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Development and implementation of VR-simulated experiences to train communication skills

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Effects of a bundle of non-pharmacological interventions on preoperative anxiety: a mixed methods study

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ABSTRACT

Introduction

Preoperative anxiety may lead to a physical and emotional stress response, negatively impacting anesthesia, surgical outcomes, postoperative care and the rehabilitation process. Reducing preoperative anxiety is crucial to improving patient care. The aim of this study was to assess the impact of a bundle of non-pharmacological interventions on preoperative anxiety in a tertiary hospital.

Methods

Using a participatory action research approach, we employed a convergent mixed-method design that combined qualitative and quantitative data. The interventions included virtual reality or music intervention for patients and a therapeutic communication skills training for healthcare professionals in the preoperative area. Data collection involved interviews, focus groups, and rating scales to evaluate the context and effectiveness of these interventions.

Results

In total, 200 patients and 15 healthcare professionals participated in this study. Quantitative data obtained before and after implementation did not show a significant improvement in satisfaction, anxiety or comfort scores. Qualitative data showed that the implemented interventions positively affected the work environment and patient experience. The interventions were experienced as useful and pleasant by patients and healthcare professionals.

Discussion

Our study revealed a discrepancy between quantitative and qualitative findings, highlighting the value of a mixed-methods approach. While quantitative data showed no significant changes, qualitative insights emphasized the impact of therapeutic communication, virtual reality, and music intervention on patient comfort. This underscores the need for triangulation to fully understand patient-centered care, enhancing preoperative interactions and reducing anxiety. Our findings suggest that adding non-pharmacological interventions may foster a more holistic and supportive preoperative experience, benefiting both patients and healthcare professionals.

INTRODUCTION

Preoperative anxiety describes a state of uneasiness or tension that is secondary to patient worries regarding disease, hospitalization, anesthesia, surgery and the unknown. As for surgery, it is independent of the type and severity of the surgery, and prevalence is estimated between 11 and 80% of all adults undergoing elective surgery (1). Large studies suggest it to be the worst aspect of the perioperative experience (2, 3).

Anxiety prior to surgery is undesirable and can have significant negative implications for patient outcomes. It is associated with a greater risk of complications during anesthetic induction, an increased demand for sedatives and analgesics and lower patient satisfaction scores. These consequences underscore the need for effective interventions. Modern medicine advocates patient-centered care, which is highly important for patient-reported outcome measures such as satisfaction and comfort (4).

Anxiolytic drugs may be used to reduce preoperative anxiety but may cause side effects that limit their routine use (5). Conversely, non-pharmacological interventions can reduce preoperative anxiety and can influence postoperative outcomes (7).

Among the non-pharmacological modalities, therapeutic communication (TC) has emerged as an important intervention (7-9). The primary aim of TC is to alleviate anxiety and enhance comfort. Many studies have evaluated the effectiveness of this type of communication, which has also been called positive language, comfort talk or hypnotic language (7, 10). TC combines verbal and non-verbal techniques such as suggestive language, reframing, and mirroring; while recognizing the impact of contextual factors within a holistic framework. These include physical, psychological, and social aspects that influence the perioperative experience (10). For instance, personalized attention given by a healthcare professional can exert a positive influence on a patient.

In our study, TC training including a patient-embodied Virtual Reality (VR) experience was offered to all healthcare providers (HCPs). In this experience, an HCP could experience what it is like to become a patient, learning the importance of contextual factors (11). We previously demonstrated that experiential learning is useful for TC skills (12,13).

An additional non-pharmacological avenue to decrease anxiety involves the use of music medicine (14,15). The anxiolytic effect of prerecorded music is commonly attributed to its ability to divert attention from stressors, and to induce an aesthetic experience fostering autonomous and central nervous system responses to enhance psychological well-being (16,17).

A final promising non-pharmacological intervention involves patient use of VR. By using a head-mounted device, VR immerses users in alternative worlds by generating realistic sensory experiences. Several studies have found VR to be an effective tool to alleviate pain and anxiety (3,18,19).

Although the prevalence and negative effects of preoperative anxiety have been established, advancements in preoperative management are lacking. The current study aimed to optimize the implementation process and assess the impact of a bundle of non-pharmacological interventions on preoperative anxiety and patient satisfaction. We hypothesized that the combination of different non-pharmacological interventions could work synergistically, thereby improving patient comfort in the preoperative setting. Furthermore, we anticipated that this holistic interventional approach would positively affect patient-reported outcomes, particularly in terms of self-reported satisfaction and comfort levels.

We assumed the 'intervention' participants would have a better patient experience due to intervention 1 (TC training for healthcare professionals). This experience would be more improved in the concomitant use of another intervention (2 or 3).

MATERIALS AND METHODS

This exploratory research was carried out at the Leiden University Medical Center (LUMC, Leiden, the Netherlands), a large tertiary academic hospital. The protocol was approved by the Institutional Science Committee and received a waiver to be performed by the Institutional Review Board (Medical Research Ethics Committee, METC Leiden the Hague Delft, Leiden, the Netherlands) and adhered to local regulations. Personal data protection and consent from the research participants were obtained prior to data collection. The data were collected and recorded between December 2021 and May 2022. Patients were contacted by phone at least one week prior to surgery. Healthcare professionals (HCP) were recruited by e-mail, and written informed consent was obtained from all participants prior to study execution. The participants received no financial compensation.

Design

For this study, we employed a participatory action research (PAR) methodology that introduced a bundle of interventions after a control situation analysis. PAR can be defined as "an empirical methodological approach in which people directly affected by a problem under investigation engage as coresearchers in the research process, which includes action, or intervention, into the problem".[20] It is a suitable method for optimizing an implementation process because researchers, patients and HCP work together (20). Cycles of diagnosis, action, measurement and reflection are repeated in the context of

organizational change (**Figure 1**). These cycles were repeated until the objectives were achieved using qualitative and quantitative data, equivalently adopting a convergent mixed method approach (21).

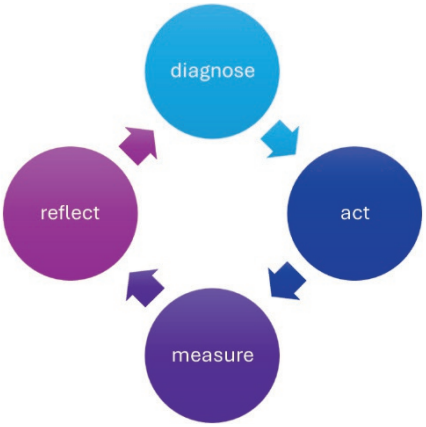

Figure 1. Four stages of PAR and participatory action research.

Participants and recruitment procedure

Participants in this study included patients and HCPs. Dutch-speaking adult patients waiting in the preoperative holding area for at least 15 minutes before elective surgery were included in the study. The use of anxiolytics or analgesics other than paracetamol was an exclusion criterion, as was participation in another interventional study. Patients who could not provide informed consent, who could not complete the questionnaires due to an altered mental state, or who, due to any physical condition or disability, could not use VR glasses or a computer tablet were also excluded from the study. All HCP working in the preoperative holding area were instructed about the study and invited to participate in the TC training.

Interventions

The bundle of three interventions in this study consisted of training in therapeutic communication for healthcare professionals, VR goggles and music intervention using tablets with earplugs for patients (**Figure 2**).

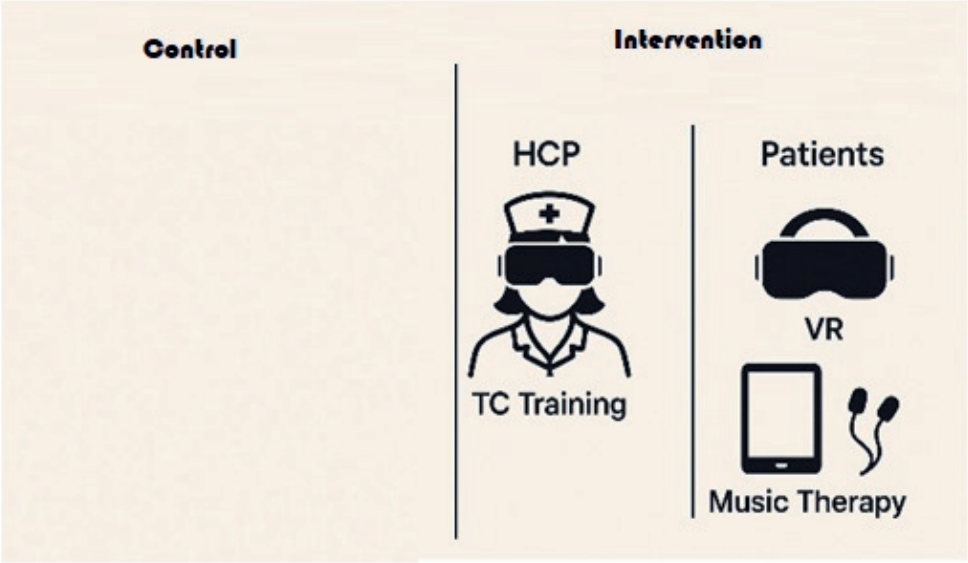

Figure 2. Three study interventions. For healthcare providers: TC training. For patients: VR or Music Therapy. HCP, healthcare professionals. VR, virtual reality. TC, therapeutic communication.

During preoperative admission, participating patients could choose to use VR goggles, use a computer tablet to listen to music, switch between devices, or not use any device. A detailed description of the interventions can be found in **Appendix 1**.

Intervention one: therapeutic communication training

All HCP working in the preoperative holding area were invited to participate in TC training which included a patient-embodied VR experience (12,13) (**Figure 3**) and an interactive training.

Figure 3. Patient-embodied VR experiences for healthcare professionals.

In the latter, HCP were trained in establishing rapid rapport and 'word choice' techniques using hypnotic language, such as reframing, mirroring, and positive suggestions, while avoiding the nocebo effects of negative experiences or expectations that the patient may experience (8-10).

Intervention two: VR-goggles

Patients who chose to use VR goggles had free choice between different relaxing videos. Additionally, a Hypno-VR© application relaxation experience was used (22). The duration, type of voice, and type of music could be adopted for patient preference. A healthcare provider helped with the setup of the VR goggles.

Intervention three: Music intervention

Patients who chose to use a tablet to listen to music had a choice between different pre-selected music playlists. To incorporate appropriate songs for our playlists we researched playlists validated by music listeners on the music streaming service 'Spotify' (Spotify Technology S.A., Stockholm, Sweden). By using different search terms in the search engine, we identified playlists of different genres that were used by music listeners. These were sorted based on 'likes' and 'follows'. Subsequently, the most liked and validated songs were compiled into different playlists.

Since slower music with a tempo of 60-80 bpm is associated with greater relaxation (23). We opted to filter the music based on bpm and excluded music outside of the 60-80 bpm range. This process resulted in having five playlists with five different genres (classical, country, jazz, pop and electronic music). Our final step filtered the songs on bpm, which was done manually using a BPM filter (24).

ENDPOINTS

Qualitative endpoints

A trained interviewer (MW) invited patients for stemi-structured interviews to collect detailed accounts of their thoughts, attitudes, and beliefs about their preoperative experiences. Broad introductory questions about their first impressions of their day of surgery were followed by more in-depth questions where patients were invited to elaborate about their lived perioperative experiences.

Focus group interviews were conducted with HCPs to collect interactive data commenting on each other's experiences, questioning each other, and group interaction (25). The characteristics of the focus group participants were aimed at selecting diverse groups of professionals in terms of demographics, years of work experience, educational background and professional ranking to establish a heterogeneous collection of responses (26). During the focus group interviews, challenges and successes of the implementation process were explored, as well as healthcare professionals' interactions on the work floor. The facilitator (MH) actively invited contributions from each participant, monitored group dynamics, and ensured all individuals had the space to speak candidly.

Finally, field notes of participatory and non-participatory observations were collected during the entire study period to document contextual information (27).

Quantitative endpoints

Patient-reported outcome measures (PROMs) pertaining to satisfaction, comfort, and anxiety were assessed using a 0 to 10 Likert scale, and an inverted Likert scale was used for the anxiety score. Scores were collected at several time points after admission to the preoperative holding area, as shown in **Figure 4**. A composite score encompassing comfort, anxiety, and satisfaction (CAS) was collected prior to surgery (CAS-T1). At arrival (CAS-T2) and prior to departure of the preoperative holding area (CAS-T3), as well as prior to leaving the postoperative care unit (CAS-T4), were also collected, as shown in **Figure 4**.

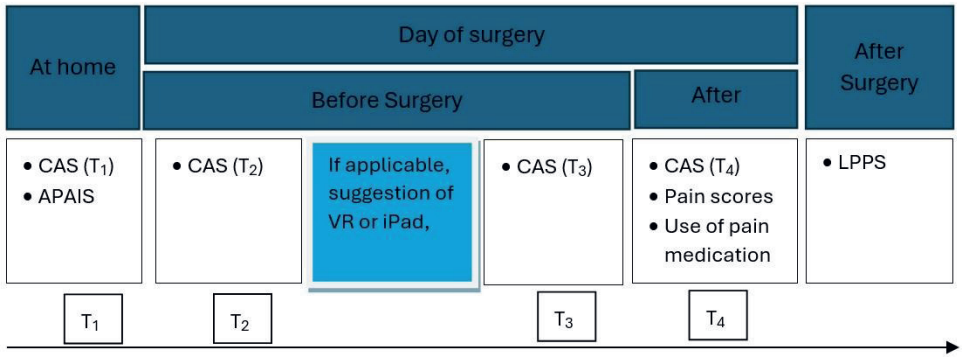

Figure 4. Collection of quantitative data. CAS scores = comfort (1-10), anxiety (10-1) and satisfaction (1-10) scores. T1, remotely before day of surgery; T2, at arrival on holding; T3, after intervention on holding before surgery, T4, post-surgery on recovery/PACU; PACU, post anesthesia care unit. APAIS, Amsterdam Preoperative Anxiety and Information Scale; LPPS, Leiden Perioperative Care Patient Satisfaction Scale.

The primary outcome measure was the CAS-T3 score, which was obtained immediately prior to departure from the preoperative holding area. This time point was considered most relevant for assessing the impact of the interventions on patient anxiety.

Secondary outcome measures included the disparity in combined scores between the preoperative holding area arrival and departure timepoint and between the holding arrival and postoperative time points. Furthermore, we analyzed individual CASs before and after TC implementation.

Additional assessments included two surveys administered at multiple time points (**Figure 4**). First, the Amsterdam Preoperative Anxiety and Information Scale (APAIS), a validated survey, was used to quantify preoperative anxiety on a psychological spectrum. With respect to the four items (questions 1, 2, 4, and 5), each item is rated on a scale from 1 to 5. The aggregate anxiety score is the sum of these four items, yielding a possible score ranging from 4 to 20. Participants were deemed anxious if their APAIS anxiety score was 11 or higher (28). The survey is a valid, reliable, quick, and user-friendly tool for assessing preoperative anxiety (5). Postoperative satisfaction was assessed using the validated LPPS scale, covering information provision (4–20 points), medical expertise (15–68), patient approach (13–65), and service quality (3–9); demographics were excluded (29).

Finally, the data collected included the use of postoperative pain medication, postoperative pain ratings on a 0 to 10 Likert scale, and the length of hospital stay at recovery.

Sampling and data collection

To estimate the needed sample size of the intervention groups, a one-sided independent two sample t-test calculation was used for the analysis of the quantitative primary outcome CAS-T3 score: comfort score, anxiety score, and satisfaction score immediately prior to leaving the preoperative holding area where a difference of 2 points seemed clinically significant. With this effect size of 2, and in absence of prior CAS data, we assumed a SD of 5, 100 patients per group would be sufficient to analyze the primary quantitative endpoint.

Qualitative data were retrieved without calculating the needed sampling size a priori but rather pursuing data saturation; that is, until the researchers were empirically confident, a category was saturated, and additional data would not lead to any new emergent input (3).

An overview of the collection of quantitative data after providing informed consent can be found in **Figure 4**.

Phases of participatory action research

Phase 1: (initial planning and reflecting): In the initial phase, HCP and researchers converged to blueprint the outlines of the research project and its subsequent development. This phase included a range of participants, encompassing preoperative holding area nurses, medical students, surgeons, anesthesiologists and nurse anesthetists.

Phase 2 (act): The implementation of action plans enlisted the active participation of HCPs. Over the course of one week, they engaged in TC training sessions. This period also featured practical demonstrations involving the VR headset and tablet used for the patients. Nurses were given the opportunity to serve as study ambassadors, offering them access to additional workshops, regular interactions with lead researchers, and a platform for contributing to research implementation. At the start of each day shift, the chief nurse mentioned the presence of the researchers and their approachability. Lessons drawn from previous evaluations were frequently revisited to identify strengths and weaknesses to guide necessary program adjustments.

Phase 3 (observation): A vigilant watch over the implementation process was maintained by the chief nurse and researchers. They closely monitored the frequency of nurses suggesting patient use of VR glasses or tablets, assessed the integration of TC communication techniques, scrutinized possible obstacles, and deliberated on feasible solutions. Focus group discussions examined corrective measures that were required for the next cycle.

Phase 4 (reflection): In focus group discussions with healthcare professionals, their perspectives, feelings and observations were shared, reflecting on the execution of

the program. They received feedback from colleagues, and the meeting ended when a consensus was reached. Additionally, informal reflection meetings took place to foster a comprehensive collection of information.

Statistical analysis

In this mixed method study, quantitative and qualitative data used in distinct phases were merged and analyzed convergently.[31] The decision to employ several mixtures was pragmatic, as incomplete comprehension could have been obtained by relying on one method only. This triangulation strategy tests validity among data sources through convergence (32).

Quantitative data

Quantitative data were collected via Castor EDC and analyzed in R (R Core Team, 2023) following a predefined analysis plan. Missing values and outliers were assessed. Statistical significance was set at $p < 0.05$. Categorical variables were reported as frequencies and percentages; continuous variables as means or medians. Outcome measures (comfort, anxiety, satisfaction, LPPS, APAIS) were compared to control using independent t-tests, and within groups using one-sample t-tests or Wilcoxon tests based on normality.

Correlations between APAIS, cumulative score, age, and sex were examined using linear regression. We analyzed CAS with a multivariable linear mixed-effects model to account for repeated observations within participants (random intercept for subject). Fixed effects were intervention group, APAIS high/low, sex, age, procedure size, and surgical specialty; we prespecified intervention×covariate interactions. Models were fit by restricted maximum likelihood; denominator degrees of freedom used the Satterthwaite approximation (two-sided $\alpha=0.05$). Analyses were performed in R (lme4/lmerTest).

Qualitative data

Qualitative thematic analysis was used to identify themes and categories. Lead researcher KH oversaw the process, while MW, uninvolved in preoperative care, conducted interviews using a phenomenological, constructivist approach. Participant reflections provided mutual insights (33).

A semi-structured guide was used for both focus group and individual interviews and can be found in **Appendix 2**. Both interview guides were piloted on a researcher; this data was discarded. All formal interviews were audio-recorded and transcribed verbatim. Quotes were translated from Dutch to English after transcription and before coding with efforts to preserve authenticity while reflecting on how translation choices might influence meaning. Identifiers were removed to maintain confidentiality of the transcripts. Other data, such as reflections, observations, and field notes, contributed to the reliability

of the data using the triangulation method.[32] All the data were kept in password-protected files with limited user access on protected hospital network drives.

The research team reflected on their own positions throughout the study: KH, as both anesthesiologist and qualitative researcher, acknowledged her dual role as insider within the clinical setting and overseer of the analytic process, while MW's outsider status in preoperative care provided distance during data collection. Reflexive memos and regular team discussions were used to surface assumptions, challenge interpretations, and ensure that multiple perspectives informed coding and theme development.

Data was analyzed via thematic analysis via an inductive process based on the following six phases of thematic analysis: data familiarization, code generation, theme development, theme revision, theme definition and report production.[34] A codebook was developed as themes emerged MW. Codes were clustered into emergent categories, then structured and grouped yielding overarching themes., discussed within the research team until a consensus was reached. Final validation of the codes against the data extracts was completed by a third researcher (ES) who reviewed all transcripts to enhance trustworthiness and ensure interpretative rigor.

RESULTS

Sample recruitment

Of the 746 patients identified between December 2021 and May 2022, 361 patients were recruited by phone. Two hundred patients were included and analyzed for quantitative analysis (**Figure 5**). HCP working in the preoperative area (n=45) received a printed handout with information on therapeutic communication. A subset of 24 professionals participated in the TC training regimen. This training outreach extended to various other healthcare professionals, including anesthesiologists, nurse anesthetists and operating room assistants. In tandem, seven preoperative holding area nurses in focus group interviews, and eight patients participated in individual interviews. All HCP and patients recruited for quantitative or qualitative analysis agreed to participate in the study and provided informed consent.

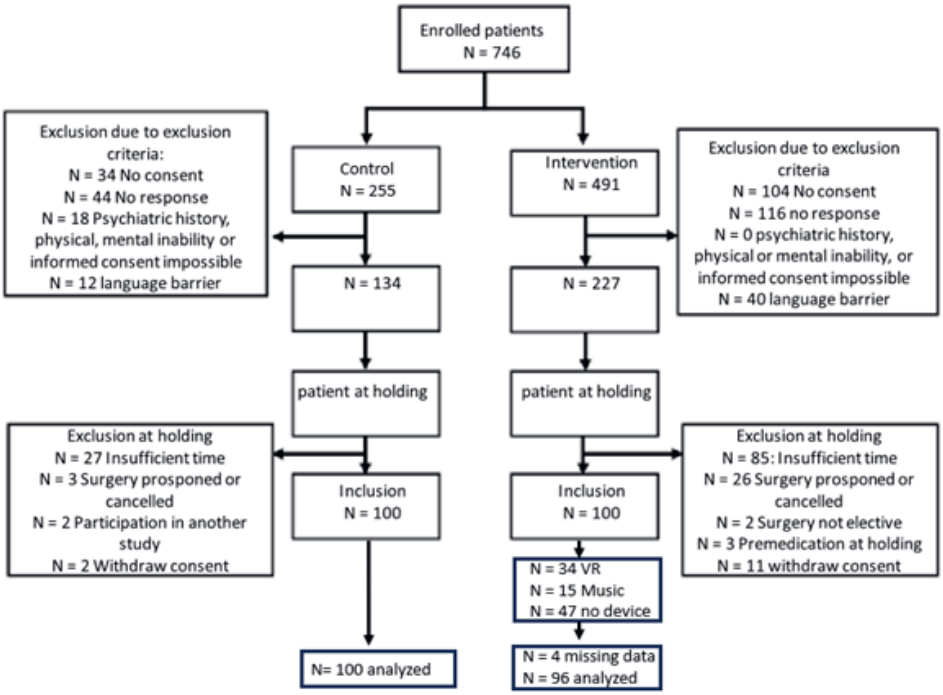

Figure 5. Flow diagram.

Characteristics

Demographics and procedure-related characteristics of the included patient cohort are outlined in Table 1. Groups were comparable in terms of age and surgical history. The intervention group included a greater proportion of female participants. A relatively greater number of participants in the intervention group exhibited elevated APAIS scores. Five out of eight patients had elevated APAIS scores (>11), and 62% were female. Notably, four out of eight patients opted for VR goggles, while the remaining four chose to engage in music intervention.

Among the seven preoperative holding nurses included, six had participated in TC training. All were female, ranging in age from 20 to 58 years (mean 39.6 years, SD 12.9 years), reflecting the working population of our holding area. Four were trained intensive care nurses, two were trained recovery nurses, and one was a trainee in recovery nursing.

Table 1. Patient characteristics for quantitative analysis

Characteristics	Control (N=100)	Intervention (N=100)	Total	P-value
Age (yr)				0.812
Mean ± SD	53.9 ± 16.2	53.4 ± 15.4	53.6 ± 15.8	
Range	18-83	21-83	18-83	
Sex at birth				0.001
Male	51	33	84	
Female	49	67	116	
BMI (kg/m^2)				0.458
Mean ± SD	26.8 ± 4.6	26.7 ± 4.3	26.7 ± 4.5	
Range	18.8-40.5	18.0-38.4	18.0-40.5	
ASA physical status n (%)				0.288
I	23 (23.2)	22 (22.9)	45 (23.1)	
II	61 (61.6)	63 (65.6)	124 (63.6)	
III	15 (15.2)	11 (11.5)	26 (13.3)	
APAIS score at baseline				0.186
Mean ± SD	9.3 ± 3.2	9.7 ± 3.6	9.5 ± 3.4	
≥ 11 (%)	31.6	41.4	36.5	
Prior surgery (%)				0.797
Yes	84.3	84.8	84.5	
No	15.7	15.2	15.5	
Duration of stay in holding area (min)				0.730
Mean ± SD	43.9 ± 52.7	44.7 ± 31.8	44.3 ± 43.4	
Range	16-518	16-254	16-518	

SD, standard deviation; yr, years; BMI, body mass index; ASA, American Society of Anesthesiologists; APAIS, the Amsterdam Preoperative Anxiety and Information Scale

Findings from quantitative analysis

The primary outcome measure of this study was the combined score of comfort, anxiety and satisfaction (CAS) measured immediately prior to departure from the preoperative holding area. This composite score did not differ significantly between the two groups,(median [IQR] 21.5 [19.0–24.3] vs 22.5 [19.8–26.0], $p = 0.15$). Secondary outcomes such as singular scores at different timepoints, or the difference in combined scores between at different time points did not differ significantly clinically and/ or statistically.

Also, In a multivariable linear mixed-effects model with a subject-level random intercept, the overall effect of intervention group on CAS was not significant (Type III: F(3, 145.4) = 1.03, P = 0.38). Adjusted findings did not materially change the conclusions from the primary unadjusted comparisons.

No adverse effects, such as motion sickness, associated with the use of the devices were reported.

Qualitative analysis

Concurrent focus groups and individual interviews were conducted (up until 34 minutes) with distinct participant groups, ensuring data independence. Fieldnotes and observations were carefully recorded by KH and MW. The interview guides can be found in **Appendix 2**. Data collection continued until saturation was achieved. After three cycles, recurring themes stabilized, and participants in subsequent focus groups reported no further suggestions beyond familiarization with the intervention. This point of saturation was reached before completion of quantitative patient inclusion. The qualitative analysis revealed eighteen codes that we clustered into five subthemes and three main themes, as shown in **Table 2**.

Table 2. Main Themes, Subcategories, and Corresponding Codes

Main Themes	Subcategories	Codes
General Support	Positive Impacts	Emotional uplift from music, Enhanced comfort due to VR glasses, High satisfaction with postoperative care, Growing preference for VR glasses over iPads, Positive reception of VR and music by nurses
	Empathy and Proactive Care	Proactive comfort inquiry by nurse, Empathic response by nurse-to-patient anxiety, Curiosity about VR effectiveness in anxiety reduction,
Challenges	Technology Usability and Accessibility	Usability issues with VR glasses, Desire for realistic VR settings, Frustration with length of VR introduction, Dissatisfaction with inability to choose personal music
	Operational Constraints	Declining participation due to preoperative stress, Frustration due to long waiting times in holding, Limited familiarity and routines
Brought Up Solutions	Suggestions for Improvement	Priority access to devices for study participants, Growing nurse proficiency in using VR devices, Nurse assistance with VR installation

General Support

Positive Impacts. Patients and HCP reported various positive impacts of the interventions. Emotional uplift from music and enhanced comfort due to VR glasses were commonly highlighted. All HCPs expressed overall support for the implemented bundle of interventions. All confirmed to have had at least one positive experience where they felt that the use of VR decreased patients' preoperative anxiety. Several quotes can be found in the Appendix (**Appendix Table 1**).

Empathy and Proactive Care. Empathy and proactive care by nurses were significant factors in patient comfort. Nurses often proactively inquire about patient comfort; for example, in this observation documenting a nurse asking,

> *"Are you warm enough?" instead of "Are you cold?" (Observation November 2021).*

Six out of seven HCP confirmed that they used the skills learned in TC training; one of these seven had not participated in the training but reported applying elements from the handout and ward environment. Most of them also advised continuing the training for new colleagues, such as one participant who stated the following:

> *"It's another way of approach. The videos of VR were very nice. Visually, you experience the difference in approach. These can be shown to new colleagues, that would be great and helpful to continue learning" (healthcare professional 1, focus group 1).*

Patients appreciated the empathy shown by nurses, which helped reduce anxiety:

> *"I arrived very tense, nurses took time to calm me down and were very empathetic" (Patient Interview 4).*

Challenges

Technology Usability and Accessibility. Several challenges related to the usability and accessibility of technology were identified. Patients reported issues with VR glasses, such as

> *"I could not see the VR image well. The glasses were repositioned on my head, but the problem persisted" (Patient Interview 7).*

Additionally, there were frustrations with the length of VR introductions and dissatisfaction with the inability to choose personal music:

> *"I think the intro when you go to the environment takes too long" (Patient Interview 8).*

In observation notes from the same interview, the researcher recorded that the patient regretted not being able to choose his own music (Observation, June 2021). Other remarks raised by the nurses can be found in Appendix (**Appendix Table 2**).

Operational Constraints. Operational constraints pose significant challenges. Some patients declined participation due to preoperative stress, stating,

> *"I did not want to participate upon arrival at the holding area, I preferred to focus on the surgery and already had enough on my mind" (Patient Interview 4).*

Nurses highlighted time constraints as a barrier to using VR:

> *"Nurse tells me that they sometimes do not have time for the VR and therefore sometimes skip it" (Field Note June 2021).*

Brought-Up Solutions

Suggestions for improvement. Various suggestions for improvement were provided during the interviews and can be found in SI-Table 3. Nurses indicated a growing proficiency in using VR devices, with one stating,

> *"Nurse says she is getting the hang of using the VR glasses more and more" (Field Note MH, August 2022).*

Additionally, the importance of nurse assistance with VR installation was noted, as one of the researchers was frequently asked to help set up the devices*:*

> *"The nurse comes to me to ask if I will help install the VR glasses" (Field Note February 2022).*

Among the barriers mentioned in the initial focus group and subsequent informal conversations with healthcare professionals, the issue of forgetting to use the device emerged. One possible solution was to use posters within the preoperative ward as well as to add a description of the possibility of using a device in the preoperative patient information letter provided by the anesthesiologist.

> *"It would be nice to be reminded of the possibility to use the devices. Maybe the use of a poster for patients and nurses" (healthcare professional 2, focus group 1).*

Above each hospital bed, a paper poster was placed, ensuring that every patient was informed about the possible use of the device. Furthermore, several large posters with pivotal aspects of TC training served as visual reminders for healthcare professionals, enhancing their engagement and retention of the training content. All participants acknowledged the positive effects of these adaptations. Four out of seven HCP stated that the presence of the TC posters reminded them to use therapeutic communication. Several quotes on brought-up solutions can be found in Appendix (**Appendix Table 3**).

DISCUSSION

The aim of this study was to assess the effect of a bundle of non-pharmacological interventions on preoperative anxiety in a tertiary hospital. Using participatory action research and a mixed methods design, we observed a positive influence on both healthcare providers and patients.

Although the quantitative data did not show statistically significant differences, the qualitative findings clearly favored the intervention bundle. As a result, the clinical relevance of our findings remains uncertain. This conclusion contrasts with both our qualitative outcomes and prior research, which reported positive effects on patient-reported outcomes for the same interventions.

Divergence between quantitative and qualitative data

To understand the divergence between the quantitative and qualitative data that we observed in our study, we followed a systematic approach described by Pluye (35). Pluye and colleagues describe divergence as differences between qualitative and quantitative findings that should not automatically be seen as errors or contradictions. Instead, divergence can generate new insights. They outline four main strategies to handle divergence: reconciliation (reinterpret results to align), initiation (ask new questions, collect more data), bracketing (present scenarios when data remain irreconcilable), and exclusion (discard data if invalid). This framework encourages researchers to use divergence constructively to deepen interpretation in mixed methods, a visual aid can be found in **Figure 6**.

Appraisal of quality of components

Quantitative outcomes:

The chosen quantitative outcome measures for this study were judiciously selected. We have opted to use quick patient reported outcomes for anxiety, pain, and comfort rather than relying on the NRS, which focuses solely on pain and may not fully capture the complexity and unique characteristics of a patient's pain experience. However, we observed a tendency toward relatively high PROM ratings, likely due to a ceiling effect, where the upper limit of the scale restricts the ability to measure higher values, leading to a response bias, where participants' answers may not accurately reflect their true experiences (36,37). These elements limit its effectiveness in distinguishing between groups.

One of the salient strengths of a PAR approach is its adaptive and optimizing nature. The inclusion of solutions and program enhancements that emerged during the study resulted in a dynamic evolution. Importantly, it is plausible that the cumulative effects of these adaptations were underestimated during quantitative analysis.

Qualitative outcomes:

The qualitative exploration uncovered important information that might have been difficult to access otherwise(38). Through in-depth discussions led by a facilitator, we gained valuable insights into people's attitudes, perceptions, and opinions. These conversations clearly showed how factors like coercion, conformity, group dynamics, and shared tendencies significantly influence whether an intervention is accepted or rejected(25). The reflections, observations and fieldnotes provided essential contextual information. The harmonization of findings from qualitative data improved our confidence in the validity of the constructs and enhanced the plausibility of the findings.

Comparison of quantitative and qualitative analyses

Despite observing an overall improvement in quantitative outcomes after the implementation, no statistical significance was observed. This could be attributed to an insufficiency of statistical power influencing the ability to detect significant quantitative differences, or to other determinants as described below.

As is common within tertiary hospital settings, not all HCP could participate in TC training due to logistical challenges. Nevertheless, these professionals were provided with digital and paper handouts, and they heard about the project through colleagues, the chief nurse, principal researcher or an ambassador of the implementation program. One researcher noted in an observation during one of the focus group interviews:

> *"I can clearly differentiate which nurse has followed the training and which nurse has just read the hand-out. The questions and challenges that are brought up by the nurse who did not follow the training are actually answered by colleagues who did follow the training" (KH, observation after focus group interview 4).*

The relatively limited effect of the TC instruction by reading a hand-out, as opposed to following the interactive TC training, may have diluted the impact of the overall intervention and might account, to some extent, for the lack of observed quantitative effects.

Analysis of the barriers reported by HCPs revealed two major obstacles. The first important barrier that was identified was the lack of time to use the devices. When revisiting the quantitative data, we observed that patients stayed at the preoperative holding area for an average of thirty-two minutes. During this timeframe, patients are set up at the preoperative holding area, an intravenous cannula is placed, and control measures and checklists are to be completed. The opportunity to use a tablet or VR goggles was often offered only after these mandatory protocols were finalized. The interviews with patients supported this finding, as they reported that they would have wanted to use the device for an extended period. A field note of one of the researchers also concords with this finding:

"It is too short. I've just given the tablet, but before the patient can finish the first song, he is already called to be brought to the operating room" (Fieldnote February 2022, MW).

Other barriers included limited familiarity and established routines. For many healthcare professionals, using a VR device was new. Similarly, the adoption of therapeutic communication was a novel concept. Behavioral transformation requires time, and the intricacies of behavioral change depend not only on individual capabilities but also on the broader ecosystem. In this context, PAR has emerged as the most appropriate method because it facilitates authentic behavioral changes within a real-world context.[20] The use of reminders for HCP and the provision of patient information were possible solutions. Importantly, it is possible that the added effects from these adaptations may have been underestimated during quantitative analysis.

Furthermore, we note that the intervention group contained more patients with a relatively higher APAIS score, possibly underestimating the effects of the bundle of interventions.

Evaluation of the need for additional data collection and analysis

We conclude to approach the qualitative and quantitative data as complementary rather than positioning them in competition, a standpoint aligned with any *true* version of the phenomenon of adapting constructive realism as a theoretical framework.[39] By using triangulation, we explored the phenomenon from various perspectives, leading to a more intricate and nuanced analysis.[40] To harmonize the divergence, a reanalysis of the available data was conducted that accounted for plausibility and coherence.

DISCUSSION

A key strength of this study was the use of PAR, which bridges research, development, and clinical practice by combining researcher models with HCP's perspectives.

The thematic analysis of the qualitative data permitted the identification, analysis and reporting of patterns within the dataset and facilitated the creation of a rich description of the subject matter. The responsibility of one team member for analysis (MW) enhanced the internal consistency of the coding. Validation criteria, such as generalizability, reliability, and verifiability, were used.[30]

An acknowledged limitation of the study is its single-hospital setting. The findings, while insightful, may not mirror the experiences or perspectives of HCPs in other hospitals due to inherent clinical and contextual variations between hospitals and even countries. This

limitation is most particular for focus group discussions, which might not comprehensively represent the viewpoints of a larger population.

Secondly, a note should be made on the dates of inclusion of this study. The study was conducted partly during the COVID-19 pandemic, which might have influenced patient experiences. Due to a lack of personnel, elective surgeries were also postponed, which slowed down the inclusion process of our study. It also influenced data analysis and submission as the researchers had concurrent clinical responsibilities. Another limitation of this study is a possible selection bias. This study aimed to limit preoperative anxiety; however, anxious patients inherently tend to refuse study participation (as described in several fieldnotes and observations). As shown in Table 1, initial preoperative anxiety was relatively low. This may have led to underestimation of the true possible effects of our intervention.

Finally, the costs of implementing this bundle of interventions were not a predefined outcome in our study. In our hospital setting, VR goggles and tablets were already available, which facilitated implementation at minimal additional cost. We recognize, however, that in other settings where such resources are not readily available, implementation may have greater financial challenges.

Conclusion

Music medicine, VR, and therapeutic communication appear to have potential positive effects on patients and HCP in the preoperative setting. These modalities are safe and could play an important role in alleviating anxiety among preoperative patients. Within this study, we've provided a bundle of three interventions to increase patient experiences in perioperative setting. This paper illustrates that divergence can emerge when employing different data collection methods. Whereas quantitative analyses revealed changes without statistical significance and apparent little clinical impact, qualitative data revealed a broad impact experienced by patients and healthcare professionals. We embraced these divergent findings as complementary aspects of the social phenomenon and operated under the notion that each set of data enriched the other.

A majority of HCP and patients advocated the possible benefits of the distraction and comfort offered by the devices, in addition to acknowledging the value of therapeutic communication in a preoperative setting.

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Authors' contributions

K. Hoek had the original idea for the study, and she wrote the original draft, methodology and final article. **EYS** and **MvV** contributed to conceptualization. **MW** and **KH** contributed to the data collection. **MW** transcribed and performed the initial coding. KH and **MW** analyzed the qualitative data. **RMvdS** contributed to the quantitative data analysis. All authors have read and approved the final manuscript.

Competing interests

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APPENDIX 1

Interventions

The TC training consisted of the following:

->E-learning: this e-learning was split in two parts of 20 minutes. The e-learning deploys key insights of therapeutic communication with explanation of important terminology such as placebo, nocebo, negative and positive suggestions, reframing, and *rapport*.

->VR-embodied experiences. Two 2 VR-embodied experiences were available and shown. The description and validation of these VR experiences can also be found in our earlier published work.[1,2] In these two experiences HCP can experience the journey of a patient undergoing an elective knee surgery. The experience starts when the patient arrives in the preoperative holding area, where check questions are verified, and an intravenous drip is placed. The anesthesiologist brings the patient to the operating room where the team performs last checks before the induction of general anesthesia where the experiences stop. Both experiences resemble, only modest changes are noted, with the use or absence of therapeutic communication.

->physical hands-on training using mirroring rapport techniques and applying therapeutic communication skills with reframing in small groups. An example is placing a (fake) intravenous drip on a colleague who acts as a patient, while using newly learned therapeutic communication skills.

Intervention 2: VR-goggles

The VR-goggles were equipped with the Hypno VR app. This application uses therapeutic tools to generate anxiolytic effects by inducing in the patient a state of hypnotic trance. The application has several studies validating it's use in elective settings.[3,4] Several VR-goggles were at the disposition of the nurses and researchers during the study. They were able to visualize and set up the goggles with the use of a tablet, adapting the settings to the needs and wishes of the patient.

If patients did not want to use the Hypno VR app, several relaxing 360degree videos were available as well. These videos were a selection of slow nature settings: swimming with dolphins, a walk in a forest, the beach, and a snowy landscape.

Intervention 3: Music

In our study, we used a variety of search terms based on common music genre, such as "classical," "country," "jazz," "pop," and "electronic." on the Spotify platform (Spotify Technology S.A, Stockholm, Sweden). We also looked for terms related to relaxation, focus, and calmness. Additionally, we selected songs from these playlists based on the number of "likes" and "follows" to ensure that the playlists had been validated by a significant number of listeners. Our final step filtered the songs on bpm, which was done manually using a BPM filter.[5]

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5 SongBPM. BPM filter <https://songbpm.com/> (

APPENDIX 2

Interview Guide

Patients

Topic	Script
Introduction (5 minutes)	I want to thank you for taking the time to talk with me today. I'll briefly explain the aim of this interview and that it will take about 20–30 minutes. I am interested in your personal experiences and how you felt during the perioperative process. Before we start, we'll go through the consent form together. I will sign it as well, and you will get a copy. I will now switch on the audio recorder. Everything you say will be kept confidential, and the recording will be coded so that you cannot be identified. To begin, could you tell me your age, the type of surgery you had, and whether you used the VR headset or the tablet?
Main Interview (15–25 minutes)	
Experiences with the device	Can you tell me about your experience with the device? What program or music style did you choose, and what influenced your choice? How was the device introduced to you, and how did you feel about that?
Perceived effects	How did using the device make you feel before and after surgery? What was your impression of the virtual environment (VR) or of the music (tablet)? In what ways, if any, did the device affect your hospital stay?
Broader meaning and evaluation	What did the use of the device mean to you personally in this context? Did it change how you thought about your surgery or the hospital environment? Would you recommend the device to friends or family? Why or why not? If you could change something about the experience, what would that be?
Closing probe	Is there anything else about your experience that we haven't talked about but that you find important?
Ending (5 minutes)	To finish, I'll briefly explain again what we will do with the results, as outlined in the consent form. If you have any questions after today, you can always contact us. Thank you very much for your time and for sharing your experiences with me.

Healthcare Providers

Topic	Script
Introduction (5 minutes)	Thank you for participating today. I'll explain the aim and expected duration of this discussion. All perspectives are valuable here, regardless of role or hierarchy, and everything you share will remain confidential. Before we begin, let's go through the consent form together. I will sign it too, and you'll each get a copy. I will now switch on the audio recorder. The data will be anonymized and coded. Could you briefly introduce yourself by telling me your age, gender, your professional role, and whether you participated in the TLC-training?
Main Interview (15–25 minutes)	
First impressions and training	Can you tell me about your experience with the TLC-training? How did the training make you feel, and did it influence your daily routine?
Experiences with devices	Have you tried the VR headset or tablet yourself? What program or music did you choose, and why? Have you offered a device to patients? What guided your decision to do so?
Perceptions of implementation	What is your impression of how patients used the device? What benefits did you notice for patients or staff? What barriers did you encounter? Can you think of ways these barriers might be addressed?
Broader meaning and future outlook	How do you see the training and devices fitting into your professional role in the long term? Would you recommend continued use of these devices in your hospital? Do you think implementation would be feasible in other hospitals? Why or why not?
Closing probe	Is there anything we haven't asked that you think is important to mention?
Ending (5 minutes)	To wrap up, I'll explain again what we will do with the results, as mentioned in the consent form. If you have any further questions later, please feel free to contact us. Thank you all for your time and for sharing your experiences with me today.

Appendix Table 1

Quotes from Qualitative Analysis

Main Themes: General Support
Subcategory: Positive Impacts

''*He was happy with it now, even singing along"* (healthcare professional 1, use of tablet (focus group 1)).

These ideas were supported by a participant who had already proposed VR glasses several times and who was also an ambassador of the implementation program: *You can notice some kind of relaxation. Just fine and calm. They can focus on something other than the surgery"* (healthcare professional 2, use of VR (focus group 1)). Among patients, all participants were in favor of the possibility of using VR or a tablet. For example, one patient stated, *"What beautiful music, I almost want to cry,"* while another mentioned, *"I almost fell asleep because the music is so relaxing"* (Patient Interview 1, Observation MH May 2021). High satisfaction with postoperative care was also noted, with a patient expressing, *"I am very satisfied with the care and enjoyed the music"* (Patient Interview 3). Moreover, there was a growing use as the study advanced, as observed in field notes*: "I notice that more and more people have been choosing the VR glasses in the past few weeks"* (field note KH July 2021). Nurses expressed curiosity about the effectiveness of VR in reducing anxiety*: "The nurse asks if the VR glasses truly help with anxiety"* (Field Note MH, May 2021).

Appendix Table 2. Challenges raised.

Three nurses noted that their habits needed to be changed before being able to use a device. *"I still work on automatic pilots"* (healthcare professional 2 (focus group 2)). Another example: *"It still has to get in our system I think, I just have to keep trying to make it work" (*healthcare professional 3, use of VR) (focus group 2).

Two nurses also noted the challenge of being able to use the lessons learned during the therapeutic communication course. *"I find it difficult with giving an IV. Sometimes I still say, 'here comes the sting'. It's still difficult for me, but I'm starting to get the hang of it"* (healthcare professional 2 (focus group 1)).

Operational constraint:

Fieldnote 6/4/2021 (observation of nurse reporting to KH)

Patient was approached on 5/4/2021 regarding inclusion in the comfort study. Did not want to participate. Said: I want to focus on the surgery.

On 6/4: patient lies in bed, stiff as a board, indicates being very afraid of needles. Says very difficult to puncture.

Nurse: suggests trying some music or VR glasses. Patient agrees. Says it was also suggested to him yesterday, but they weren't in the mood then.

Anesthesiologist: later comes with ultrasound to place the IV. Pt lies in bed with VR glasses and seems to undergo it calmly.
After IV placement, patient still wants to use the VR glasses to play a game.

Postop: (informal conversation by KH)

Patient indicates that next month they will start EMDR therapy for his needle phobia.

Patient says that with the glasses on, their anxiety was reduced by 75%. In addition, even in the hour after, they were much less tense because they had something to do with the glasses.

How should we approach future patients?

As we do now, by phone.
I mention that the glasses will be available throughout this year, and we will continue depending on funding: they say they would be willing to testify and is glad it might be available next time.
Patient gives me a fist bump. "Keep it up," they say.

Appendix Table 3. Quotes on brought-up solutions

One participant stated: *"Patients lie in their beds, they see the posters, and it has happened several times they tell me that they read about it in the letter they had received. I felt patients were more open to it" (healthcare professional 3, focus group 2).*

Four out of seven HCP stated that the presence of the TC posters reminded them to use therapeutic communication: *"The poster is nice; it gives some extra examples to help you in daily practice" (healthcare professional 2, focus group 2).*