Original Article

Effectiveness of a Nature-Based Virtual Reality Intervention on Preoperative Anxiety among First-Time Major Surgery Patients: A Quasi-Experimental Study

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ARTICLE INFO

Article History

Submit : December 28, 2025
Accepted : March 18, 2026
Published : March 21, 2026

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Citation:

Farama, D. A. ., Gani, A. ., & Wibowo, W. D. A. . (2026). Effectiveness of a Nature-Based Virtual Reality Intervention on Preoperative Anxiety among First-Time Major Surgery Patients: A Quasi-Experimental Study: Efektivitas Terapi Virtual Reality Berbasis Alam dalam Menurunkan Kecemasan Preoperatif pada Pasien Operasi Besar di Rumah Sakit Lahat. Journal of Applied Nursing and Health, 8(1), 424–437. https://doi.org/10.55018/janh.v8i1.535

ABSTRACT

Background: Major surgery is frequently associated with high levels of preoperative anxiety, which can negatively affect physiological stability and postoperative recovery. Despite evidence supporting the effectiveness of nature-based virtual reality (VR) therapy in reducing anxiety in high-income settings, its applicability in low- and middle-income countries (LMICs), particularly district hospitals, remains unclear. This study aimed to evaluate the effectiveness of nature-based VR therapy in reducing preoperative anxiety among first-time major surgery patients.

Methods: This study employed a quasi-experimental pre-test–post-test control group design, reported in accordance with the TREND guideline. A total of 104 adult patients scheduled for first-time elective major surgery were recruited using consecutive sampling and equally allocated to an intervention group (n=52) and a control group (n=52). The independent variable was nature-based VR therapy, and the dependent variable was preoperative anxiety. Anxiety was measured using the State Anxiety subscale of the State–Trait Anxiety Inventory (STAI), a validated instrument with good reliability (Cronbach's α = 0.83). The intervention group received a single 5-minute nature-based VR session 20–30 minutes before surgery, while the control group received standard preoperative care. Data were analyzed using paired and independent t-tests, and effect size was calculated using Cohen's d.

Results: Participants were predominantly aged 46–60 years (39.4%), equally male and female, mostly classified as ASA II (69.2%), and commonly scheduled for abdominal surgery (40.4%). The intervention group showed a significant anxiety reduction (mean difference = −16.10; $p < 0.001$; Cohen's d = 1.98), whereas the control group showed no significant change (−2.38; $p = 0.062$). Post-intervention anxiety scores were significantly lower in the VR group than in the control group ($t = 9.074$; $p < 0.001$; Cohen's d = 1.78).

Conclusion: Nature-based VR therapy is an effective, nurse-led, non-pharmacological intervention for reducing preoperative anxiety in first-time major surgery patients. Integration of VR into routine preoperative nursing care may enhance patient-centered care and support anxiety management in resource-limited hospital settings.

Keywords: Preoperative Anxiety; Complementary Therapies; Nature-based virtual reality; Perioperative Nursing

Implications for Practice:

- Nature-based virtual reality (VR) therapy can be applied as a brief, nurse-led non-pharmacological intervention in preoperative care to reduce patient anxiety, improve comfort, and enhance psychological readiness

Implications for Practice:

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for major surgery, particularly in resource-limited hospital settings.

- Nurses and perioperative teams can integrate VR therapy into routine preoperative protocols for first-time major surgery patients with high anxiety to promote relaxation and support better perioperative outcomes.
- Hospitals and health authorities can incorporate affordable and reusable VR technology into perioperative care guidelines as part of digital health innovation, offering a scalable and cost-effective strategy for improving perioperative mental health in low- and middle-income and resource-constrained healthcare settings.

Introduction

Major surgery refers to procedures requiring general anesthesia, involving entry into major body cavities, carrying a risk of severe hemorrhage, or placing the patient's life at risk (Martin et al., 2020; Newsome et al., 2021). Globally, major surgical procedures represent a substantial component of healthcare services, with an estimated 310 million major surgeries performed annually, including approximately 40–50 million cases in the United States and 20 million in Europe (Dobson, 2020). Despite this high surgical volume in high-income countries, perioperative psychological problems such as preoperative anxiety remain under-recognized, particularly in low- and middle-income countries (LMICs) (Martini et al., 2024). This high surgical volume underscores the importance of addressing perioperative factors that may influence patient safety and outcomes worldwide (Martin et al. 2020).

One of the most prominent problems experienced by patients undergoing major surgery is preoperative anxiety. Preoperative anxiety affects 60–80% of surgical patients and is recognized as a significant psychological response before surgery. This condition represents a maladaptive psychological response to surgical stressors, and is clinically important because anxiety before surgery has been associated with adverse physiological and psychological outcomes that may compromise surgical success and recovery (Shebl et al. 2025).

In Indonesia, surgical procedures rank 11th among 50 disease management interventions. In 2020, the number of surgical procedures in Indonesia reached approximately 1.2 million cases, showing an increasing trend each year, with more than 800,000 procedures performed annually. In terms of gender distribution, surgical procedures were more common among females, accounting for 50.15%, compared to males at 30.5%, while pediatric surgeries represented approximately 10–15% of the total cases (Maulina, Susilowati, and Diel 2023). These data illustrate a growing surgical burden in an LMIC context, where non-pharmacological perioperative interventions remain limited.

Data from Lahat Hospital (RSUD Lahat) further demonstrate this increasing trend. Medical record data over the past three years showed that major surgical cases increased from 622 patients in 2022 to 690 patients in 2023, and 768 patients in 2024 (RSUD LAHAT 2025). This steady rise highlights an expanding population of patients at risk of preoperative anxiety within a district hospital setting.

Preoperative anxiety has been shown to negatively affect surgical outcomes, including increased anesthetic requirements, hemodynamic instability, higher postoperative pain levels, delayed wound healing, prolonged hospital stays, and slower recovery (Shebl et al. 2025). Contributing factors include age, gender, educational level, marital status, type of anesthesia, type of surgery, and previous surgical experience (Adhikari et al. 2023).

Several studies have reported that virtual reality therapy, such as natural-

based virtual reality, can reduce preoperative anxiety by creating a calm and comfortable environment (Putri et al.,2020; Yang et al., 2019). Virtual reality (VR) therapy extends these approaches by providing immersive, interactive, and multisensory experiences**,** enabling users to engage deeply with simulated environments (Karujan et al., 2023). Previous studies have demonstrated the effectiveness of VR therapy in reducing anxiety and pain (Bouchard et al., 2018; Buyuk et al, 2021; Dehghan et al., 2019; Jung et al., 2021; Yulianti et al., 2021).

A randomized clinical trial by Chiu et al., (2023) showed that adults receiving immersive 360° VR experiences before elective surgery experienced significantly lower anxiety levels. Similarly, Suleiman-Martos et al., (2022) reported consistent findings supporting nature-based virtual reality, particularly those using calming, nature-based environments. Short-duration VR therapy sessions (approximately 5 minutes) have also been effective in reducing anxiety in pediatric surgical populations (Buyuk et al., 2021; Dehghan et al. 2019; Jung et al. 2021).

Despite increasing interest in virtual reality therapy, evidence in adult populations remains limited, as most existing studies predominantly focus on children and adolescents (Trueba et al. 2024). Applications of VR therapy among adults such as for anxiety, depression, or chronic pain are still underrepresented, with few large randomized controlled trials and mainly small pilot studies or case reports, particularly in low-and middle-income countries (LMICs) (Felnhofer et al. 2025). Most existing evidence originates from high-income settings or pediatric samples, leaving uncertainty regarding effectiveness in adult patients within district hospitals in LMICs.The feasibility of implementing virtual reality therapy in LMIC settings is not well understood due to high equipment costs, limited infrastructure, and varying levels of technological familiarity (McDaniel et al. 2025).

Guided by Roy's Adaptation Model, which conceptualizes individuals as adaptive systems responding to environmental stimuli, this study frames preoperative anxiety as a maladaptive response to surgical stressors. Nature-based virtual reality therapy is positioned as the independent variable and functions as a focal stimulus, while preoperative anxiety is the dependent variable reflecting adaptive outcomes. Exposure to calming virtual environments supports adaptive responses and psychological stability, consistent with Roy's theoretical framework (Browning Callis 2020; PPNI 2018).

This study provides an important international contribution by addressing the limited evidence on the feasibility and effectiveness of nature-based virtual reality therapy for reducing preoperative anxiety among adult patients in district hospitals within low-and middle-income countries (LMICs). most previous VR therapy studies conducted in high-income settings or pediatric populations, this research evaluates a brief, nurse-led, non-pharmacological virtual reality therapy in a real-world, resource-limited hospital context, grounded in Roy's Adaptation Model. This study aimed to evaluate the effectiveness of nature-based virtual reality therapy in reducing preoperative anxiety among patients undergoing major surgery at Lahat Hospital.By examining whether nature-based virtual reality therapy can function as an adaptive stimulus to reduce maladaptive anxiety responses before major surgery, this study extends existing theoretical and empirical evidence and offers practical insights into the potential integration of affordable digital

therapeutics into routine perioperative nursing care in LMIC settings.

Methods

Study Design

A quasi-experimental pre-test–post-test control group design was selected due to ethical and practical constraints in the district hospital setting, where randomization was not feasible without disrupting routine perioperative care. The study was conducted in accordance with the TREND guidelines for nonrandomized designs. Selection bias was minimized through consecutive recruitment using identical eligibility criteria and the same preoperative assessment period for both groups. Measurement bias was reduced by employing a standardized and validated anxiety instrument administered at consistent time points (Sugiyono 2016).

Participants

The study was conducted at Lahat Regional General Hospital (RSUD Lahat), Indonesia, from January to August 2025. The study population consisted of all patients scheduled to undergo major surgery during the study period. Participants were recruited using consecutive sampling, whereby all eligible patients meeting the inclusion criteria during the study period were invited to participate until the required sample size was achieved.

Sample size calculation for two-group research (nature-based VR therapy intervention vs. control) used the standard formula for comparing two independent means with 80% power and a two-sided α of 0.05, based on effect size estimates from previous research (β = −5.46; pooled SD = 9.5) (Chiu et al., 2023). The calculation yielded 47 participants per group (total n = 94). After adjusting for an anticipated dropout rate of 10–20%, a total of 104 participants were required and successfully recruited (52 per group). No participant dropouts occurred during the study period.

The inclusion criteria were patients aged ≥18 years, scheduled for their first elective major surgery, able to communicate effectively, conscious, and willing to participate. Exclusion criteria included patients with cognitive impairment, severe visual or hearing disorders, a history of epilepsy or motion sickness related to VR use, those receiving sedative premedication before anxiety assessment, and patients who refused to participate. A recruitment flow describing eligibility assessment, group allocation, and analysis inclusion is provided in Figure

Participants were assigned to either the nature-based virtual reality therapy group or the control group using a quasi-experimental allocation method based on the hospital admission schedule, ensuring comparable baseline characteristics between groups (TREND item: allocation method). Blinding of participants was not feasible due to the nature of the virtual reality therapy; however, outcome assessors were blinded to group assignment to minimize measurement bias (TREND item: blinding). To ensure intervention fidelity, all VR therapy sessions were delivered according to a standardized protocol. Each participant in the intervention group received an immersive nature experience using identical VR therapy content and headset, guided by trained nursing staff who monitored adherence and engagement. All sessions were documented in structured logs, including start and end times, participant responses, and any adverse events.

Instruments

Preoperative anxiety was measured using the State–Trait Anxiety Inventory (STAI), specifically the State Anxiety Scale (S-Anxiety). The STAI consists of 20 item**s** scored on a 4-point Likert scale, with total

scores ranging from 20 to 80, where higher scores indicate greater anxiety. Scores were categorized as mild (20–39), moderate (40–59), and severe anxiety (60–80) (Pratiwi & Ningsi, 2022). The STAI has demonstrated strong psychometric properties and has been validated in an Indonesian adult surgical patient population comparable to the participants in this study, with a reported Cronbach's alpha of 0.83, indicating good internal consistency.

Intervention

The nature-based virtual reality therapy intervention used a smartphone-based VR Box system, which is feasible for use in resource-limited clinical settings. The hardware consisted of a lightweight VR Box headset with adjustable lenses and head straps, paired with an Android smartphone (minimum Full HD resolution 1920 × 1080 pixels) equipped with gyroscope and accelerometer sensors to enable head-motion tracking. Audio output was delivered via standard earphones, providing immersive audiovisual stimulation ((Yudhanto & Sulistiawan, 2022). The software used was Underwater Adventure VR (WolfHowlGames), a free application available on the Google Play Store, presenting a calming underwater natural environment designed for passive visual exploration and relaxation.

A standard operating procedure (SOP) was applied uniformly across sessions, including participant briefing, proper positioning, headset adjustment, delivery of a single 5-minute nature-based virtual reality therapy session 20–30 minutes before surgery, and continuous monitoring for discomfort. A single 5-minute nature-based virtual reality therapy session delivered 20–30 minutes before surgery was selected to balance efficacy, safety, and feasibility in the perioperative setting. Evidence suggests that brief VR therapy (3–5 minutes) is sufficient to induce relaxation and reduce anxiety (Buyuk et al., 2021; Dehghan et al. 2019; Jung et al. 2021). Nature-based content, such as forest or beach environments, promotes parasympathetic activation through calming visual and auditory stimuli without causing cognitive overload. The timing of 20–30 minutes preoperatively was chosen to coincide with the peak anxiolytic effect of VR and to integrate smoothly into routine preoperative workflows, allowing physiological stabilization before anesthesia induction without disrupting standard surgical preparations (Felnhofer et al. 2025; Trueba et al. 2024).

Participants in the control group received standard preoperative care routinely provided at the hospital, which included preoperative nursing assessment, vital signs monitoring, verification of surgical consent, patient education regarding the surgical procedure and anesthesia, psychological support through routine therapeutic communication, and administration of prescribed preoperative medications as indicated. Intervention fidelity was ensured using a fidelity checklist documenting adherence to session duration, timing, content, and equipment setup. The intervention was administered by trained perioperative nurses who received instruction on the operation of the nature-based virtual reality therapy device, SOP adherence, and patient safety monitoring.

Data Collection

Data collection was conducted by trained nurse enumerators who received standardized training on STAI administration and data recording procedures. Baseline anxiety levels (pre-test) were assessed before the intervention, and post-test anxiety levels were measured immediately after the nature-based virtual reality therapy session or standard preoperative care for the control group.

Outcome assessors were not blinded to group allocation due to the nature of the intervention; however, measurement bias was minimized by using a standardized and validated instrument, consistent assessment procedures, and uniform timing of data collection across both groups. No missing data were identified; therefore, no imputation methods were required. The data collection workflow is illustrated in **Figure 1.**

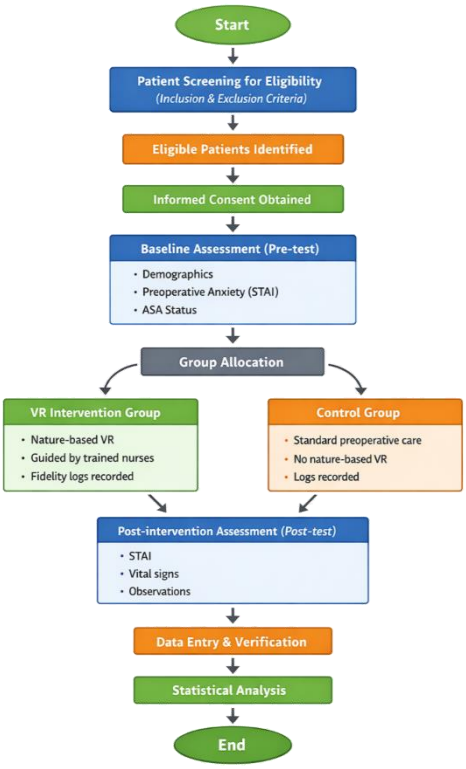

Figure 1. Workflow Data Collection

Procedure

Data Analysis

Data were analyzed using SPSS software. Descriptive statistics were used to summarize demographic and clinical characteristics. Normality of anxiety scores was assessed using the Shapiro–Wilk test before inferential analysis. Paired t-tests were used to compare pre- and post-test anxiety scores within groups, while independent t-tests compared post-test scores between groups. Effect size was calculated using Cohen's d, with interpretation based on standard criteria (small = 0.2, medium = 0.5, large = 0.8), calculated using the Social Science Statistics effect size calculator (Social Science Statistics, 2016).

Ethical Considerations

This study received ethical approval from the Health Research Ethics Committee of the Palembang Health Polytechnic, Ministry of Health, Indonesia (Ethics Approval No. 0761/KEPK/Adm2/V/2024). All procedures were conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants, and confidentiality and anonymity were strictly maintained.

Results

Table 1. Demographic and Clinical Characteristics of Participants (N = 104)

Characteristics	Intervention Group nature-based virtual reality therapy (n=52)	Control Group (n=52)	Total (N=104)
Age Group (Years)			
18 – 30 years	10 (19.2%)	11 (21.2%)	21 (20.2%)
31 – 45 years	15 (28.8%)	14 (26.9%)	29 (27.9%)
46 – 60 years	20 (38.5%)	21 (40.4%)	41 (39.4%)
> 60 years	7 (13.5%)	6 (11.5%)	13 (12.5%)
Gender			
Male	26 (50.0%)	26 (50.0%)	52 (50.0%)

Characteristics	Intervention Group nature-based virtual reality therapy (n=52)	Control Group (n=52)	Total (N=104)
Female	26 (50.0%)	26 (50.0%)	52 (50.0%)
Education Level			
Primary/Middle School	10 (19.2%)	12 (23.1%)	22 (21.2%)
High School	30 (57.7%)	28 (53.8%)	58 (55.8%)
Higher Education	12 (23.1%)	12 (23.1%)	24 (23.1%)
Type of Major Surgery			
Digestive/Abdominal	22 (42.3%)	20 (38.5%)	42 (40.4%)
Orthopedic	15 (28.8%)	16 (30.8%)	31 (29.8%)
Obstetric & Gynecology	10 (19.2%)	11 (21.1%)	21 (20.2%)
Oncology/Others	5 (9.6%)	5 (9.6%)	10 (9.6%)
ASA Physical Status			
ASA I (Healthy)	11 (21.2%)	11 (21.2%)	22 (21.2%)
ASA II (Mild Systemic Disease)	36 (69.2%)	36 (69.2%)	72 (69.2%)
ASA III (Severe Systemic Disease)	5 (9.6%)	5 (9.6%)	10 (9.6%)

Table 1 summarizes the demographic and clinical characteristics of the study population using frequency and percentage distributions. The age distribution indicated that the largest proportion of participants was in the 46–60 years age group (39.4%, n = 41), followed by those aged 31–45 years. Gender distribution was balanced, with 52 males (50%) and 52 females (50%), and no significant difference between the intervention and control groups. In terms of educational background, the majority of participants had completed secondary education (high school), accounting for 55.8% (n = 58), while 23.1% (n = 24) had attained higher education, and the remainder had primary education.

Regarding clinical characteristics, the most frequently scheduled type of major surgery was digestive or abdominal surgery (40.4%, n = 42), followed by orthopedic surgery (29.8%, n = 31). Based on the American Society of Anesthesiologists (ASA) physical status classification, most participants were classified as ASA II (69.2%, n = 72), indicating mild systemic disease. In comparison, ASA I accounted for 21.2% (n = 22) and ASA III for 9.6% (n = 10) of the sample.

Table 2. Normality Test of Anxiety Scores (Shapiro–Wilk)

Variable	Group	p-value	Distribution
Pre-test anxiety	Intervention	0.186	Normal
Post-test anxiety	Intervention	0.092	Normal
Pre-test anxiety	Control	0.121	Normal
Post-test anxiety	Control	0.078	Normal
**Shapiro–Wilk*			

Table 2 presents normality testing using the Shapiro–Wilk test showed that pre-test and post-test anxiety scores in both the intervention and control groups were normally distributed (p > 0.05 for all variables)

Table 3. Comparison of STAI Anxiety Scores Pre- and Post-Intervention (N = 104)

Group	Pre-test (Mean ± SD)	Pre-test Range	Post-test (Mean ± SD)	Post-test Range	Mean Difference (Δ)	*p-value
Intervention (n=52)	54.25 ± 7.82	42 – 72	38.15 ± 6.45	24 – 52	-16.1	0.001
Control (n=52)	53.80 ± 8.10	40 – 74	51.42 ± 8.35	38 – 70	-2.38	0.062

** Paired T-test*

Table 3 showed that the baseline analysis showed that participants in both groups experienced moderate to high levels of preoperative anxiety. The mean STAI score in the intervention group was 54.25 ± 7.82, while the control group had a mean score of 53.80 ± 8.10, indicating comparable anxiety levels before intervention.

Following the implementation of nature-based VR therapy, the intervention group demonstrated a significant reduction in anxiety scores, with the mean STAI score decreasing from 54.25 ± 7.82 to 38.15 ± 6.94, representing a mean reduction of 16.10 points. Paired t-test analysis revealed a statistically significant difference ($p < 0.001$). The magnitude of the intervention effect was large, with a Cohen's d value of 2.10, indicating a strong clinical impact of VR therapy on reducing preoperative anxiety.

In contrast, the control group showed only a slight decrease in mean anxiety scores, from 53.80 ± 8.10 to 51.42 ± 7.95, which was not statistically significant ($p = 0.062$). This finding suggests that standard preoperative care alone was insufficient to reduce anxiety levels among patients undergoing major surgery meaningfully.

Table 4. Analysis of Mean Differences in Post-intervention Anxiety Levels

Group	Mean Score	SD	t-value	df	p-value
Intervention	38.15	6.45	9.074	102	0.001
Control (Standard)	51.42	8.35			

** Independent T-test*

A comparison of post-test anxiety scores between groups was performed using an independent t-test to determine differences in preoperative anxiety levels following the intervention. As shown in **Table 4,** the intervention group reported a significantly lower mean anxiety score (M = 38.15, SD = 6.45) compared to the control group (M = 51.42, SD = 8.35).

The statistical analysis yielded a t-value of 9.074 with 102 degrees of freedom, resulting in a p-value of < 0.001, which is well below the established alpha level of 0.05. The magnitude of the between-group difference was large, with a Cohen's d of 1.78, indicating a strong intervention effect.

These findings provide robust evidence that nature-based virtual reality therapy is significantly more effective than standard preoperative care in reducing preoperative anxiety among first-time major surgery patients at RSUD Lahat.

Tabel 5. Item-Level Changes of STAI-State Scores In The Intervention Group

Item	Statement (Abbreviated)	Anxiety Domain	Pre-test Mean ± SD	Post-test Mean ± SD	Mean Change (Δ)
2	I feel nervous and restless	Affective	3.32 ± 0.61	2.05 ± 0.58	−1.27
7*	I feel calm and in control	Affective	3.05 ± 0.69	1.88 ± 0.55	−1.17
11	I have disturbing thoughts	Cognitive	3.18 ± 0.64	2.01 ± 0.60	−1.17
17	Unimportant thoughts bother me	Cognitive	3.10 ± 0.67	2.00 ± 0.59	−1.10
20	I feel tense or overwhelmed	Somatic	3.40 ± 0.59	2.20 ± 0.63	−1.20

**Reversed Score*

Table 5 presents the STAI-State items that demonstrated the largest changes following the nature-based virtual reality (VR) intervention in the intervention group. The table focuses on representative items that capture key dimensions of preoperative anxiety, including affective, cognitive, and somatic components.

Items related to affective anxiety, such as feeling nervous and restless (Item 2), showed the greatest reduction, indicating that the virtual reality therapy effectively reduced emotional tension before surgery. The reverse-scored item assessing calmness and self-control (Item 7) also demonstrated a substantial decrease in score, reflecting improved emotional regulation after exposure to the calming virtual environment.

Several cognitive anxiety items, including intrusive or disturbing thoughts (Item 11) and excessive concern over unimportant matters (Item 17), exhibited marked reductions. This suggests that nature-based VR helped redirect attention away from ruminative thoughts and reduced cognitive preoccupation with surgical stressors. In addition, the somatic anxiety item reflecting feelings of tension or being overwhelmed (Item 20) showed a notable decrease, indicating improved physiological relaxation following the intervention.

Discussion

The predominance of participants in the 46–60 years age group (39.4%) reflects the epidemiology of major surgery at RSUD Lahat, where chronic comorbidities often necessitate elective procedures in middle-aged adults. This age distribution is consistent with surgical trends in other low- and middle-income countries (LMICs), where the burden of surgical disease peaks during the most productive years of life (Chan et al. 2021; Xing et al., 2025). While younger cohorts (18–30 years) showed lower representation, they are often perceived to have greater technological familiarity, which may influence their receptivity to VR. In the context of a district hospital, where patients often have varying levels of digital literacy, the high acceptance of VR across all age groups in this study suggests that nature-based content is intuitive and culturally accessible (Maulina et al. 2023). Furthermore, the uniformity in ASA II status (69.2%) ensured that extreme variations in physical health or surgical risk did not confound the observed reduction in anxiety.

The significant reduction in preoperative anxiety in the VR group Mean difference = -16.1, and p value < 0.001 compared to the control group Mean difference = -2.38 and p value > 0.062 supports the efficacy of immersive distraction. While this study did not directly

measure biomarkers, the observed psychological improvement likely aligns with Kaplan's (1995) Attention Restoration Theory (ART) (Shebl et al. n.d.). Nature-based immersion—featuring forests and waterfalls—provides "soft fascination," which helps replenish the cognitive resources depleted by the stress of an impending surgery. This is particularly relevant in the noisy and crowded environments of public district hospitals in Indonesia, where patients are frequently exposed to high-decibel clinical triggers (Suleiman-Martos et al., 2022), by replacing the stressful hospital atmosphere with a peaceful virtual world, VR serves as a "sensory shield" that prevents the environment from overstimulating the patient's stress response (Falguière et al. 2021).

Previous literature has suggested that immersive experiences may influence neurophysiological pathways, such as heart rate variability and cortisol regulation; however, in the absence of direct biological measurements in this study, the primary mechanism of action is interpreted through the psychological construct of "Presence" (Li et al. 2025). The 360° nature immersion effectively engages the visual and auditory senses, consuming limited cognitive capacity and redirecting attention away from ruminative fears of anesthesia or surgical outcomes (Ma et al. 2025). This multisensory engagement is especially beneficial in LMIC settings like Lahat, where pharmacological anxiolytics may be costly or associated with side effects that prolong postoperative recovery (Shebl et al. 2025)

The large effect size (Cohen's d = 1.78) observed in this study confirms that nature-based VR is a robust intervention for first-time major surgery patients. These findings are consistent with Ma et al. (2025) and Chan et al. (2024), who reported that nature-based VR content consistently outperforms urban or educational scenarios in reducing anxiety. Our study extends this evidence to the Indonesian district hospital context, demonstrating that even with limited resources, high-tech non-pharmacological interventions are feasible and effective.

Guided by Roy's Adaptation Model, the virtual reality therapy functioned as an effective focal stimulus that supported the patient's adaptation process. By mitigating the "maladaptive" response of high preoperative anxiety (Tulsa 2023), VR enabled patients to achieve a more stable psychological state before anesthesia induction (Jung et al. 2021). Ultimately, this study provides a practical blueprint for integrating nurse-led digital therapeutics into standard preoperative care in regional hospitals, addressing a critical gap in patient-centered psychological support within the LMIC healthcare framework.

Implications and limitations

This study advances perioperative nursing science by providing empirical support for Roy's Adaptation Model in the acute preoperative context at RSUD Lahat. The findings indicate that nature-based virtual reality therapy functions as an effective focal stimulus that activates both regulator and cognator subsystems, helping reduce anxiety among patients undergoing their first major surgery. Conceptually, the study challenges the assumption that advanced digital therapeutics are limited to tertiary urban hospitals by demonstrating that virtual reality interventions can be feasibly implemented in a district hospital setting with patients who have moderate technological familiarity. These results support the integration of scalable, non-pharmacological anxiety management approaches into routine preoperative nursing protocols, particularly in resource-limited settings. However, several limitations should be considered. The quasi-experimental, non-randomized design may

introduce selection bias and limit the comparability between groups. The single-center setting at RSUD Lahat restricts the generalizability of the findings to other healthcare facilities and regions. In addition, the sample was limited to adult patients undergoing elective major surgery with ASA I–III status, which limits applicability to emergency procedures, pediatric populations, or patients with higher anesthetic risk. Finally, anxiety assessment relied on the State-Trait Anxiety Inventory (STAI) self-report scale without objective physiological measurements that might provide a more comprehensive evaluation of the relaxation response.

Relevance to Practice

This study demonstrates that nature-based virtual reality can be feasibly integrated into routine preoperative care at RSUD Lahat as a non-pharmacological strategy to reduce anxiety in patients undergoing major surgery for the first time. For effective clinical implementation, nurses can apply a structured approach by prioritizing patients with high preoperative anxiety, providing a 15–20 minute VR session one day before surgery in a quiet environment, and maintaining strict hygiene procedures such as using disposable eye covers and disinfecting the headset after each use. These findings highlight the practical role of nurse-led virtual reality therapy and support its inclusion in standard preoperative nursing checklists to ensure consistent and safe care. From an institutional perspective, hospital administrators may consider VR technology as an affordable and reusable tool that supports cost-efficient care without increasing pharmacological burden or clinical complexity, while providing basic technical training for nursing staff to facilitate adoption. More broadly, these results offer practice-based evidence to support hospital-level implementation and inform perioperative care policies within digital health transformation initiatives, particularly in resource-limited healthcare settings.

Conclusion

This study demonstrates that nature-based virtual reality therapy is effective in reducing preoperative anxiety among patients undergoing major surgery at RSUD Lahat, showing better outcomes than standard care by helping patients transition from higher to lower anxiety levels through multisensory relaxation experiences. Future research should conduct multicenter randomized controlled trials across different hospital levels in Indonesia to improve the generalizability of these findings. In addition, incorporating objective physiological indicators such as heart rate variability and salivary cortisol would strengthen the biobehavioral evaluation of the intervention. Further studies are also needed to examine the cost-effectiveness of virtual reality therapy and its long-term impact on postoperative outcomes, including pain intensity and length of hospital stay.

Funding

This study was financially supported by the Ministry of Health of the Republic of Indonesia.

CrediT Authorship Contributions Statement

Dodi Aflika Farama: Conceptualization, Methodology, Supervision, Writing – Original Draft, Project Administration.

A. Gani: Investigation, Resources, Data Curation, Project Administration.

Wahyu Dwi Ari Wibowo: Software, Validation, Formal Analysis, Writing – Review & Editing.

Conflicts of Interest

There is no conflict of interest.

Acknowledgments

The authors would like to express their sincere appreciation to the management and nursing staff operating room teams at Lahat Hospital for their cooperation and support during the implementation of this study, particularly in facilitating access to patients and research settings.

Supplementary Materials

Supplementary File S1: Research Instrument contains the full questionnaire used for data collection.

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