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Impact of Artificial Intelligence-based Preoperative Education in Reducing Anxiety among Nephrolithotomy Patients

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ABSTRACT

Background: Nephrolithotomy is a major surgical procedure that often triggers significant anxiety in patients due to fear of pain, anesthesia, and surgical complications. Preoperative anxiety may adversely affect physiological stability and surgical outcomes. Recent technological advancements enable artificial intelligence (AI) tools, such as Meta AI on WhatsApp, to be utilized as interactive media for Preoperative education. ***Purpose*:** This study sought to evaluate how effective Preoperative education delivered through Meta AI was in reducing anxiety among patients scheduled for nephrolithotomy. ***Methods*:** A quasi-experimental, non-randomized pre-test and post-test control group design was employed. Seventy nephrolithotomy patients were purposively and non-randomly assigned to either an intervention group or a control group. The intervention group received preoperative education via Meta AI, whereas the control group received conventional verbal instruction. Anxiety levels were assessed using the Amsterdam preoperative Anxiety and Information Scale (APAIS), and data was analyzed with an independent sample t-test. ***Results*:** Both groups experienced a decline in anxiety after education; however, the intervention group showed a significantly greater reduction in anxiety scores ($p = 0.001$) compared to the control group. ***Conclusion*:** AI-based Preoperative education through Meta AI effectively reduced Preoperative anxiety among nephrolithotomy patients more than conventional verbal methods. ***Implications for Nursing*:** Nurses can integrate AI-based platforms into Preoperative education to provide accessible, interactive, and patient-centered information that enhances psychological preparedness and reduces surgical anxiety.

Keywords: Artificial Intelligence, Anxiety, AI-based, Preoperative education, Nephrolithotomy.

What does this paper add?

1. This study provides new empirical evidence that Artificial Intelligence–based preoperative education, delivered through Meta AI, significantly reduces anxiety levels among patients undergoing nephrolithotomy, compared to conventional verbal education.
2. It highlights the role of interactive and personalized AI communication as an effective nursing strategy to enhance patient understanding, engagement, and psychological readiness before surgery.
3. The findings emphasize that the potential integration of AI-assisted educational tools into preoperative nursing practice offers an innovative and accessible approach to support patient-centered care and improve surgical outcomes.

Introduction

Surgical procedures are among the most stressful experiences for patients, as they often involve uncertainty, fear, and potential physical discomfort. Nephrolithotomy, a major surgery performed to remove kidney stones that cannot be treated conservatively, frequently triggers significant preoperative anxiety among patients due to concerns about pain, anesthesia, and post-operative recovery (Aloweidi et al., 2022; Shebl et al., 2025). Studies have shown that unmanaged anxiety increases sympathetic nervous activity, leading to elevated blood pressure, heart rate, and respiratory rate, all of which may complicate the surgical process and delay recovery (Chiu et al., 2023; Christal Vimala et al., 2021).

An important contributor to preoperative anxiety is the lack of information and understanding regarding surgical procedures. Patients often experience uncertainty about pain, anesthesia, and surgical outcomes, which heightens their anxiety levels (Deniz Doğan et al., 2024; Zhuo et al., 2023). Providing structured and comprehensive Preoperative education is therefore a key nursing intervention to help patients develop a sense of control and psychological preparedness (Atchison et al., 2022; Saltali, 2023). Conventional education methods, such as verbal counseling, brochures, and short educational sessions, can improve knowledge, but are limited by time constraints and passive one-way communication (Kwon et al., 2023; Wahyuni et al., 2024).

The emergence of digital health innovations offers new opportunities to address these limitations. Artificial Intelligence (AI) technologies have been increasingly utilized in healthcare for diagnostics, patient education, and decision support due to their accessibility, interactivity, and personalization capabilities (Liu et al., 2021; Trenggono & Bachtiar, 2023). Integrating AI into preoperative nursing education allows patients to interactively obtain relevant information, clarify concerns, and enhance comprehension at their own pace (Zhang et al., 2025). Such interactive systems can strengthen patients' self-efficacy and engagement, leading to reduced anxiety and improved satisfaction with care (Chiu et al., 2023; Saltali, 2023).

Background

Preoperative anxiety is a frequent psychological reaction among patients awaiting surgery and is widely acknowledged as a significant nursing issue in perioperative care. This emotional reaction may arise from fear of anesthesia, pain, complications, or even death, and can affect both physiological and psychological stability (Aloweidi et al., 2022; Shebl et al., 2025). High anxiety levels before surgery have been linked to increased sympathetic nervous system activity, which can elevate heart rate, blood pressure, and cortisol levels, thereby complicating anesthesia induction and post-operative recovery (Chiu et al., 2023; Ewees et al., 2025).

Anxiety before surgery not only influences physiological parameters, but also impacts the patient's emotional well-being and perception of care. When patients do not receive sufficient information about their surgery, uncertainty and negative expectations tend to increase, worsening anxiety and reducing satisfaction with care (Deniz Doğan et al., 2024; Zhuo et al., 2023). Therefore, providing comprehensive Preoperative education is an essential nursing intervention that helps patients understand the procedure, improve readiness, and reduce emotional distress (Ewees et al., 2025; Wahyuni et al., 2024).

Conventional methods of preoperative education, such as verbal explanations, booklets, or audio-visual presentations, have shown benefits in reducing anxiety, yet their effectiveness is limited by time, patient engagement, and the one-way nature of communication (Kwon et al., 2023; Saltali, 2023). Recent developments in digital health technologies have created new possibilities to deliver more personalized, interactive, and accessible educational interventions. Artificial Intelligence (AI) has emerged as a powerful tool in healthcare education, allowing patients to access accurate, responsive, and tailored information regarding medical procedures (Liu et al., 2021; Trenggono & Bachtiar, 2023).

AI-based communication platforms, such as Meta AI on WhatsApp, enable patients to actively engage in the learning process by asking questions, clarifying concerns, and receiving real-time responses. This interactive model promotes self-efficacy and cognitive control, which are essential for anxiety reduction (Hou et al., 2023; Zhang et al., 2025).

Given the global trend toward technology-integrated healthcare, the use of AI in nursing education represents a progressive step toward improving patient outcomes. Understanding its impact on preoperative anxiety among nephrolithotomy patients is crucial for developing evidence-based, patient-centered educational strategies that align with modern nursing practice (Liu et al., 2021; Zhang et al., 2025).

Artificial intelligence–based education has emerged

as an innovative approach in perioperative nursing practice. Meta AI, integrated into messaging platforms, such as WhatsApp, enables real-time and interactive communication that provides patients with tailored information about surgery, anesthesia, and post-operative care. Compared with conventional verbal education, this patient-centered approach enhances accessibility, autonomy, and repeated learning, which are essential for reducing preoperative anxiety and improving psychological preparedness (Eteng-Uket & Effiom, 2025).

Methods

A quasi-experimental, non-randomized pre-test and post-test control group design was employed. Seventy nephrolithotomy patients were purposively assigned to either an intervention group or a control group. The study was carried out at Sultan Agung Islamic Hospital, Semarang, between July 2025 and October 2025, involving 70 purposively selected patients aged 18-60 years who met the eligibility criteria. Participants were evenly allocated to an intervention group (n = 35) and a control group (n = 35). The intervention group received AI-based education via Meta AI on WhatsApp, enabling interactive discussions on surgical preparation, anesthesia, and post-operative recovery, whereas the control group received conventional verbal education from nurses. Each educational session lasted approximately from 10 minutes to 15 minutes.

Measurements

Preoperative anxiety was measured using the Amsterdam Preoperative Anxiety and Information Scale (APAIS), developed by Moerman et al. (1996) to assess anxiety related to anesthesia and surgery as well as patients' need for information. The APAIS consists of six items rated on a five-point Likert scale, with higher scores indicating greater anxiety. The instrument has demonstrated good psychometric properties, with reported Cronbach's alpha values ranging from 0.80 to 0.87 for the anxiety sub-scale.

Data Collection, Ethical Consideration and Analysis

Inclusion criteria were adult patients aged 18-60 years scheduled for nephrolithotomy, able to communicate effectively, and willing to participate. Exclusion criteria were patients with diagnosed psychiatric disorders, cognitive impairment, or those receiving anxiolytic medication.

Data collection was carried out from July to October 2025 at Sultan Agung Islamic Hospital, Semarang, Indonesia. Patients scheduled for nephrolithotomy who met the inclusion criteria were approached during their preoperative assessment visits. After receiving detailed explanations about the study objectives and procedures, participants who agreed to join provided written informed consent before data collection.

Data was collected using the Amsterdam preoperative Anxiety and Information Scale (APAIS), a validated and widely applied instrument for assessing preoperative anxiety. The questionnaire was administered twice, before and after the educational intervention, through face-to-face interviews conducted by trained research assistants. The pre-test measurement was conducted one day before surgery before the educational intervention, while the post-test measurement was conducted on the same day after completion of the educational session and before transfer to the operating room. Each session lasted approximately 10-15 minutes and was held in a quiet, private room within the surgical ward to maintain participant comfort, focus, and confidentiality.

Ethical approval for this study was obtained from the Health Research Ethics Committee of Sultan Agung Islamic Hospital, Semarang, Indonesia (Approval No. 159/KEPK-RSISA/VII/2025). All participants were informed of their right to withdraw from the study at any time without affecting their medical treatment. To ensure confidentiality, all personal data was anonymized, and research files were securely stored in password-protected systems accessible only to the research team.

Data analysis was conducted using the Statistical Package for Social Sciences (SPSS). Descriptive statistics were applied to summarize demographic variables and anxiety scores. Data normality was assessed using the Shapiro–Wilk test, followed by independent sample t-tests to compare anxiety scores between the intervention and control groups at baseline and after the intervention. No statistically significant difference was observed between groups prior to the intervention ($p > 0.05$), indicating baseline equivalence. This analytical approach was selected to examine between-group differences within a quasi-experimental design in which randomization was not feasible due to clinical and ethical considerations. A p-value of less than 0.05 was considered statistically significant.

Results

Table 1 presents the age characteristics of respondents in both groups. The mean age of participants in the intervention group was 27.37 ± 2.18

years, while that of the control group was 27.40 ± 1.93 years, with age ranges between 23 and 30 years in both groups. These results indicate that the respondents were relatively homogeneous in age, suggesting that differences in anxiety outcomes were not influenced by age variations between the groups.

Table 1. Characteristics of respondents (n = 70)

Age	Mean	Minimum	Maximum	Standard Deviation
Intervention group	27.37	23	30	2.18
Control group	27.40	24	30	1.93

Table 2 describes the respondents' characteristics based on gender, education, occupation, and surgical experience. The majority of participants in both groups were male (60% in the intervention group and 62.9% in the control group) and had completed high school education. Most respondents worked in informal sectors, such as factory work, trading, or self-employment, while only a few were unemployed or farmers. Regarding surgical experience, more than a half of the participants in both groups were undergoing surgery for the first time, followed by smaller proportions with prior surgical history. These similarities indicate that both groups were demographically comparable, supporting the validity of subsequent analyses.

Table 2. Respondent characteristics based on gender, education, occupation, and surgical experience (n=70)

Characteristics	Intervention group		Control group	
	n	Percentage %	n	Percentage %
Gender				
Male	21	60	22	62,9
Female	14	40	13	37,1
Total		100		100
Education				
Primary/Junior	6	17.14	9	25,7
High School	25	71.43	21	60
Higher Education	4	11.43	5	14,3
Total		100		100
Occupation				
Factory worker	8	22.86	7	20
Employee	6	17.14	5	14.29
Self-employed	5	14.29	5	14.29
Construction worker	3	8.57	2	5.71
Housewife	5	14.29	5	14.29
Not yet employed	3	8.57	1	2.86
Trader	5	14.29	7	20
Farmer	0	0	3	8.57
Total		100		100
Surgical Experience				
First operation	23	65.71	24	68,6
Second operation	8	22.86	6	17,1
Third operation	3	8.57	3	8,6
>3 times	1	2.86	2	5,7
Total		100		100

Table 3 shows the comparison of preoperative anxiety scores before and after the educational intervention in both groups. The intervention group experienced a decrease in mean anxiety score from 15.46 to 11.37, while the control group showed a smaller reduction from 15.06 to 13.57. These findings indicate that both types of education effectively reduced anxiety levels, but the AI-based preoperative education provided to the intervention group resulted in a greater reduction of anxiety level compared to conventional verbal education.

Table 3. Preoperative patient anxiety scores before and after preoperative education was given in both groups (n=70)

Group	Mean Pre-test	SD Pre-test	Mean Post-test	SD Post-test
Intervention	15.46	3.21	11.37	3.22
Control	15.06	2.98	13.57	2.20

Table 4 displays the results of the independent sample t-test comparing post-intervention anxiety scores between the intervention and the control groups. The analysis revealed a statistically significant difference ($t = -3.339$, $df = 68$, $p = 0.001$), with a mean difference of –2.20 and a 95% confidence interval ranging from –3.515 to –0.885. This result statistically supports a greater reduction in anxiety among patients who received AI-based preoperative education compared with those who received conventional verbal education.

Table 4. Results of the independent sample t-test analysis (n=70)

Group	N	Mean	SD	t	df	Sig. (2-tailed)	Mean difference	95% CI (Lower–Upper)
Intervention	35	11.37	3.218	-3.339	68	0.001	-2.200	-3.515 to -0.885
Control	35	13.57	2.200					

Discussion

The findings of this study demonstrate that preoperative education delivered through Artificial Intelligence (AI) using Meta AI significantly reduced anxiety levels among patients undergoing nephrolithotomy compared to those who received conventional verbal education. Both groups showed a decline in anxiety after the educational intervention, but the reduction was more pronounced in the AI-based group. These results indicate that technology-supported education is an effective approach to enhance psychological readiness before surgery, aligning with previous studies showing similar outcomes in digital and virtual health education interventions (Chiu et al., 2023; Zhang et al., 2025).

The significant decrease in anxiety among patients who received AI-based education may be attributed to the interactive, personalized, and readily accessible nature of the Meta AI platform. Unlike traditional one-way education, AI-based systems allow patients to ask questions, clarify information, and receive immediate, evidence-based responses engagingly. This supports the concept of patient empowerment, where increased understanding and perceived control contribute to reduced anxiety and greater psychological stability (Kwon et al., 2023; Rochmawati et al., 2021).

These findings are consistent with research by Zhang et al. (2025), who reported that AI-assisted preoperative counseling significantly improved patient comprehension and reduced anxiety before urolithiasis surgery. Similarly, Chiu et al (2023) found that virtual reality–based interventions effectively lowered anxiety and improved preparedness in patients awaiting elective surgery. The interactive dimension of technology, whether through AI or virtual simulation, appears to foster engagement and cognitive absorption, leading to lower anxiety levels (Hou et al., 2023; Kwon et al., 2023).

In contrast, conventional verbal education, while beneficial, often suffers from limitations, such as time constraints, information overload, and passive patient engagement (Deniz Doğan et al., 2024; Ewees et al., 2025). Patients may not fully retain information when explanations are brief or delivered under stressful conditions before surgery. Although anxiety levels decreased in both groups, the between-group comparison demonstrated a statistically significant difference favoring the AI-based intervention.

Another possible explanation is that AI-based education promotes continuous learning and repetition, allowing patients to revisit information at their own pace. According to Zhuo et al (2023), repeated exposure

to structured educational material reinforces cognitive processing and confidence in medical understanding, which in turn reduces anxiety. Additionally, the accessibility of AI tools through smartphones or messaging platforms ensures that educational support is available anytime and anywhere, a key advantage in modern patient-centered care (Alzayyat et al., 2024; Liu et al., 2021; Trenggono & Bachtiar, 2023).

From a nursing perspective, integrating AI-based educational systems into preoperative care aligns with the principles of holistic nursing, addressing not only physical preparation, but also psychological comfort and emotional resilience. This approach enhances the nurse's role as an educator and advocate for patient well-being (Ewees et al., 2025; Oliveira et al., 2024). Furthermore, digital interventions have been recognized for their cost-effectiveness, scalability, and ability to standardize information delivery across healthcare settings (Liu et al., 2021; Zhang et al., 2025).

In summary, the findings reaffirm that AI-assisted preoperative education is a valuable innovation in nursing practice, capable of enhancing patient understanding, reducing anxiety, and improving the quality of surgical preparation. By combining human empathy with intelligent digital tools, nurses can deliver more personalized, accessible, and effective preoperative care that aligns with evolving healthcare technologies and patient needs.

Conclusion

This study concludes that AI-based preoperative education, delivered through the Meta AI platform, is significantly more effective in reducing preoperative anxiety among patients undergoing nephrolithotomy compared with conventional verbal education. The results highlight that interactive, technology-driven education enhances patients' understanding, strengthens psychological preparedness, and promotes emotional stability before surgery.

The outcomes of this research reinforce the growing evidence that digital and AI-assisted interventions can improve patient engagement, reduce uncertainty, and empower individuals to take an active role in their care. Similar findings have been reported in other contexts where technology-enhanced education increased self-efficacy, lowered anxiety, and improved satisfaction with healthcare services (Martinez-Ortigosa et al., 2023). Furthermore, the integration of AI in nursing practice aligns with global healthcare transformations emphasizing patient-centered digital literacy and smart health communication systems (Ramírez-Baraldes et al., 2025).

Incorporating AI-based learning tools into preoperative nursing care can optimize educational delivery, particularly in settings with limited staff resources. It offers an opportunity to personalize patient education while ensuring accessibility and consistency. These advantages contribute to improving the quality of perioperative nursing services and may indirectly enhance recovery outcomes (Shahrezaei et al., 2024).

Future studies should include larger, multi-center designs to examine the long-term impact of AI-based education on recovery, emotional resilience, and patient satisfaction. Collaboration among nurses, data scientists, and behavioral experts is essential to develop AI tools that are empathetic and culturally appropriate. Integrating AI into nursing practice marks a significant step forward, re-defining nurses' roles as educators, supporters, and providers of compassionate, technology-enhanced care.

Implications for Nursing

The findings of this study have important implications for nursing practice, particularly in enhancing preoperative patient education through technology. The demonstrated effectiveness of AI-based education using Meta AI suggests that nurses can integrate digital tools to provide interactive, personalized, and accessible learning experiences that reduce anxiety and improve surgical preparedness. Incorporating AI into nursing not only supports patient-centered care, but also expands the nurse's role as an educator and innovator in the digital era. To ensure safe and ethical implementation, nursing education should emphasize digital literacy, data privacy, and responsible AI use, while healthcare institutions must develop supportive policies and infrastructure for technology-based interventions.

Limitations

This study has several limitations. The sample size was relatively small and drawn from a single healthcare facility, which may limit the generalizability of the findings. Anxiety levels were measured only at two time points, without long-term follow-up to assess sustained

effects. In addition, the quasi-experimental design without randomization may have introduced selection bias. Another limitation is that physiological indicators of anxiety, such as heart rate, blood pressure, and cortisol levels, were not measured, despite their relevance to preoperative stress. Future studies should incorporate both psychological and physiological measures to provide a more comprehensive assessment of anxiety reduction.

Conflict of Interests

The authors have no conflict of interests to declare.

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Author Contributions

Study Design: **CF, SY**. Data Collection: **CF**. Data Analysis: **CF, SY**. Study Supervision: **SY, DCR, RW**. Manuscript Writing: **DCR**. Critical Revision for Important Intellectual Content: **SY**.

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