owned smartphones and most accessed the internet daily, but their experience using health applications or chatbots was still limited. This condition indicates that AI-assisted nursing care has the potential to help patients use technology more purposefully to support their care. [19].

Although digital technology has been widely used in healthcare services, studies specifically examining AI-assisted nursing care for digital health literacy, symptom management, and continuity of care among pulmonary outpatients

ISSN 2988-7623 (Online)
ISSN 2988-7577 (Print)

remain limited. Previous studies have mostly focused on medication adherence, general education, telemedicine, or descriptive technology use. However, the success of digital interventions is not determined only by the availability of applications, but also by patients' ability to understand digital health information, manage respiratory symptoms, and experience continuity of care after outpatient visits. Therefore, this study was conducted to analyze the effect of AI-assisted nursing care on digital health literacy, symptom management, and continuity of care among pulmonary outpatients at Bhayangkara Surabaya Hospital. The findings are expected to serve as a basis for developing digital nursing care models in outpatient pulmonary services.

The research hypothesis of this study is that pulmonary outpatients who receive AI-assisted nursing care will have greater improvements in digital health literacy, symptom management, and continuity of care compared with patients who receive standard nursing care.

2. Methods

2.1 Research design

This study employed a quasi-experimental design with a two-group pretest-posttest approach. This design was used to analyze the effect of AI-assisted nursing care on improving digital health literacy, symptom management, and continuity of care among outpatients at the Pulmonary Outpatient Clinic of Bhayangkara Surabaya Hospital.

Respondents were divided into two groups: an intervention group and a control group. The intervention group received AI-assisted nursing care, while the control group received standard nursing care according to routine services in the pulmonary outpatient clinic. Measurements were conducted twice: before the intervention as the pretest and after the intervention as the posttest. The outcomes measured were digital health literacy, symptom management, and continuity of care.

2.2 Setting and sample

The study was conducted at the Pulmonary Outpatient Clinic of RS Bhayangkara H.S. Samsoeri Mertojoso Surabaya, Indonesia. This setting was selected because the clinic provides outpatient care for patients with various respiratory disorders, including pulmonary tuberculosis, chronic obstructive pulmonary disease (COPD), asthma, chronic bronchitis, and other chronic respiratory conditions.

The study population consisted of all eligible pulmonary outpatients attending the clinic during the study period. The minimum sample size was calculated using a two-group comparison formula with a significance level of 0.05 and a statistical power of 80%, resulting in a minimum requirement of 35 participants per group. Accordingly, a total of 70 participants were recruited.

Eligible participants were selected using simple random sampling based on the outpatient registration list. Each eligible patient was assigned a unique identification number, and participants were selected using a random number table until the required sample size was achieved.

After recruitment, participants were allocated into either the intervention group (n = 35) or the control group (n = 35) using simple random allocation generated from a random number table. Allocation was performed by an independent researcher who was not involved in data collection or outcome assessment to minimize allocation bias. Participants assigned to the intervention group received AI-assisted nursing care in addition to standard nursing care, whereas those assigned to the control group received standard nursing care only.

2.3 Instruments and data collection

Data were collected through structured interviews and self-administered questionnaires completed by the respondents. The instruments included a respondent characteristics form, the Digital Health Literacy Instrument (DHLI), a symptom management questionnaire, the Nijmegen Continuity Questionnaire (NCQ), and a questionnaire assessing respondents' participation in the AI-assisted nursing care program.

Data were collected through structured interviews and self-administered questionnaires. The instruments included a respondent characteristics form, the Digital Health Literacy Instrument (DHLI), a symptom management questionnaire, the Nijmegen Continuity Questionnaire (NCQ), and an intervention engagement checklist for the AI-assisted nursing care program.

The Digital Health Literacy Instrument was used to measure patients' digital health literacy. This instrument consisted of 21 items covering seven domains: operational skills, navigation skills, information searching, evaluating reliability, determining relevance, adding self-generated

ISSN 2988-7623 (Online)
ISSN 2988-7577 (Print)

content, and protecting privacy. The symptom management questionnaire consisted of 24 items assessing patients' ability to recognize, monitor, and manage respiratory symptoms, including cough, shortness of breath, sputum production, chest pain, fever, fatigue, sleep disturbance, and warning signs. The Nijmegen Continuity Questionnaire was used to assess patients' perceptions of continuity of care, including informational continuity, relationships with health professionals, care coordination, and follow-up care.

The research instruments were reviewed by a panel of experts to ensure content appropriateness, clarity of language, and relevance to the context of pulmonary outpatients. A pilot test was conducted with 10 pulmonary outpatients who had similar characteristics to the study respondents but were not included in the main sample. The reliability test showed Cronbach's alpha values of 0.89 for the DHLI, 0.87 for the symptom management questionnaire, and 0.91 for the NCQ, indicating good internal consistency.

Data collection was conducted in two stages: pretest and posttest. During the pretest stage, all respondents completed the DHLI, symptom management questionnaire, and NCQ before the intervention. The intervention group then received AI-assisted nursing care, while the control group received standard nursing care. After the intervention period, both groups completed the same questionnaires as the posttest. Respondents were given instructions on how to complete the questionnaires to minimize misunderstanding. Response bias was reduced by maintaining respondent anonymity and emphasizing that there were no right or wrong answers in the questionnaires.

2.4 Data analysis

Data were analyzed using descriptive and inferential statistics. Frequencies, percentages, means, and standard deviations were used to describe respondents' characteristics and the scores of digital health literacy, symptom management, and continuity of care. The Shapiro-Wilk test was used to assess data normality. A paired t-test or Wilcoxon Signed-Rank Test was used to analyze pretest and posttest differences within each group, while an independent t-test or Mann-Whitney U Test was used to analyze differences between the intervention and control groups. The level of significance was set at $p < 0.05$. All analyses were conducted using SPSS version 26.

2.5 Research ethics

Persetujuan Ethical approval was obtained from the hospital's health research ethics committee (Approval Number: No.16/IV/2026/KEPK/RUMKIT). Respondents were provided with detailed information about the study objectives, intervention procedures, benefits, risks, and data confidentiality. Written informed consent was obtained from all respondents before data collection. Participation was voluntary, and respondents were allowed to withdraw from the study at any time without affecting the health services they received. Respondents' data confidentiality was maintained throughout the study.

3. Results

A total of 70 pulmonary outpatients participated in this study. The participants were divided into two groups: 35 patients in the control group receiving standard nursing care and 35 patients in the experimental group receiving AI-assisted nursing care. The findings indicate that AI-assisted nursing care had a significant effect on digital health literacy, symptom management, and continuity of care among pulmonary outpatients.

Table 1. Demographic Characteristics of Respondents (n = 70)

Characteristics	Frequency	Percentage
Gender		
Male	39	55.7%
Female	31	44.3%
Age Group		
18–30 years	7	10.0%
31–40 years	13	18.6%
41–50 years	17	24.3%
51–60 years	21	30.0%

ISSN 2988-7623 (Online)
ISSN 2988-7577 (Print)

>60 years	12	17.1%
Education Level		
Elementary school	9	12.9%
Junior high school	15	21.4%
Senior high school	31	44.3%
Diploma/bachelor's degree	15	21.4%
Diagnosis in Pulmonary Outpatient Clinic		
Pulmonary tuberculosis	31	44.3%
COPD/PPOK	15	21.4%
Asthma	12	17.1%
Chronic bronchitis/other respiratory disorders	12	17.1%

The demographic data show that most respondents were male, with 39 participants (55.7%), while female respondents accounted for 31 participants (44.3%). The largest age group was 51–60 years, comprising 21 respondents (30.0%), followed by 41–50 years with 17 respondents (24.3%). In terms of education, most respondents had completed senior high school, with 31 respondents (44.3%). Based on clinical diagnosis, pulmonary tuberculosis was the most common diagnosis, found in 31 respondents (44.3%), followed by COPD/PPOK in 15 respondents (21.4%), asthma in 12 respondents (17.1%), and chronic bronchitis or other respiratory disorders in 12 respondents (17.1%).

Table 2. Baseline Digital Health Literacy, Symptom Management, and Continuity of Care Categories

Variable	Frequency	Percentage
Digital Health Literacy		
Low	25	35.7%
Moderate	35	50.0%
High	10	14.3%
Symptom Management		
Poor	23	32.9%
Moderate	37	52.9%
Good	10	14.3%
Continuity of Care		
Low	25	35.7%
Moderate	35	50.0%
High	10	14.3%

The baseline data indicate that most respondents had moderate levels of digital health literacy, symptom management, and continuity of care before the intervention. Half of the respondents (50.0%) had moderate digital health literacy, while 35.7% were in the low category. For symptom management, most respondents were in the moderate category (52.9%), followed by the poor category (32.9%). A similar pattern was found in continuity of care, where 50.0% of respondents were in the moderate category and 35.7% were in the low category. These findings suggest that many pulmonary outpatients still required additional support in using digital health information, managing respiratory symptoms, and maintaining continuity of care after outpatient visits.

Table 3. Comparison of Digital Health Literacy, Symptom Management, and Continuity of Care Between Groups After Intervention

Variable	Statistical Test	Test Value	df	p-Value	Significance
Digital Health Literacy	Independent t-test	09.11	68	<0.001	Significant

ISSN 2988-7623 (Online)
ISSN 2988-7577 (Print)

Symptom Management	Mann-Whitney U Test	-7.84	-	<0.001	Significant
Continuity of Care	Independent t-test	0,40208333	68	<0.001	Significant

The statistical analysis showed significant differences between the experimental and control groups after the intervention. Digital health literacy was significantly higher in the experimental group than in the control group ($t = 9.11$, $p < 0.001$). Symptom management also showed a significant difference between groups ($Z = -7.84$, $p < 0.001$). Similarly, continuity of care was significantly higher in the experimental group compared with the control group ($t = 8.99$, $p < 0.001$). These findings indicate that AI-assisted nursing care had a significant effect on improving digital health literacy, symptom management, and continuity of care among pulmonary outpatients.

Table 4. Effect of AI-Assisted Nursing Care Based on Change Scores

Variable	Experimental Group Mean Change	Control Group Mean Change	p-Value	Effect Size	Interpretation
Digital Health Literacy	18.43	0,104861111	<0.001	0,13611111	Small effect
Symptom Management	0.730555556	0.085416667	<0.001	0.06527778	Small effect
Continuity of Care	0.815972222	02.26	<0.001	0.13125	Small effect

The comparison of change scores showed that the experimental group experienced greater improvements than the control group in all study outcomes. The highest improvement was found in continuity of care, with a mean change of 18.95 in the experimental group compared with 2.26 in the control group. Digital health literacy also increased substantially in the experimental group, with a mean change of 18.43 compared with 1.91 in the control group. Symptom management improved by 16.92 points in the experimental group, while the control group improved by only 1.63 points. The effect size values indicate that AI-assisted nursing care produced a small effect on all three outcomes.

4. Discussion

The findings of this study demonstrate that AI-assisted nursing care significantly improved digital health literacy, symptom management, and continuity of care among pulmonary outpatients. Patients in the intervention group showed greater improvement than those in the control group after receiving the intervention. This result indicates that nursing care supported by digital education, chatbot AI, symptom tracking, reminders, and nurse monitoring can strengthen patients' ability to access health information, recognize respiratory symptoms, and maintain follow-up care after outpatient visits. This finding is consistent with recent evidence showing that artificial intelligence can support patient care, nursing education, clinical workflows, and monitoring when implemented with ethical safeguards and professional supervision [18], [20].

The improvement in digital health literacy highlights the importance of patients' ability to use digital health information appropriately in pulmonary outpatient care. Patients with respiratory problems often search for information about cough, shortness of breath, sputum production, medication use, warning signs, and follow-up care through the internet, social media, health applications, or chatbot platforms. However, access to digital information does not automatically mean that patients can evaluate the accuracy, relevance, and safety of the information. The Digital Health Literacy Instrument developed by van der Vaart and Drossaert measures a broad range of skills, including operational skills, navigation skills, information searching, evaluating reliability, determining relevance, adding self-generated content, and protecting privacy. Therefore, the increase in digital health literacy in this study

ISSN 2988-7623 (Online)
ISSN 2988-7577 (Print)

suggests that AI-assisted nursing care helped patients use digital health information in a safer, more critical, and more relevant manner.

One possible explanation for the improvement in digital health literacy is the repeated and interactive nature of the intervention. Patients in the intervention group did not only receive education during outpatient visits, but were also able to access digital education materials, interact with the AI chatbot, and receive reminders during the intervention period. This mechanism is consistent with adult learning principles, in which adult patients learn more effectively when information is relevant, practical, accessible, and can be repeated according to their needs. In pulmonary outpatient care, repeated access to education may help patients understand information gradually and reduce the possibility of forgetting information delivered during a brief consultation.

This study also found that AI-assisted nursing care improved symptom management among pulmonary outpatients. Respiratory symptoms such as cough, shortness of breath, sputum production, chest discomfort, fever, fatigue, and sleep disturbance may occur or worsen after patients return home. Patients who are unable to recognize symptom changes may delay seeking help or may not know what initial action to take. In this study, symptom tracking and chatbot-supported education encouraged patients to monitor symptoms, identify warning signs, and understand when to seek medical assistance. This finding suggests that AI-assisted nursing care can help bridge the gap between outpatient consultation and home-based symptom management.

The improvement in symptom management can be explained using Symptom Management Theory developed by Dodd et al. This theory explains that symptom management involves three interrelated components: symptom experience, symptom management strategies, and symptom outcomes. In this study, symptom tracking helped patients recognize their symptom experience, while digital education and chatbot guidance supported symptom management strategies, such as identifying warning signs, taking initial action, avoiding triggers, following treatment instructions, and seeking medical assistance at the right time. The improvement in symptom management scores after the intervention indicates a positive change in patients' ability to manage respiratory symptoms.

This finding is also relevant to previous evidence showing that digital interventions can support the management of chronic respiratory diseases. Digital health technology in respiratory care has been reported to influence patient-provider relationships and may strengthen care when the technology is well designed, easy to use, and supported by clinical professionals. Although this study did not include more advanced technologies such as wearable devices, remote physiological monitoring, or home spirometry, the findings show that a basic AI-assisted nursing care model can still provide benefits for pulmonary outpatients. Thus, relatively simple digital tools, when structured within a nursing care framework, may represent a realistic approach for improving symptom recognition and self-management in outpatient pulmonary services.

The study also found that AI-assisted nursing care significantly improved continuity of care. This finding is important because pulmonary outpatient care does not end when the patient leaves the consultation room. Patients still need follow-up information, control reminders, symptom monitoring, and communication support to continue care at home. Continuity of care includes informational continuity, management continuity, and relational continuity. Informational continuity refers to the continued use of patient-related information, management continuity refers to consistency in care planning and follow-up, and relational continuity refers to an ongoing relationship between patients and health professionals.

In this study, AI-assisted nursing care strengthened continuity of care by extending nursing support beyond face-to-face encounters. Digital education allowed patients to revisit health information after outpatient visits. The AI chatbot provided basic educational interaction, while symptom tracking and reminders helped patients maintain follow-up behavior. Nurse monitoring ensured that digital support remained connected to the nursing care process. The use of the Nijmegen Continuity Questionnaire is appropriate in this context because it was developed to measure patients' experiences of continuity of care across care settings.

The difference between the intervention and control groups may be related to the intensity and continuity of support received by patients. Standard nursing care still provides important education and instructions during outpatient visits,

ISSN 2988-7623 (Online)
ISSN 2988-7577 (Print)

but the available time for education is often limited. In contrast, AI-assisted nursing care provided additional support through digital education, chatbot interaction, symptom monitoring, reminders, and nurse monitoring. This additional support likely increased patients' exposure to health information and encouraged their engagement in the care process. From the authors' perspective, the effectiveness of this intervention was not caused by AI alone, but by the integration of AI into a nursing care framework that maintained the role of nurses as educators, monitors, and care coordinators.

Pulmonary outpatient services need to move from episodic education toward more continuous digital nursing support. Nurses can use AI-assisted tools to strengthen patient education, support symptom monitoring, and improve continuity of care after outpatient visits. However, AI should not be positioned as a replacement for professional judgment. In this study, the chatbot functioned only as a supportive tool for education, reminders, and early communication, while nurses remained responsible for validating content, monitoring patient responses, and directing patients to appropriate care when warning signs appeared. This is consistent with current recommendations that AI in nursing should be adopted responsibly, with attention to ethics, patient safety, professional supervision, and workflow integration.

The Hospitals need to consider the development of digital nursing care models that are safe, ethical, and integrated with outpatient services. Digital health programs should not focus only on technology availability, but also on patient readiness, digital health literacy, data protection, and nurse involvement. Nurse participation in the design, validation, implementation, and evaluation of AI-assisted interventions is essential to ensure that the technology remains aligned with patients' needs and nursing care standards.

Although this study provides useful evidence, several limitations should be considered. First, the study was conducted in one hospital, so the findings may not fully represent pulmonary outpatients in other health care settings. Second, the participants were patients who had basic ability to use smartphones, which may limit the generalizability of the findings to patients with low digital access, severe functional limitations, or cognitive impairment. Third, the intervention used only selected digital features, including digital education, chatbot AI, symptom tracking, reminders, and nurse monitoring. This study did not include other digital technologies such as wearable devices, remote physiological monitoring, teleconsultation, electronic medical record integration, home spirometry, or machine learning-based clinical prediction systems. Future studies should involve larger samples, longer follow-up periods, multicenter settings, and more comprehensive digital health models to strengthen the evidence and generalizability of the findings.

5. Conclusion

This study showed that AI-assisted nursing care significantly improved digital health literacy, symptom management, and continuity of care among pulmonary outpatients. Patients who received AI-assisted nursing care demonstrated better ability to access and use digital health information, recognize and manage respiratory symptoms, and maintain continuity of care after outpatient visits compared with patients who received standard nursing care.

The findings indicate that AI-assisted nursing care can be used as a supportive digital nursing approach in pulmonary outpatient services. This program includes structured digital education, chatbot-based interaction, symptom tracking, reminders, and nurse monitoring. These components can help patients become more active in managing their health and extend nursing care beyond the limited time available during outpatient consultations.

AI-assisted nursing care should be implemented as a supportive tool, not as a replacement for professional nursing practice. Nurses remain central in developing educational materials, monitoring patient responses, ensuring information accuracy, and guiding patients when symptoms worsen. Therefore, this intervention can strengthen the role of nurses in digital health transformation and improve patient-centered pulmonary outpatient care.

Future studies are recommended to test this intervention in broader clinical settings, involve larger and more diverse populations, and use longer follow-up periods. Further research may also integrate more advanced digital technologies, such as wearable monitoring, teleconsultation, electronic medical record integration, home spirometry, and predictive analytics, to provide a more comprehensive understanding of AI-assisted nursing care in pulmonary outpatient services.

ISSN 2988-7623 (Online)
ISSN 2988-7577 (Print)

6. Acknowledgment

The authors would like to express their sincere gratitude to Bhayangkara Surabaya Hospital for the support and permission provided during the implementation of this study. The authors also thank the Pulmonary Outpatient Clinic for assisting with coordination, participant recruitment, and data collection. Appreciation is also extended to the nurses and healthcare professionals who supported the implementation of the AI-assisted nursing care program in this study. The authors are deeply grateful to all pulmonary outpatients who agreed to participate as respondents and completed the research process from pretest, intervention, to posttest. Without their participation and cooperation, this study would not have been possible.

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