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

Innovative approaches for training in high stress communication, therapeutic communication for patient comfort, and team culture in the operating room.



Krista Hoek

Stellingen behorende bij het proefschrift getiteld:

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

1. *Patient-reported outcomes in perioperative care are significantly influenced by contextual and relational factors that are not captured in standard clinical metrics. (this thesis)*

2. *Embodied VR experiences provide a valid method to approximate experiential learning. (this thesis)*

3. *Team culture improvement can be an interesting collateral benefit of a team training in therapeutic communication. (this thesis)*

4. *Embodiment in virtual reality enhances learning primarily through perspective-taking mechanisms. (this thesis)*

5. *Communication is not an individual competence, but rather a relational and context dependent competence between people, within a system. (this thesis)*

6. Adaptability is key in high level clinical simulation.

7. More fidelity does not equal better learning.

8. Transfer is hard.

9. "None of us live in an objective world, but instead in a subjective world that we ourselves have given meaning to. The world you see is different from the one I see, and it's impossible to share your world with anyone else." Ichiro Kashimi (but VR can get fairly close!)

10. Pressure is more often a reflection of purpose than of burden. (Inspired by Billy Jean King "Pressure is a privilege")

11. The meaning people assign to an experience is shaped more by where they direct their attention than by the experience. (Inspired by Epictetus "You become what you give your attention too")

12. The difference between ambition and an achievement is sustained action. (inspired by Érik Orsenna "La différence entre la réalité et un rêve est une date")



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Dit is een uitgave van	Proefschrift Maken | proefschriftmaken.nl | Rotterdam
Auteur	Krista Hoek
ISBN / EAN	978-94-6534-564-2
NUR code	876
Taal	Engels

TECH FOR FUTURE

VRDAYS FOUNDATION

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

Proefschrift

ter verkrijging van
de graad van doctor aan de Universiteit Leiden,
op gezag van rector magnificus prof. dr. S. de Rijcke,
volgens besluit van het college voor promoties
te verdedigen op vrijdag 4 september 2026
klokke 10.00 uur

door Krista Hoek

PROMOTIECOMMISSIE

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For my own Beech Circle. You know who you are.

I hear and I forget
I see and I remember
I do and I understand

Confucius
551 BC–479 BC



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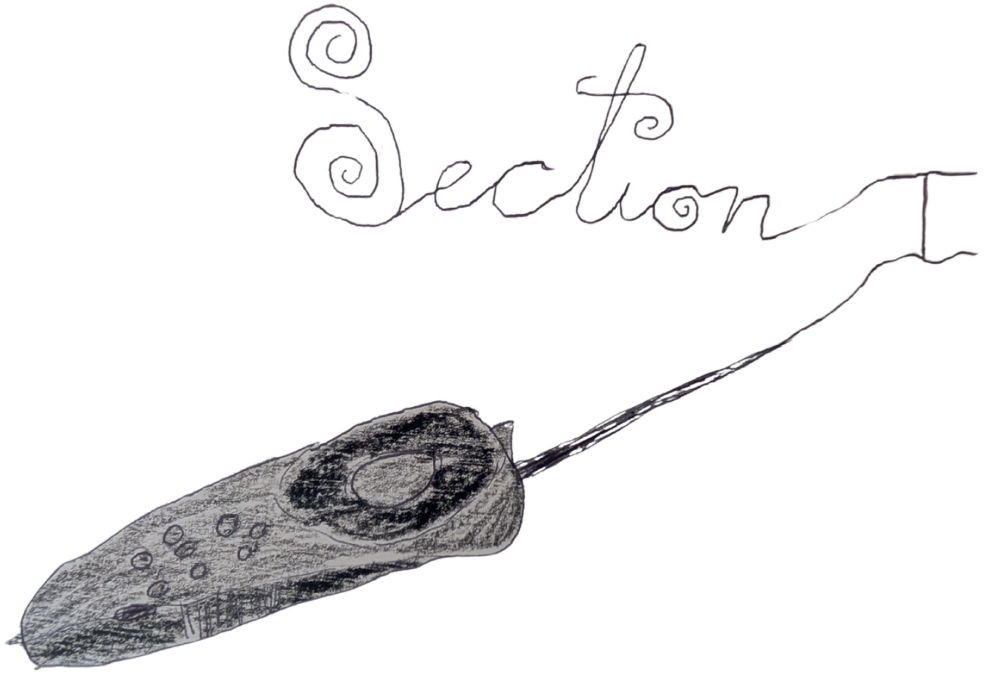
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Introduction

General Introduction

Medical education evolves as traditional training methods are being reimagined through innovative technologies and pedagogical approaches. This thesis investigates the use of Virtual Reality (VR) simulations and embodied experiences as tools in medical education, specifically focusing on their application in communication training.

In recent decades, communication has increasingly been recognised as a core component of patient safety, driven by insights from human factors research and major patient-safety reports that revealed how breakdowns in communication rather than technical incompetence often lie at the heart of adverse events. This shift has reframed communication as a system property shaped by context, cognitive load, and team dynamics, rather than a simple interpersonal skill.

This introduction outlines the research questions, contributions, and structure of this thesis.

LITERATURE REVIEW AND RESEARCH GAP

Communication in High-Stress Situations

Simulation-based training has become an essential part of medical education, particularly in anaesthesiology, where healthcare providers (HCP) are frequently required to manage high-stakes, low-frequency events. These include acute airway problems, haemodynamic instability, and unexpected complications during surgery. Simulation offers a structured, risk-free environment in which both technical and non-technical skills can be practised and refined without putting patients at risk (1, 2).

The ability to communicate effectively, make decisions under pressure, and work as a team is increasingly recognised as critical. To address these interpersonal and cognitive demands, Crew Resource Management (CRM) training, originally developed in aviation, has been adapted for healthcare. The importance of CRM in healthcare was widely acknowledged after the Institute of Medicine's *To Err is Human* report highlighted the central role of communication errors in adverse events (3, 4). Indeed, adverse outcomes in acute care settings often stem not from technical failures, but from disruptions in communication, lapses in situational awareness, and cognitive overload during time-critical events. Its principles, including shared mental models, closed-loop communication, mutual performance monitoring, and debriefing provide a theoretical backbone for understanding why high-stress clinical communication so often breaks down.

Traditionally, CRM has been taught using manikin-based simulations. While effective, this method requires significant resources, scheduled group sessions, and access to simulation centers. These requirements cannot always be fullfilled, limiting execution. These

limitations were amplified during the COVID-19 pandemic, which forced many training programs to cancel or severely restrict in-person simulation (5).

VR has emerged as a viable and scalable alternative, offering immersive environments where learners can engage with scenarios on demand. In theory, VR simulation allows for dynamic scenario control: for instance, trainers can modify a patient's physiological responses in real time, supporting adaptive challenge levels that match the learner's pace (6, 9, 10). These affordances may reduce cognitive overload and enhance engagement, aligning with principles from Cognitive Load Theory (7). Cognitive Load Theory (CLT), developed by John Sweller, explains that our working memory has a limited capacity for processing new information. It distinguishes between **intrinsic load** (task complexity), **extraneous load** (inefficient presentation), and **germane load** (effort to build understanding). Effective teaching reduces extraneous load and balances difficulty—enough to stimulate learning, but not so much that the learner becomes overwhelmed or shuts down (8). During high-stress events, poorly designed information flow can overwhelm working memory, increasing the likelihood of communication errors.

Effective simulation should therefore be built through an iterative, user-informed process. User-centered design (UCD) is particularly valuable when combined with risk assessment tools like Failure Modes and Effects Analysis (FMEA), which systematically identifies potential points of system failure during early development (11, 12).

Incorporating human-factors principles at the design stage ensures that simulations do not merely represent clinical tasks but resemble real-world team behaviour.

In summary, CRM training through VR holds substantial potential. However, further evidence is needed to demonstrate its feasibility in communication skill acquisition and clinical performance. This thesis addresses these challenges through developing, validating, and early evaluation of a multiplayer, scenario-adaptive VR training system for anaesthesiology, built through a user-centered process and tested using both qualitative and quantitative methods.

Communication for Patient Comfort and Anxiety Reduction

Hospitalisation and medical procedures can provoke significant anxiety in patients, particularly in the preoperative setting. This anxiety amplifies physiological stress responses, increases pain sensitivity, and is associated with poorer postoperative outcomes and prolonged recovery (13-16). Routine interactions and procedures, as 'simple' as the placement of an IV cannula or drawing blood, can leave a lasting emotional imprint on patients reinforcing or relieving their distress (17-19).

Therapeutic communication refers to the use of suggestive and positive language, careful non-verbal cues, and rapid rapport techniques to create a sense of safety, trust, and comfort in the clinical encounter. It is both an attitude and a technique—requiring the healthcare professional to be aware of how words, gestures, and tone may implicitly influence a patient's physical and emotional experience through the creation of a connection with the patient, also referred to as rapport.

Findings from neuroscience and cognitive psychology increasingly support the clinical importance of this skill in increasing patient comfort. Language does not merely describe but actively shapes perception, including the experience of pain. Negative phrasing, such as "this might hurt" or "don't worry", can draw attention to threat, reinforcing anxiety and discomfort via nocebo effects. In contrast, positive suggestions have been shown to reduce pain and even modulate neurophysiological pathways associated with stress and comfort (18, 20, 21)."

Despite this growing body of evidence, therapeutic communication is still underrepresented in medical education. While most curricula cover the basics of patient interaction, these are often confined to structured checklists or theoretical instruction. In reality, communication behaviours are shaped implicitly—through the clinical environment, observation of senior colleagues, and organisational culture. This *hidden curriculum* can perpetuate habits that prioritise efficacy, inadvertently modelling communication styles that undermine patient trust (22, 23).

Addressing this gap requires training methods that move beyond technical skill acquisition. Experiential and immersive approaches are particularly promising, as they engage not only the cognitive but also the affective and reflective dimensions of learning (24). Patient-embodied VR simulations, where the user experiences a clinical interaction from the patient's perspective, allow clinicians to *feel* the impact of tone, phrasing, and non-verbal communication. These experiences draw on the *Proteus effect*, where embodiment influences perception and behaviour, and they are aligned with experiential learning theories such as Kolb's cycle, which emphasises reflection on lived experience as a pathway to lasting behavioural change (10, 25, 26).

In summary, therapeutic communication is a powerful yet underused skill in patient-centered care. Integrating immersive training with patient-embodied VR into education may help create deeper awareness, empathy, and behavioural adjustment. This thesis explores how these interventions can enrich clinician training.

Communication and Team Culture in the Operating Room

The operating room (OR) is a high-stakes environment where communication is both critical and complex. It brings together diverse professional roles—surgeons, anaesthesiologists, nurses, and trainees—who must coordinate their actions under time pressure and in close physical proximity. In this setting, communication extends far beyond spoken words. It includes routines, tacit norms, glances, hand gestures, and even silence. The subtle cues exchanged among team members often determine whether a procedure runs smoothly or breaks down (26, 27).

Within the OR, nonverbal communication plays a particularly important role in shaping team rapport and ensuring patient safety. Elements such as sustained eye contact, open postures, and supportive touch—though often overlooked—can signal attentiveness, solidarity, or readiness to act (28, 29). In dynamic clinical settings like endoscopy or emergency surgery, nonverbal synchrony among healthcare professionals has been associated with more fluid teamwork and higher perceived trust. These cues are not always consciously recognised but contribute significantly to how team members interpret one another's intentions and emotions.

Yet many of these communicative behaviours are not formally taught. Instead, they are absorbed informally—through observation, imitation, and trial-and-error. This process forms part of what is often referred to as the *hidden curriculum* in medical education: the set of implicit values, behavioural norms, and unspoken rules that shape professional identity and conduct (30, 31). In the OR, this hidden curriculum is particularly potent, as trainees are acutely aware of power hierarchies and often hesitant to ask questions or disrupt expectations. Over time, these silent lessons may reinforce not only communication habits but also assumptions about status, authority, and belonging.

Together, these observations highlight a central educational challenge. If nonverbal communication and team norms in the OR are largely implicit, and context-dependent, how can they be studied, made visible, and addressed in training? Traditional educational approaches tend to focus on explicit knowledge and verbal skills, leaving these aspects of teamwork underexplored. As a result, critical elements of rapport and team culture often remain invisible, despite their influence on collaboration, learning, and psychological safety.

In this thesis, a video-ethnographic approach is used to examine nonverbal elements of rapport.

Research Aims and Objectives

The central aim of this thesis is to explore how VR simulations and embodied experiences can be used to enhance communication skills among HCPs in different clinical contexts. The research is structured around three key sections:

Section II: Communication in High-Stress Situations

- Investigating if and how VR simulations can help HCPs train CRM skills for handling stressful clinical scenarios.

Section III: Communication for Patient Comfort

- Examining if and how HCPs can be trained in therapeutic communication with the use of patient-embodied VR experiences.

Section IV: Communication and Team Culture in clinical practice

- Analyzing team rapport and non-verbal communication among HCPs in clinical practice.
- Developing and validating a VR experience designed to help new medical interns navigate communication challenges and adapt to the OR environment.

To achieve these objectives, this thesis follows a structured approach: first, establishing the theoretical foundation for using VR in communication training; second, developing novel VR simulations tailored to each domain; third, validating their usability in a clinical setting; and finally, implementing these VR experiences in real-world medical training programs.

By addressing these three domains, this research provides a comprehensive analysis of how VR-enhanced training can equip HCPs with essential communication skills, ultimately improving patient care and team dynamics in clinical practice.

Methodology

The research methodology employed in this thesis are quantitative and qualitative, with a strong emphasis on user-centered design (UCD) and phenomenological approaches. For the development of the VR simulation prototype (section II), iterative design cycles were informed by feedback from multidisciplinary expert teams, employing qualitative techniques such as interviews, focus groups, and prototype testing. The embodied VR experiences (section III) were assessed and validated through semi-structured interviews with healthcare providers, analyzed using thematic analysis to capture the lived experiences and impact on therapeutic communication.

Structure of the Thesis

This thesis is organised into three main sections, each addressing a specific domain of clinical communication and how it can be enhanced through simulation-based education and immersive VR. Across eight chapters, it explores how VR tools and embodied experiences can be validated and used to train healthcare professionals in complex communication tasks.

Section II: Communication in High-Stress Situations

This section investigates how VR simulations can help HCPs develop communication skills for managing stressful clinical scenarios, with a focus on improving situational awareness, decision-making, and teamwork during crises.

- **Chapter 1** gives an overview of how simulation in anaesthesiology is applied in practice, illustrating how active learning experiences support the acquisition of both technical and non-technical skills.
- **Chapters 2A, 2B, and 2C** present the development and validation of the first prototypes of a VR simulation for anaesthesia training.

Section III: Communication for Patient Comfort and Anxiety Reduction

This section examines how VR-based embodied experiences can be used to train HCPs in therapeutic communication, with the aim of fostering patient-centered care and reducing preoperative anxiety.

- **Chapter 3** introduces the core message that *a good intention does not suffice*, illustrating the subtle yet powerful effects of language and suggestion in healthcare settings.
- **Chapters 4A, 4B, and 4C** investigate the development, validation and use of patient-embodied VR to increase awareness of therapeutic communication strategies.
- **Chapters 5A and 5B** outline the study protocol and results of integrating the VR experience into a communication training in the acute admission ward.
- **Chapter 6** describes the use of this training format, combined with other non-pharmacological interventions, to decrease patient anxiety in the preoperative holding area.

Section IV: Communication and Team Culture in the Operating Room (OR)

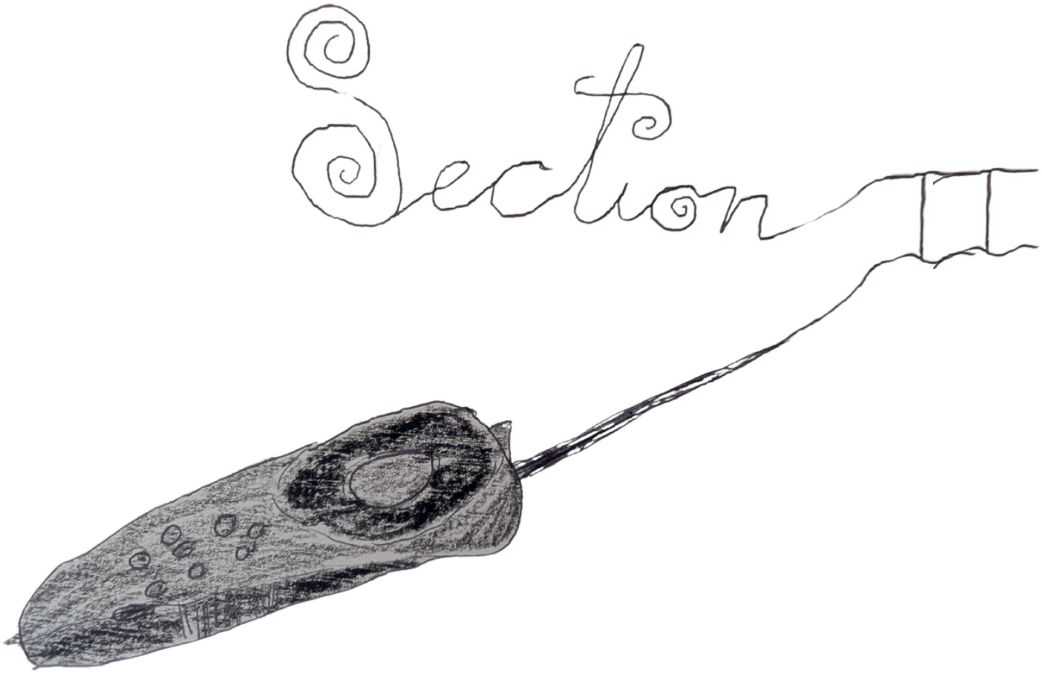
This section explores communication skills and team dynamics in the OR, focusing on non-verbal rapport and the hidden curriculum that shapes team culture and intern enculturation.

- **Chapter 7** investigates the non-verbal elements of rapport in the OR, and how these influence team cohesion and trust.
- **Chapter 8** focuses on the adaptation of new medical interns to OR team dynamics, describing the development of VR-embodied experiences designed to expose and reflect on the hidden curriculum in the surgical setting.

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Communication in High-Stress Situations

1

FROM THEORY TO PRACTICE: SIMULATION IN ANAESTHESIOLOGY THROUGH ACTIVE LEARNING EXPERIENCES

ARTICLE INFO

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Keywords:

Simulation,
Immersive learning,
Proteus effect,
Medical education,
Crew resource management,
IVEs,
Immersion,
Human factors,
SBLE,
EPA,
SBE

DOI: https://doi.org/10.1007/978-3-031-88705-5_3

Intelligent Human Computer Interaction



29 May 2025
Pages 29-40

ABSTRACT

Simulation training has emerged as a cornerstone of medical education in anesthesiology, providing an immersive and experiential learning environment for healthcare professionals in training. In recent years, virtual reality has introduced a groundbreaking paradigm to simulation-based training, uncovering many benefits for educational developers, teachers and learners. By enabling high-fidelity practice in situational awareness, decision-making, and multitiered response systems, VR offers an ecological training platform for clinical skills within a safe yet highly authentic environment. This article offers an overview of the current landscape of simulation education in medical settings, addressing challenges faced by educational developers. Additionally, this study provides a comparative analysis of more traditional manikin-based simulations and VR simulations, highlighting their respective strengths and limitations in medical training.

INTRODUCTION

Simulation in medical education serves as a cornerstone in preparing anesthesiologists for their future roles by equipping them with essential knowledge and skills. Simulation is a methodology, rather than a technology, aimed at substituting or enhancing real experiences with guided experiences. Central to this preparation is the utilization of clinical scenarios to foster effective learning (1-3). Simulation-based learning experiences (SBLE) have emerged as a pivotal tool, offering a secure environment for trainees to gain practical experience in managing medical emergencies or rare complications within a controlled setting, thus minimizing risks to real patients (4-6).

For anesthesiologists, managing acutely deteriorating patients demands a combination of technical and nontechnical skills within high-stress and unpredictable settings. Technical competencies include skills such as tracheal intubation, difficult airway management, vascular catheter placement, and regional anesthesia. Extensive medical knowledge covers applied physiology, differential diagnoses and drug dosages. Nontechnical skills may include action triage, effective teamwork and crisis resource management (CRM) (7). Crisis resource management is part of human factor competencies and refers to interpersonal and cognitive behaviors that contribute to optimal team performance. CRM originated in the aviation industry, where human error was established to be a major cause of aviation accidents in the 1970s (8). Crucially, proficiency in situational awareness, decision-making, teamwork, communication, and leadership, as underscored by the Institute of Medicine Committee on Quality of Health Care, remains indispensable in clinical practice. Improved patient outcomes often depend on the implementation of multitiered rapid response systems, underlining the importance of effective CRM training (9). Weller established the ecological validity of simulated CRM training in anesthesiology training (10).

The process of learning encompasses internal changes in learners' attitudes, beliefs, behaviors, and knowledge acquisition (2). Effective medical education demands adaptability from educational developers to meet the evolving demands of the healthcare landscape. Traditional pedagogical approaches, such as didactic lectures and bedside demonstrations, have long been relied upon; however, they present limitations, including minimal learner engagement and insufficient development of practical competencies tailored to diverse learning styles. Recognizing that knowledge is constructed within social contexts, fostering active engagement among learners becomes paramount (2, 11). Kolb's experiential learning cycle provides insights into the cognitive processes essential for skill development, offering a framework for effective teaching and learning (12).

As technology advances, new modalities like virtual simulations, and game-based learning have emerged. While these methods offer advantages, their add-on effectiveness against traditional teaching modalities such as clinical courses or bedside teaching, and their impact on clinical skill development remains uncertain. Thus, rigorous evaluation of these newer methods becomes imperative as they gain widespread adoption.

This research article seeks to elucidate the rationale for evaluating new simulation modalities amidst limited existing evidence. By exploring educational theoretic frameworks and elucidating the effectiveness of different teaching modalities, educational developers, educational institutions, and policymakers can design curricula that effectively cultivate the future generation of competent anesthesiologists.

Design

The current study evaluates two simulation modalities—manikin-based and VR-based—through a comparative analysis focused on their respective advantages in terms of fidelity, educational impact, and practical feasibility. This framework is intended to provide insights for educators and curriculum developers to inform the design and implementation of simulation-based education programs that effectively address the diverse learning needs in anesthesiology training. Additionally, the study examines the current state of simulation education, challenges associated with each modality, and potential solutions for optimizing future applications of these simulation methods.

Current State of Simulation Education

Manikin-based simulation

The gold standard of current simulation education in anesthesiology is manikin simulation. It generally involves an initial instructional briefing, explaining the clinical case and roles of participants, a lived simulation experience where participants work on the case study with the guidance of the trainer, followed by a debriefing phase allowing participants and trainers to evaluate the simulation, as shown in **Figure 1**.

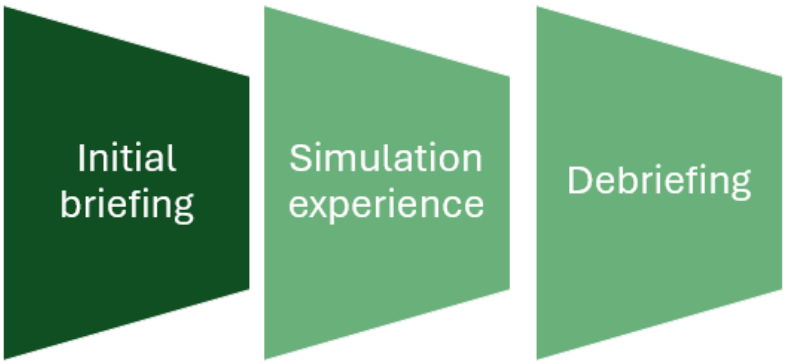


Figure 1. Manikin simulation

The initial briefing serves multifaceted pedagogical purposes. First, they are instrumental in elucidating the overarching goals of exercise. By outlining specific learning objectives, participants gain clarity on what skills or knowledge they are expected to acquire or improve upon during the simulation. This enhances participant engagement and facilitates targeted learning outcomes (13). Moreover, they allocate distinct roles to participants, fostering a collaborative learning environment. Each participant is encouraged to actively contribute their insights, observations, and reflections during the simulation experience. Through this participatory approach, participants may benefit from diverse perspectives offered by their peers.

The simulation experience itself, guided by a trained facilitator or trainer, serves as a pivotal pedagogic tool in manikin simulation training. Unlike more traditional didactic methods, simulations immerse participants in realistic scenarios, providing them with hands-on experience in a controlled but authentic environment. Under the guidance of the trainer, participants navigate through various clinical challenges and decision points, applying theoretical knowledge to practical situations. This experiential learning approach enables participants to bridge the gap between theory and practice by practicing their critical thinking, problem-solving, and decision-making skills. By actively engaging in simulated scenarios, participants develop the confidence and competence necessary to handle similar situations in real-world settings. According to the principles of cognitive load theory (CLT) (14), there is a limit on how much information one can process simultaneously, impacting information storage and retrieval. A trainer may not know beforehand how the trainees will perform during the scenario; hence, he/she may not know beforehand how they want the scenario to evolve. This highlights the importance of the adaptability of a scenario that is possible with manikin simulation, enabling a more effective and valuable learning experience.

Following the simulation experience, debriefing sessions offer participants an opportunity to reflect on their lived experience and evaluate their performance. Unlike traditional evaluations, which may focus solely on outcomes, debriefing encourages participants to delve deeper into their thought processes, emotions, and actions during the simulation (6). During debriefing, both participants and the trainer engage in a comprehensive evaluation of the simulation experience. Participants articulated their thoughts, feelings, and reactions to the scenario, identifying strengths, areas for improvement, and lessons learned. This reflective process may enhance self-awareness and self-directed learning. By leveraging the expertise of the trainer, participants gain valuable insights into best practices, evidence-based strategies, and alternative approaches to problem solving. Through this collaborative endeavor, manikin simulation training achieves its pedagogic objectives of enhancing clinical skills, promoting teamwork, and ultimately improving patient outcomes (15, 16).

VR-based simulation and game-based learning

VR is a computer-generated simulation of an environment that immerses users in a simulated three-dimensional, interactive experience. Immersive VR uses a head-mounted display projecting in front of the eyes, allowing users to focus on display without interaction with the outside world. It offers novel capabilities that provide new qualitative support for educators and trainees, as it can be used independent of geography, time and space, and it is cost-effective (17, 18).

Immersive VR can produce a visceral feeling of being in a simulated world, a form of spatial immersion called *presence* (17, 19). Additionally, in virtual interactions, participants' avatars can affect their attitude, perception and behavior in conscious or unconscious matter, which is known as the *Proteus effect* (20, 21). Users tend to align their behavior with the traits of their avatars, adapting to virtual identities that may differ from their real-life selves. For instance, individuals who embody avatars with physically attractive features tend to engage in more confident and assertive behavior, mirroring the perceived traits of their avatars (22).

Today's VR simulation programs often use preset scenarios (23-26). Standardized patients (SPs) or standardized scenarios have been utilized for procedural skills assessment and nontechnical skills development (18). Prewritten scenarios offer a structured approach to medical training and assessment. These scenarios are designed to replicate diverse clinical encounters and challenges, providing learners with opportunities to practice decision-making, critical thinking, and teamwork in a controlled environment. Especially in the case of learning strict protocols, such as cardiopulmonary resuscitation and basic life support training, VR simulation programs are apt to create easy standardized assessment options (27, 28).

Current VR simulation programs generally encompass an initial possibility to learn how to train in VR simulation, which is also called onboarding (29). After this initialization, participants often receive an online briefing describing the clinical scenario and roles, followed by the VR simulation and evaluative debriefing, as depicted in **Figure 2**. The briefing and debriefing are generally digitalized, with little interaction with the trainer (27, 28, 30).

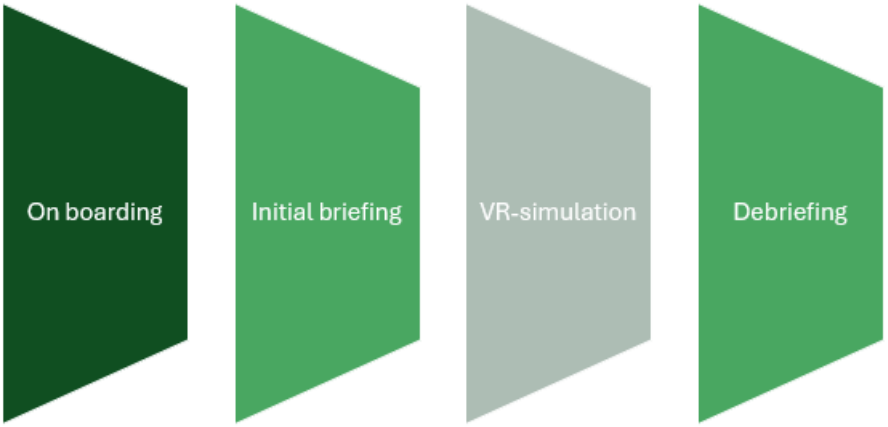


Figure 2. VR simulation

Challenges in Simulation Education

To address the challenges encountered during simulation-based learning experiences, we explore key educational aspects that can impede effective learning experiences and their specific implications for both manikin and VR simulations, as shown in **Figure 3**.

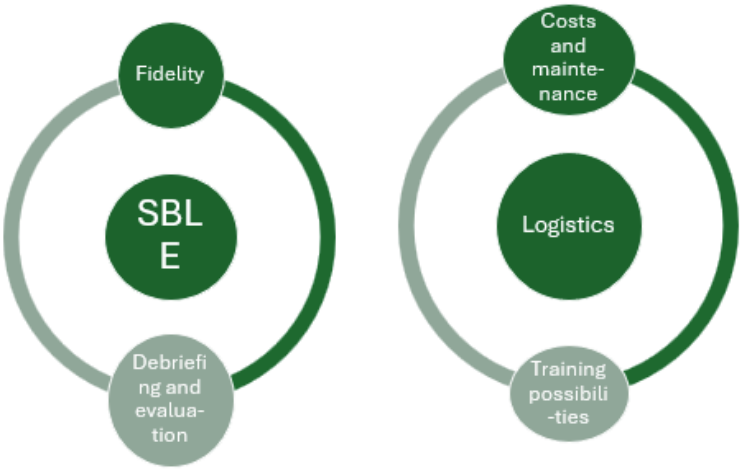


Figure 3. Schematic view of key elements of simulation-based learning experiences (left) and their logistical challenges (right). SBLE: simulation-based learning experience.

Simulation-based learning experience

By adopting a constructivist framework, realism enhances the active learning process. Both manikin simulation and VR simulation are designed to be as real as possible, enabling the feeling of *presence* and immersion. *Fidelity* refers to how accurately the simulated world reflects the real world. In VR simulations, a higher degree of freedom (DOF) refers to the range of motion or movement. Modern VR allows movement along three axes (x, y, z) and rotation around those axes (6-DOF), providing a high-fidelity, generally well-tolerated system that limits simulation nausea or sickness. Another adaptation to VR can be provided by a sufficient amount of time to adapt to the simulator conditions (31).

Fidelity and immersion

Higher fidelity simulators are able to provide physical, psychological, and conceptual fidelity (32).

Physical fidelity

Physical fidelity is facilitated by audio, kinesthetic, and visual elements. Kinesthetic and tactile feedback remains a challenge in both manikin simulation and VR simulation. Technical procedures in simulation often lack the true skin and tissue feedback experienced by real patients. To address this issue, manikin simulations are incorporating more sophisticated materials, such as soft plastic and rubber, to better mimic human skin and tissue. Similarly, VR simulations are advancing with controllers featuring various tactile feedback options and the emergence of hypersensitive haptic gloves to enhance the sense of touch and realism within virtual environments.

Psychological fidelity

Psychological fidelity pertains to the extent to which a simulation activity elicits emotional responses from participants as if the experience were real. In manekin-based simulations, achieving psychological fidelity can be challenging due to the inherent artificiality of the physical environment and limitations of simulator manikins, which may hinder full immersion and emotional engagement. Similarly, in VR simulations, challenges in psychological fidelity may arise from issues such as simulation sickness, technical constraints, and limitations in creating truly immersive virtual experiences that evoke genuine emotional responses.

Conceptual fidelity

Conceptual fidelity reflects the essential principles, behaviors, and relationships inherent in real-world systems. As CRM revolves around effective team communication, the conceptual fidelity of group interactions plays a crucial role. Manikin simulation easily enables group training sessions. Up to six participants may train in the same space. This facilitates effective communication, that is, communication with the message being understood as intended. Challenges in manikin simulation related to conceptual fidelity may include limitations in scenario design and the veracity of patient simulators, which may impact the accuracy and authenticity of the simulation. In VR simulations, challenges in conceptual fidelity may stem from the complexity of accurately representing authentic scenarios in virtual environments, requiring careful scenario design and content expert input to ensure fidelity to real-world principles and behaviors. Additionally, CRM training requires high-fidelity avatars that are able to reflect realistic facial expressions and non-verbal and para-verbal elements associated with effective information exchange (33, 34).

Evaluation and debriefing

Standardized evaluation

Assessment of clinical competency has evolved, favoring the "performance as competence paradigm" over traditional assessments based solely on theoretical knowledge. Entrusted professional activities (EPAs) translate competence-based training into manageable entities describing the knowledge, skills, and attitudes needed to perform an activity. EPAs have been used for standardized specialist training. Throughout the curriculum, EPAs are being incorporated, and according to explorative studies, they can be effectively evaluated in simulation-based education (35, 36).

However, insufficient research has been conducted on the implementation of EPAs within the curriculum of anesthesia residents in simulation education. Whether EPAs can be successfully used in manikin-based or VR simulations has yet to be validated.

Debriefing

Simulation debriefing is a crucial element of effective learning experiences (37). Debriefing is a guided reflection on emotional and simulation experiences, learning outcomes, and possible plans for action. It is strongly underpinned by the experiential learning model theory of Kolb, which facilitates reflective observation, abstract conceptualization, and active experimentation (12).



Figure 4. Kolb's experiential learning model

However, a lack of psychological safety or ineffective debriefing may impede its effectiveness (38). Debriefing can be facilitator-guided or self-guided, and it can occur during or after a simulation (39). Debriefing heavily relies on the competence of the debriefer in the case of facilitator-guided debriefing. An effective debriefer acts as a facilitator, guides reflective learning, creates a safe learning environment, and encourages self-reflection. Although several conversational structures may be used, they all highlight the importance of guiding from the beginning, examining events, and summarizing possible learning points (39).

Cognitive aids such as cue cards may facilitate self-assessment practices and are commonly used for anesthesiology training programs.

Traditional manikin-based simulation settings typically involve facilitator-guided in-person debriefing sessions, as participants are physically present. However, VR simulations may involve participants who are not in the same room, who necessitate a virtual debriefing room, or who use self-guided debriefing methods. Research does not prioritize one method over the other, and effective teaching of nontechnical skills can be achieved through formative self-assessment (40).

Organization

Costs and maintenance

The adoption of VR technology can be limited due to the high upfront costs of purchasing the hardware and software needed. A cost analysis was performed by Mills et al., indicating that VR training is more economically advantageous than manikin-based simulation (41). Although there is insufficient evidence to demonstrate clear cost-effectiveness, many research studies indicate that VR techniques are cost-effective (17, 42, 43).

The costs of manikin training are high due to the initial investment required for purchasing the manikins themselves, as well as ongoing expenses for maintenance and repair in case of damage (44). Additionally, there are costs associated with replacing consumable items used during training sessions, such as medical supplies and equipment.

Training possibilities

Manikin-based simulation has certain limitations, particularly concerning training logistics. It requires scheduling anesthesia residents and trainers to be available during working hours and securing access to the simulation room, which must remain unoccupied during the training session. Coordinating all individuals to be present in the same place at the same time can be challenging. Hygienic restrictions may further complicate manikin-based simulation, as was evident during the COVID-19 pandemic, when individuals were not allowed to be in a small room together.

In contrast, VR offers the potential for remote training, allowing participants from different centers to participate. Moreover, VR simulations can be conducted independently of real-time participation by trainers because of the availability of asynchronous preset VR simulations. These features alleviate some of the logistical challenges associated with manikin-based training and offer more flexibility in training opportunities.

DISCUSSION AND CONCLUSION

Discussion

In traditional clinical environments, the focus on patient safety often limits student-centered learning opportunities. Simulation activities offer a unique opportunity to tailor learning experiences to students' needs while maintaining a safe environment for skill development. The transferability of learning in simulations is of prime interest to educators. Simulation activities that closely resemble real life add a degree of authenticity that allows learners to use the knowledge and skills they develop in the simulated setting and apply them in the clinical arena.

In discussing the current state of simulation education, it is evident that both manikin-based simulation and VR simulation offer unique advantages and face distinct challenges. Manikin simulation provides a realistic physical representation of team members, fostering hands-on practice of clinical skills and teamwork. However, its fidelity is limited, particularly in terms of psychological and conceptual aspects. Conversely, VR simulation offers an immersive learning environment with significant potential for scalability. The ability to implement standardized scenarios can be advantageous in strictly protocolled procedures such as advanced life support training. However, this standardization may be disadvantageous for more sophisticated training, where the adaptability of the simulation is crucial for optimizing cognitive load and nontechnical skills training, such as CRM training. Additionally, VR simulation involves initial cost barriers and challenges related to simulation sickness and the adaptability of scenarios.

However, educational developers must carefully balance fidelity levels because high fidelity does not always equal better performance (32, 45). Therefore, thoughtful planning is crucial to avoid the misuse of resources and maintain a balanced cost–benefit ratio in simulation-based education.

The ultimate goal of simulation education should be to improve learning outcomes. Although extensive research indicates that simulation education can enhance residents' skills, knowledge, and behavior, there is limited evidence to suggest that it directly leads to better learning outcomes. In this light, the Kirkpatrick model classifies different levels of educational intervention outcomes and is commonly used to evaluate training (46, 47).

Conclusion

Simulation-based education, encompassing manikin or VR modalities, is pivotal in medical training, offering a controlled, safe environment for skill acquisition and refinement. While manikin simulations excel in providing realistic, hands-on practice, their limitations in fidelity and high operational costs cannot be overlooked. VR simulations, on the other hand, offer immersive and scalable training solutions, albeit with challenges related to initial costs and achieving high psychological fidelity in team training.

To maximize the benefits of simulation-based education, educational developers must consider the balance between the fidelity of simulations and their practical implementation. High-fidelity simulators should be critically assessed to determine whether they offer significant educational advantages over low-fidelity models. Both mannekin-based simulation and VR simulation can complement each other.

There are several ways in which VR can complement manikin-based simulation education. Collaboration among institutes can expand access to VR training, while standardized scenarios and assessment tools ensure consistency. Integrating simulation training into competency-based frameworks such as EPAs provides a structured approach to skill development.

Future research should focus on integrating simulation training into competency-based frameworks such as EPAs to provide a structured approach to skill development and evaluate improvements in patient outcomes. By leveraging the strengths of both manikin and VR simulations, medical education can be enhanced, which may ultimately lead to improved patient outcomes and more competent anesthesiologists.

Acknowledgments and disclosure of interests.

The authors have no competing interests to declare that are relevant to the content of this article.

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2A

BEYOND MANIKINS: VIRTUAL SIMULATION TRAINING IN A POST-COVID ERA

ARTICLE INFO

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Keywords:

VR-Simulation,
COVID-19
Immersive Learning,
Immersive VR, Proteus Effect,
Medical Education,
Crisis Resource
Management,
User-Centered Design.

DOI: 10.1111/medu.15685

Medial Education

medical education

Volume 59, Issue10
ISSN 0308-0110
October 2025
Pages 1127-1128

SHORT PUBLICATION

The study explored virtual reality as a solution for anaesthesiology residents' training during the COVID-19 pandemic, which disrupted traditional simulation sessions. Partnering with Saxion University of Applied Sciences, Leiden University Medical Center developed a VR training tool with customizable patient conditions to meet various learning needs. The tool was tested by 15 residents and educators, gathering feedback on its effectiveness, realism, and user experience. Despite challenges like onboarding of users to the virtual space, iterative improvements were made based on user input. The collaboration, along with support from the anaesthesiology department, paved the way for broader validation, showing that VR could be a valuable and scalable training tool for anaesthesiology.

1 WHAT PROBLEMS ARE ADDRESSED?

Anaesthesiology residents at Leiden University Medical Center regularly undergo simulation training with a full-body manikin. This is a vital aspect of the clinical programme providing a stressful yet safe environment for effective critical resource management (CRM) training. Unfortunately, the COVID-19 pandemic made real-life simulations challenging due to organizational and preventive measures.

As a result, we explored asynchronous training opportunities utilizing a multiplayer virtual reality (VR) simulation. VR simulations can create personalized scenarios, facilitating differentiated learning through enhanced sensory immersion. VR offers full immersion with a high potential for visual effects, simultaneously allowing changes in patient characteristics such as sex, weight, external trauma and age, which is impossible with regular manikin training.

The three-step approach involved (I) identifying user requirements, (II) developing a prototype and (III) assessing the project's viability and interest for expansion.

2 WHAT WAS TRIED?

To achieve our objective, a collaboration was set up between the LUMC and the Extended Reality lab at Saxion University of Applied Sciences. The latter institute is highly experienced with VR and XR as educational tools. A user-centred design (UCD) approach was used, involving a multidisciplinary expert team throughout the development process to guide design decisions, incorporating failure modes and effects analysis (FMEA) (1)

I: Identification of user requirements included the identification of a workflow for all basic components of the VR application.

II: Development of the prototype with adaptable physiological features, allowing the trainer to modify them via a trainer dashboard in a multiplayer setting. This adjustment was deemed necessary to enable the adaptation of the scenario for any trainee with learning objectives in CRM, in line with the principles of cognitive load theory.

III: Assessment included the collection of qualitative and quantitative data through observations, group interviews, and questionnaires, evaluating user experience among around 15 residents and clinical educators in line with Kirkpatrick's first evaluation level. Key concepts assessed were overall enjoyment, interaction with the hardware, physical discomfort, presence, virtual embodiment, acceptability and perceived effectiveness.

3 WHAT LESSONS WERE LEARNED?

Prototype iterations were systematically tested in simulated settings, followed by expert debriefings and FMEA. Each cycle informed design enhancements, ensuring usability and training effectiveness. Adjustments continued iteratively until the prototype was deemed optimized. User evaluations revealed that medical interns and clinical educators believed in the potential and usefulness of the VR simulation as a learning tool for CRM.

Encountered challenges included onboarding in the virtual environment requiring participants to familiarize themselves with effective navigation within the virtual space.

Another challenge involved translating clinical needs into programming possibilities outlined by the developers. This continuous need for translation persisted between user requirements and technical capabilities. Integration of simulation with UCD and FMEA facilitated design and redesign of the prototype.

The anaesthesiology department provided full support, and a collaborative partnership was made with another university medical center to facilitate further validation and broader implementation for other institutions enhancing scalability.

AUTHOR CONTRIBUTIONS

K. Hoek: Conceptualization; investigation; funding acquisition; writing – original draft; methodology; validation; visualization; writing – review and editing; software; formal analysis; project administration. M. van Velzen: Conceptualization; supervision; writing – review and editing. C. Jaschinski: Conceptualization; investigation; project administration. E.Y. Sarton: Conceptualization; supervision; resources.

CONFLICT OF INTEREST STATEMENT

None.

ETHICS STATEMENT

The protocol was approved by the Institutional Science Committee, received a waiver to be performed by the Institutional Review Ethics Committee (METC Leiden the Hague Delft, Leiden, the Netherlands) and adhered to GCP regulations. Written informed consent was obtained from all participants. Participants received no financial compensation.

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2B

DEVELOPMENT OF A REAL-TIME ADAPTABLE VIRTUAL REALITY SCENARIO TRAINING FOR ANAESTHESIOLOGY EDUCATION, A USER-CENTERED DESIGN

ARTICLE INFO

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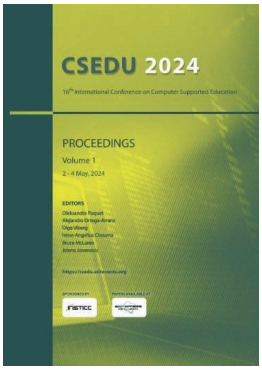
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Keywords:

VR-Simulation,
Immersive Learning,
Immersive VR,
Proteus Effect,
Medical Education,
Crisis Resource
Management,
User-Centered Design.

DOI: 10.5220/0012755600003693

Serious Games for Education



Volume 1
ISSN 2184-5026
ISBN 978-989-758-697-2
May 2024
Pages 751-757

ABSTRACT

Simulation training in medical settings has becomepivotal in clinical education. Virtual reality (VR) presents a novel approach to simulation, offering numerous advantages for both trainers and trainees by facilitating high-fidelity practice in situational awareness, decision-making, and multitiered response systems within a safe yet stressful environment. This paper outlines the development of a multiplayer VR simulation prototype tailored for anaesthesiologist-intensivists, with input from a multidisciplinary expert team throughout the process. Trainers can dynamically adjust patient physiological parameters, enabling training in crisis resource management under pressure. Following a user-centered design (UCD) methodology, iterative design cycles involve experts adapting a Failure Modes and Effects Analysis (FMEA) to prioritize trainee and trainer needs. User feedback, gathered through various qualitative and quantitative UCD techniques such as interviews, focus groups, and prototype testing, informs each iteration. Three simulation prototype versions underwent evaluation, incorporating simulation settings, debriefing sessions, and FMEA analysis. Feedback informed iterative design improvements until thematic saturation was reached, culminating in the creation of an initial prototype. This paper aims to detail the development process of a VR scenario training program, geared towards immersive simulation learning.

INTRODUCTION

One of the cornerstones of medical training is clinical scenario training using an environment to learn effectively (1, 2). Simulation based learning provides a safe learning space where healthcare providers can gain experience on medical emergencies or rare complications in a controlled setting without putting real patients at risk.

Especially for anaesthesiologists/ intensivists, management of a patient who is acutely deteriorating requires excellent technical and non-technical skills in a highly stressful and chaotic environment. Technical skills may include tracheal intubation, difficult airway management, vascular catheter placement and regional anaesthesia. Also, sufficient medical knowledge of differential diagnoses, drug dosages, triages of possible actions, and crisis resource management are crucial and may be lifesaving. Situation awareness, decision making, teamwork, communication and leadership are indispensable skills in clinical practice outlining the importance of human factors (3). Improvement in patient outcome may come from multitiered rapid response systems.

Knowledge is constructed in social contexts and students need to be active learners rather than passive recipients of knowledge (1). Although several studies have shown the effectiveness of simulation-based training over the last decade (4), increasing pressure son budget and logistic limitations, needs for alternative methods of simulation have emerged. Also, current simulation programs may not have scenarios with real-time adaptation possibilities which are seemed to be required in order to create an immersive environment with unlimited training possibilities for personalization of the scenario (2, 5, 6).

Immersive Virtual Reality uses a Head-Mounted-Display (HMD) project in front of the eyes allowing users to focus on display without interaction of the outside world. It offers novel capabilities providing new qualitative support for educators and trainees as it can be used independent of geography, time and space, and it is cost-effective (7). Immersive VR can produce a visceral feeling of being in a simulated world, a form of spatial immersion called Presence (7, 8). Also, in virtual interactions, participant's avatars can affect their attitude, perception and behaviour in a conscious or unconscious matter known as the Protheus Effect (9, 10). However, there are also potential drawbacks such as limited haptic (tactile) feedback (11) and the absence of non-verbal cues in the trainees' digital avatars (7).

The main objective of this study is to develop a prototype of a VR-scenario training program for anaesthesiologists-intensivists. The VR-scenario training program is tailored to the needs and experience of the trainees and simulation trainers with a multidisciplinary

expert team involved throughout the development process and guide all design decisions. This paper will describe the development phase of our prototype.

METHODS

Study design

We've adapted a user centered design as it employs scientifically proven methodologies of human sciences to optimize designs of human-technology interface improving its proficiency and performance and is easy to use (12).

During the development phase, three simulation prototype iterations were made, each evaluated with a simulation setting, debriefing and Failure Modes and Effects Analysis (FMEA) (13). After every simulation, feedback was provided to the development team responsible for the VR environment. This feedback loop encompassed evaluation of the simulation setting, debriefing sessions, and analysis through FMEA. The VR developers then utilized this feedback to iteratively enhance the VR simulation. Subsequently, design iterations were made, and the modified prototype underwent testing and adaptation until thematic saturation was achieved. We adapted FMEA as it identifies possible system failures and vulnerabilities in complex processes to make a system more robust before an adverse event or problem occurs (13). It is a method to identify parts of the process most in the need of change. A multidisciplinary expert team for the FMEA process was selected including 5 steps: (1) team selection, (2) process identification, (3) process flow diagram preparation (4), failure mode identification, and (5) determination of an action plan.

For the evaluation phase which is beyond the scope of this article, we will assess content validity through qualitative and quantitative measures in an exploratory sequential design.

Participants and setting

The protocol was approved by the Institutional Science Committee of the Anaesthesiology science department and obtained a waiver from the Institutional Review Board (NWMO-LUMC).

Informed consent was obtained prior to inclusion, participation was voluntary and privacy rights were in alignment with the Declaration of Helsinki and GDPR guidelines. The multidisciplinary expert team for the FMEA process was designed to include anaesthesiologists-intensivists, trainers, human factor specialists and software VR design technical experts.

Participation was voluntary. Exclusion criteria included physical incapacity to use VR which was not encountered during the study. Participants did not receive a financial compensation.

Sample characteristics

Three healthcare providers participated, of whom one the project manager. Two were anaesthesiologists-intensivists, one was a resident. Together with two developers and one experienced researcher they assembled as the multidisciplinary expert team for the FMEA process.

Conceptual framework

Commonly, simulation consists of three components: an initial briefing with explanation of the upcoming scenario, the simulation experience and a debriefing where learners are provided with a crucially important opportunity to reflect on themselves and their team in order to improve future practice (14).

Today's VR simulation programs often use preset scenarios put into practice (5, 15, 16). Standardized patients (SPs) or standardized scenarios have been utilized for procedural skills assessment and non-technical skills development.

According to the principles of Cognitive Load Theory (CLT) (17), there is a limit on how much information one can process simultaneously, impacting the information storage and retrieval. A trainer may not know beforehand how the trainees will perform during the scenario; hence he/she may not know beforehand how they want the scenario to evolve. This outlines the importance of the adaptability of a scenario, enabling a more effective and valuable learning experience.

We've hypothesized our real-time adaptable VR-training program could fill in this gap as we wanted to create a program where a trainer could change the scenario in real-time.

Data collection and analysis

User feedback was collected through various qualitative and quantitative UCD techniques including contextual inquiry, interviews, focus groups, observations, questionnaires, walk-throughs and prototype testing.

RESULTS

Three simulation prototypes underwent evaluation by the multidisciplinary expert team encompassing FMEA sessions. An example of a FMEA session can be found in Table 1.

Table 1. Failure mode simulation session two

Concern	Severity category	Potential Active Failure	Action plan
Latency	Performance impact Participant experience	Potential Active Failure	Purchase powerful server.
Bumping into each other	Performance impact	Dizziness	IT adaptations within the VR.
Teleportation	Participant experience	Failure to immerse	Testing of different standalone HMD with limited space.
Onboarding	Perfor-mance impact	Physical	Use of standalone HMD without teleport-ation option,
Onboarding	Participant safety	Failure to immerse	Virtual onboard area with tutorial

VR-Simulation requirements

The VR- simulation was designed to be a fully immersive reality system, with auditory, visual, and tactile feedback, in real time adaptable by the trainer. This implies scenario's to be adaptable online, during the simulation. Patients' clinical presentation (skin color and rash, pupil dilation etc.), and paraclinical presentation (arterial tension, pulse oximetry, bispectral index measurements etc.) were available on the trainer's dashboard enabling a fully adaptable simulation training.

With an initial analytic phase of the UCD design, the multidisciplinary expert team produced a list of basic requirements divided in five major themes as shown in Table 2. The use of the MoSCoW prioritisation technique further classified these requirements (18).

Table 2. Basic requirements

Visuals patients	Patient morphology, age sex Anatomic details (facial hair, neck size, chin size, intra-oral anatomy)
Visuals avatars	Automated avatars Hand and eye movement
Visuals surgery	Laparoscopy Laparotomy
Equipment OR	OR table OR lights Respiratory machine Anesthesiologic equipment Surgical equipment
Multiplayer	1-5 players
Trainer dashboard	Adaptability of medical conditioning

The static requirements consisted of materials including airway devices, medication, and infusion equipment, as well as operating room equipment such as the operating table, lighting, and anaesthesiologic and surgical instruments used for procedures such as laparoscopy and laparotomy as shown in **Figure 1.**



Figure 1. view of a photo (A), the digital design (B), and the incorporation in the virtual OR environment (C).

Requirements of the visuals of the patients were morphological features as shown in **Figure 2**. Anatomic details such as facial hair, neck size, chin size, intra-oral anatomy needed to be well designed to enhance a high level of fidelity.



Figure 2. View of a patient with high resolution facial details

Furthermore, dynamic requirements encompassed procedures such as intubation, both standard and alternative techniques, and the placement of intracorporal catheters such as an intravenous line, intra-arterial catheter, stomach siphon, or central venous catheter.

Additional dynamic requirements included patient positioning, administration intravenous (IV) medication, and other related considerations. An extensive overview of these items can be found in the Appendix.

VR-Simulation requirements

The multidisciplinary expert team employed a collaborative approach to construct flow diagrams to depict dynamic interactions of which an example is depicted in **Figure 3**. This iterative process involved the utilization of various media, such as videos captured in the operating room, detailed descriptions, and photographs, among others, to facilitate communication between the different parties involved.

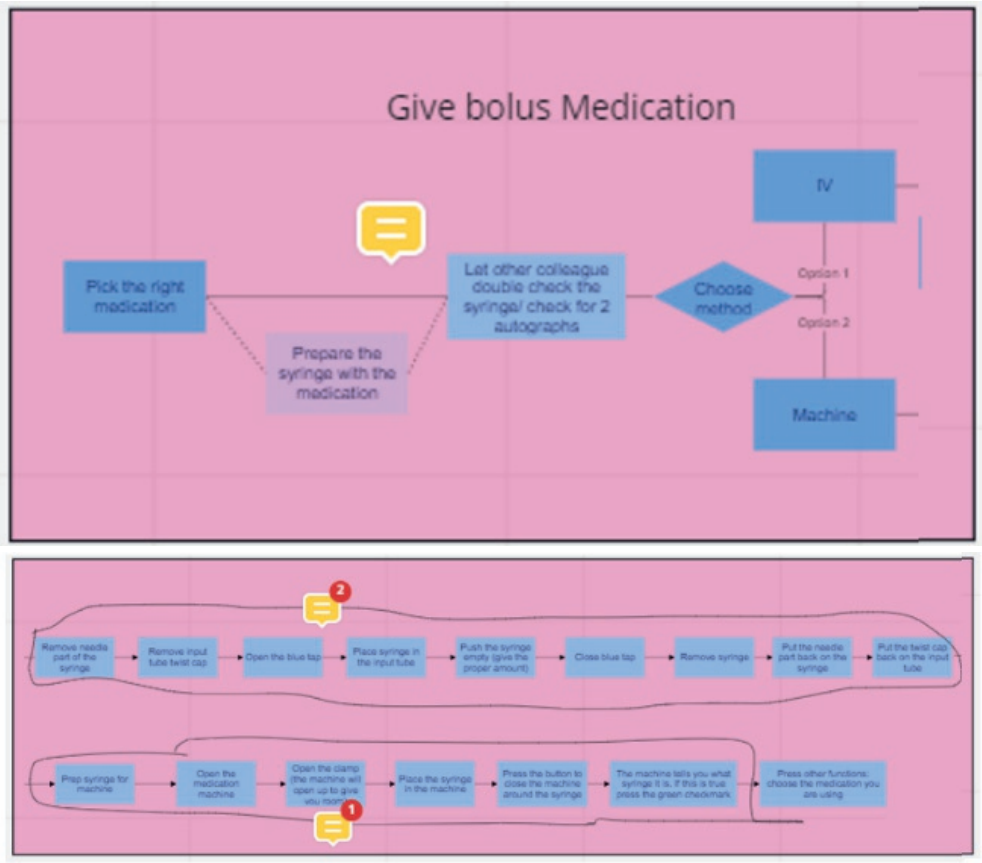


Figure 3. View flow diagram of a bolus gift medication

DISCUSSION AND CONCLUSION

This paper provides useful information on the development of a prototype of VR-scenario training program with the potency of Experiential Learning with VR. It may contribute to further research and healthcare educational programs avid to use immersive simulation learning with VR. A real-time adaptable program may fully optimize learning processes and adds flexibility within the scenario's.

Future research on the prototype, employing UCD techniques, is crucial to further validate its effectiveness through iterative cycles of evaluation, utilizing Kirkpatrick's evaluation model (19-21). This evaluation model assesses the prototype's potential impact on four levels: (a) participants' reaction to the training, (b) participants' learning outcomes from the training, (c) participants' behavioral changes resulting from the training, and (d) the subsequent organizational impact stemming from participants' changed behavior. Additionally, it also considers (e) the economic benefits or overall human welfare derived from the training (19-21).

GRANT ACKNOWLEDGEMENT

This work was supported by the Tech For Future, Centre of Expertise on research in High Tech Systems and Materials.

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APPENDIX

This appendix gives an extensive overview of the static and dynamic requirements of the VR simulation.

The requirements are annotated with the of the MoSCoW prioritisation.

Static requirements included anaesthesia supplies, airway supplies, operating room supplies, surgical procedures.

	STATIC
	Anaesthesia supplies
Must	Intravenous infusion (IV) sets in pink, green, blue, yellow, and orange
Should	Subcutaneous needle
Could	Tape
Will not have	Intravenous deep catheter
	Airway supplies
Must	Size 6 oropharyngeal tube
Should	Size 7 oropharyngeal tube
Could	Size 8 oropharyngeal tube
Will not have	Size 3 laryngoscope
	Operating room supplies
Must	IV stand
Should	Infusion pump filled with syringes
Could	ECG electrodes
Will not have	Blood pressure cuff
	Surgical procedures
Must	Laparotomy (in supine position): vertical incision
Should	Laparoscopy (in supine or (anti)Trendelenburg)
Could	Laparotomy in pregnant patients (horizontal incision)
Will not have	Limb surgery
	DYNAMIC
	Anaesthesia supplies
Must have	IV infusion sets in pink, green, blue, yellow, and orange
Should have	Subcutaneous needle
Could have	Tape
Will not have	IV catheter
	Airway supplies
Must have	Size 6 oropharyngeal tube
Should have	Size 7 oropharyngeal tube
Could have	Size 8 oropharyngeal tube
Will not have	Size 3 laryngoscope

	Operating room supplies
Must have	IV stand
Should have	Infusion pump filled with syringes
Could have	ECG electrodes
Will not have	Blood pressure cuff
	Surgical procedures
Must have	**Placement of IV line** Applying a tourniquet Finding a visible vein (lightly tapping on vein, asking patient to make a fist) Cleaning the skin Opening IV packaging Placing IV catheter Securing the catheter with tape Connecting IV bag to IV line **Administration of bolus medication** Opening the cap or valve and attaching the syringe Pushing the plunger Administration of continuous medication -Medication is in a pump that is connected to the IV line Selecting "speed" and "amount" of medication, then confirm **Placement of vital monitoring** (after connecting to the monitor, values are also visible on the screen) BIS -Placing BIS stickers on forehead -Connecting to BIS monitoring ECG: Placement of 5 electrodes -Connection to ECG monitoring Blood pressure -Placement of blood pressure cuff -Connection to monitoring Pulse oximeter -Placement of finger probe -Connection to monitoring **Intubation** Preoxygenation with placement of a mask on patient's face Induction of anesthesia: starting medication that causes patient to fall asleep Bag-valve mask ventilation Intubation -With laryngoscope -With glidescope -different views: View grade 1, View grade 2, View grade 3, View grade 4, View with vomit grade 1/2 **Positioning:** Table in Trendelenburg position Table in Anti-Trendelenburg position Placement of an additional rolled-up blanket under the neck (changes intubation conditions) Placement of arms along the sides Placement of arms on armrests Placement of sterile drapes with attachment to the anesthesia pole

	DYNAMIC
	Surgical procedures
Should	**Placement of arterial line** Palpate for pulses (inside pulse for radial artery) Sterilize the skin Injection of local anesthesia (2cc syringe with lidocaine, subcutaneous needle) Opening of arterial needle from packaging Placement of arterial needle (placement is successful: red blood returns from the hub) Withdrawal of needle Advancement of catheter Close the red cap Cover with tegaderm Connect arterial line Zeroing arterial line (optional)
	Removal of arterial blood Draw blood into arterial line hub Withdrawal of arterial blood Backflush blood from the arterial line hub Flush arterial line
	Warming Placement of upper body or lower body
	Administration of pressure infusion Place the infusion in a pressure bag Squeeze the air pump under the pressure bag.
Could have	**Placement of gastric tube** Placement of gastric tube through the nostril Advancement of the tube up to 55cm Suctioning the gastric tube will either show nothing (tube is likely misplaced) or green gastric contents (tube is in the right place) Taping the tube in place
Will not have	**Defibrillation** Placement of defibrillator pads (rhythm visible on defibrillator) Charging the defibrillator with adjustable joules Rhythm check
Should	**Placement of temperature probe** Placement of temperature probe through the nostril Connection to the monitor
Will not have	Placement of central line Placement of urinary catheter Placement of ultrasound-guided IV Placement of ultrasound-guided CVC Placement of ear oximetry Placement of TOF-CUF Measurement of neuromuscular blockade Blood draw from peripheral site Cell-saver Warming Connection to bear-hugger Activation of bear-hugger

2C

USER EVALUATION OF VIRTUAL REALITY SIMULATION FOR ANAESTHESIOLOGISTS-INTENSIVISTS FOR NON-TECHNICAL SKILLS

ARTICLE INFO

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Keywords:

VR simulation
Immersive learning
Immersive VR
Proteus effect
Medical education
Crew resource management
Kirkpatrick
Health communication skills
Virtual Reality

DOI: https://doi.org/10.1016/j.pecinn.2025.100441

Extended Reality in health promotion and health communication



Volume 7
ISSN 2772-6282
December 2025
Pages 100441

ABSTRACT

Objective Simulation training in medical settings is a cornerstone in medical education to practice technical and non-technical skills. The objective of this study was to evaluate user experiences and initial reactions to a multiplayer virtual reality simulation designed for anaesthesiologists. Methods A user-centred design approach guided the development of a VR-scenario training simulating a case of massive blood loss. Seven anaesthesiology residents and trainers from a Dutch academic hospital participated in qualitative and quantitative evaluations. Quantitative measures included questionnaires on presence, agency, physical dyscomfort, and perceived training value. Qualitative data were collected through structured observations and interviews. Results Participants reported a high sense of physical presence and moderate agency, with lower levels of self-presence. The VR environment was perceived as realistic and engaging. Challenges included unfamiliarity with VR controls, abstract avatars, and limited haptic feedback. Despite these barriers, participants recognized the potential of VR for team-based learning of non-technical skills, especially with prior onboarding or practice sessions. Innovation This study introduces a novel application of multiplayer VR simulation in anaesthesiology training, focusing on non-technical skills. The integration of user-centred design with qualitative and quantitative evaluation provides insights into the feasibility and acceptability of VR as an educational tool in this context.

INTRODUCTION

A fundamental aspect of medical education involves training through realistic clinical scenarios that enable healthcare professionals to develop their skills in a structured and safe learning environment (1, 2). Simulation-based learning creates a controlled environment where healthcare providers can safely practice responding to medical emergencies or rare complications, allowing them to gain valuable experience without risking patient safety.

For anaesthesiologists and intensivists, managing an acutely deteriorating patient demands a combination of technical and non-technical skills in high-pressure situations. These skills include procedures like tracheal intubation, airway management, and vascular access, along with crucial medical knowledge for diagnosing, dosing, and decision-making. Moreover, crew resource management (CRM), situational awareness, communication, and leadership are essential components of effective teamwork. Multitiered rapid response systems can significantly improve patient outcomes by coordinating timely and efficient interventions in critical moments.

In medical education, skill acquisition can be guided by the work of Cutrer (2017) who developed a conceptual model of Master Adaptive Learners (3). According to this model, clinical decision making may involve *routine expertise* based on specific knowledge and skills an expert has learned over time. On the other hand, *adaptive expertise* may be needed when "routine approach" is not working, and new concepts and solutions need to be sought. The mastery of both types of expertise creates an optimal adaptability corridor, necessary for optimal patient care.

Indeed, medical competency is constructed in social contexts and trainees need to be active learners rather than passive recipients of knowledge (2). Although several studies have shown the effectiveness of simulation-based training over the last decade, increasing pressure on budget and logistic limitations, needs for alternative methods of simulation have emerged. Many current simulation programs lack the ability to adapt scenarios in real-time, limiting their effectiveness in creating immersive training environments. Real-time adaptability is essential for providing personalized learning experiences that respond dynamically to the trainee's actions, allowing for a broader range of scenarios and deeper engagement in the training process (1).

Immersive virtual reality (VR) uses a head-mounted display (HMD) to fully engage users by isolating them from the outside world. It offers flexible, cost-effective training opportunities that can be accessed anywhere, enhancing learning experiences without the limitations of location or time (4). Artificial intelligence is used to visualise dynamic relationships in complex virtual environments. Immersive VR can produce a visceral feeling of

being in a simulated world, a form of spatial immersion called *Presence* (5). Also, in virtual interactions, participant's avatars can affect their attitude, perception, and behaviour in a conscious or unconscious matter known as the *Protheus Effect* (6, 7). A magnetic sensor inside the HMD feeds the magnetic sensor by informing about head or eye movements which changes the displayed graphics. However, there are also potential drawbacks such as limited haptic (tactile) feedback (8) and the absence of non-verbal cues in the trainees' digital avatars (4). How, and to what extend this influences the learning of communication skills is not known. Importantly, there is limited evidence on how anaesthesiologists themselves perceive and experience VR-based training, especially about communication and teamwork. Understanding their reactions is essential before broader implementation, since user acceptance will determine whether VR can realistically complement traditional simulation. This study therefore addresses a gap by systematically evaluating anaesthesiologists' initial experiences with a prototype VR training program.

In earlier work, we have described the feasibility and development of an adaptive VR-scenario training program for anaesthesiologists-intensivists (9). Key features of this VR-scenario training program include real-time adaptability of patient vital signs, a multiplayer environment for team-based crew management, trainer-controlled scenario adjustments during sessions as can be seen in **Figure 1.**

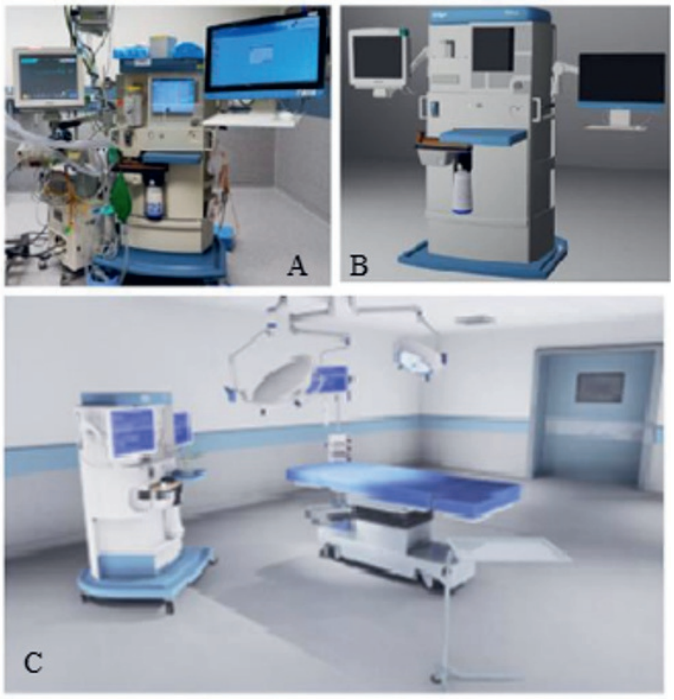


Figure 1. view of a photo (A), the digital design (B), and the incorporation in the virtual OR environment (C)

In this paper we describe the evaluation of our VR-scenario training program prototype, focusing primarily on Level 1 (Reaction) of Kirkpatrick's four-level training evaluation model as illustrated in **Figure 2** (10, 11). Specifically, we assessed participants' immediate reactions to the VR-scenario training program. Our secondary objectives also align with Level 1, as they included evaluating the perceived likability of the VR training and identifying any side effects experienced during its use. As a tertiary objective, we gathered participant recommendations for improving the prototype.

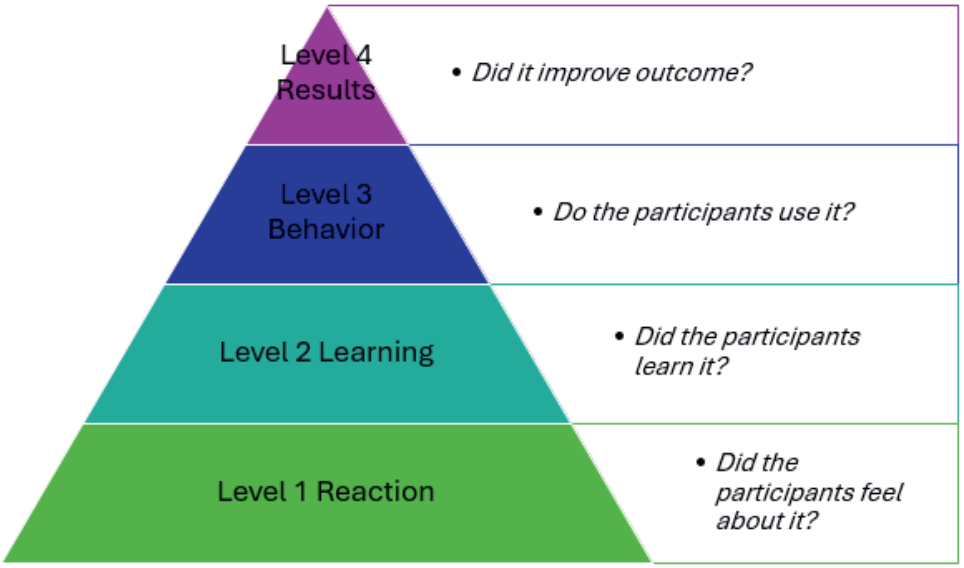


Figure 2. Kirkpatrick's four-level training evaluation model

METHODS

This research was carried out by the LUMC, a tertiary academic hospital in Leiden, the Netherlands and Saxion University of Applied Sciences. The protocol was approved by the Institutional Science Committee of the Anaesthesiology science department and obtained a waiver from the Institutional Review Board (NWMO-LUMC) and underwent independent peer-review from the Tech For Future funding body. Informed consent was obtained prior to inclusion, participation was voluntary, and privacy rights were in alignment with the Declaration of Helsinki and GDPR guidelines.

User-centred Design

The field of Human Factors and Ergonomics (HFE) focuses on understanding the interaction between humans and systems in order to design products, processes or systems to complement human behaviour in order to improve human well-being and overall system performance (12). User-centred design (UCD) is a commonly used methodologi-

cal approach in HFE to ensure that user's needs and preferences are at the core of the design process (13). UCD is an iterative process that involves users throughout the design process through a variety of quantitative and qualitative methods and tools. The UCD cycle consists of different stages starting with an in-depths analyses of the user's context and needs which directly inform the design requirements. This is typically followed by iterative design and evaluation of concepts, initial prototypes and later high-fidelity prototypes (14). In the implementation stage the final prototype is translated into a functional product and tested to ensure that the design meets the requirements. After releasing a product to the user, performance and user feedback is continuously monitored to conduct further improvements and ensure the product continues to meet user's needs(15) .

For the development of the VR-scenario training we employed a UCD approach involving simulation trainers and residents from the anaesthesiology department as our end-users. Our complete UCD approach is shown in **Figure 3**. The current paper focuses on the evaluation of the final prototype. The analysis of the context and user requirements will be published elsewhere. The iterative development process was described in a previous publication (Hoek et al. 2024).

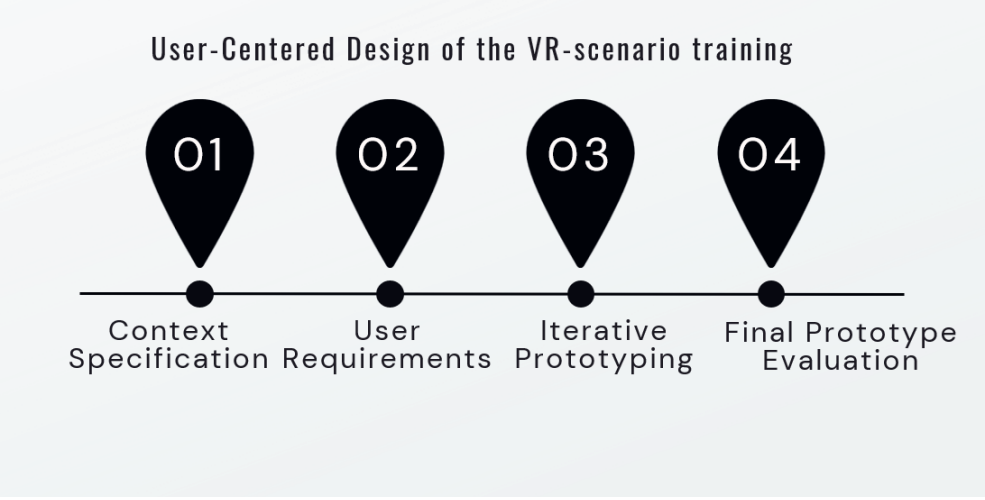


Figure 3. User-centered design approach of the VR-scenario training

Description of the final prototype

The VR prototype was developed using the Unreal Engine for use on Meta Quest 2 headsets. The current version presents a segment of a massive blood loss scenario, focusing on essential medical tasks such as applying standard anaesthesia vital monitoring, administering bolus and IVSE medication, and initiating fluid and blood transfusions. The virtual operating room closely mirrors the real OR environment at the participating hospital, with equipment and layout modelled in detail. Users navigate the scenario in a

multiplayer setting using abstract avatars, while the patient avatar displays high-fidelity visual features. During the simulation, trainers can adjust physiological parameters—including blood pressure, oxygen saturation, haemoglobin levels, skin appearance (rash), and pupil dilation—in real time via a dedicated control dashboard, allowing for dynamic scenario management.

User Evaluation of the final VR-scenario training prototype

The user evaluation of the final prototype of the VR-scenario training was conducted at LUMC. We used a combination of qualitative and quantitative measurements to assess the initial user experience and reaction to the VR-scenario training (Kirkpatrick's level 1) as shown in **Figure 4**. The quantitative data was used to get an objective impression of the user experience and served as a quantified reference point to capture the progression of user experience through different design iterations. The qualitative data provided more in-depth information about the user experience and helped to contextualize quantitative scores.

Participants: Residents and simulation trainers who worked at the LUMC hospital were invited by mail to participate. Participant with physical incapacity to use VR were excluded. Participants did not receive a financial compensation.

Procedure: Each test session began with a pre-briefing about the equipment, learning objectives and the upcoming scenario and would last up to 10 minutes. Up to 3 participants were testing the VR-training scenario at the same time to evaluate the multi-user feature. During the simulation experience an observation protocol was filled in. After the training session each test group was interviewed about their experience. Subsequently participants were provided with a link to a user experience questionnaire which they could complete in their own time.

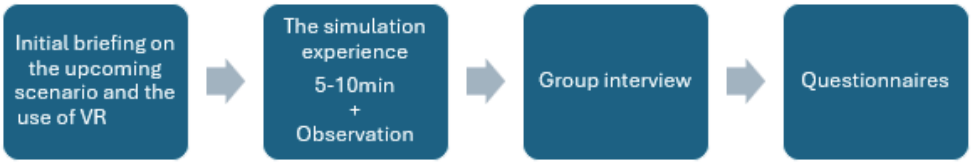


Figure 4. Schematic overview of the procedure of user evaluation study

Measurements:

The observation protocol included ten open-ended questions focused on user interaction and comfort, such as whether participants experienced difficulties handling the controllers or signs of physical discomfort (e.g. nausea or dizziness). The post-session questionnaire combined validated tools and custom items. Presence was assessed using the 15-item Multimodal Presence Scale (MPS) (16), which measures physical, social, and

self-presence environments (17). Agency—participants' sense of control over their virtual body—was measured using the agency subscale of the Virtual Embodiment Questionnaire (VEQ) (18), consisting of four items. Additional self-developed questions explored physical discomfort and the perceived value of VR compared to traditional mannequin-based training. Responses were collected using a 5-point Likert scale, except for the VEQ agency items, which used the original 7-point scale. An overview of the instruments is presented in **Table 1**.

Table 1. Overview of the quantitative measurements

Scale	No of items	Example Item	Response scale	Source
MPS-physical presence	5	While I was in the virtual environment, I had a sense of "being there".	5 point Likert scale (completely disagree – completely agree	(16)
MPS-social presence	5	I felt like I was in the presence of another person in the virtual environment.	5 point Likert scale (completely disagree – completely agree	(16)
MPS-self-presence	5	I felt like my virtual embodiment was an extension of my real body within the virtual environment	5 point Likert scale (completely disagree – completely agree	(16)
VEQ-agency	4	I felt as if I was controlling the movement of the virtual body.	7 point Likert scale (completely disagree – completely agree	(Roth & Latoschik, 2020)
Physical discomfort	3	I experienced nausea while working in the VR-environment	5 point Likert scale (completely disagree – completely agree	*Self-developed*
Perceived value	2	Once I am experienced in working in virtual reality, training simulations in the virtual environment would be a good alternative to physical simulations with a mannequin.	5 point Likert scale (completely disagree – completely agree	*Self-developed*

The interview lasted approximately 20 minutes and consisted of three parts. First, participants were asked about their general experience with the VR-scenario, including enjoyment, hardware interaction, discomfort, and perceptions of presence and agency. The second part focused on specific features, such as administering IVs and using the anaesthesia machine. Finally, participants reflected on the VR-scenario's perceived value for training non-technical skills in a simulation context. Participants were also invited to share their ideas on further development of the prototype.

Data analysis

Quantitative data were analysed using descriptive statistics in IBM SPSS, focusing on physical presence, social presence, self-presence, agency, physical discomfort, and perceived value. Due to the small sample size, no inferential tests were conducted. Thematic analysis was used to examine qualitative data (19). Observations and interviews were reviewed for recurring patterns related to user experience, presence, agency, and perceived training value. Themes were identified by one researcher (CJ), and illustrative quotes

were selected. We collected both quantitative and qualitative data, which were analysed separately and considered with equal importance to provide complementary insights.

RESULTS

Sample characteristics

Seven anaesthesiology professionals from LUMC participated in the user evaluation. Five completed the full survey; two left interviews early due to clinical duties. The group included two simulation trainers and five residents, aged 28 to 63, none of whom had prior VR experience. Participant details are shown in **Table 2**.

Table 2. Demographics

Participants	Interview	Survey	Gender	Age	Role	Years at LUMC	VR Experience	
							Private	Professional
P1	x	x	Female	28	Resident	1		
P2	x		Female		Resident			
P3	x	x	Female	33	Resident	4		
P4	x	x	Male	33	Resident	6		
P5	x	x	Male	38	Trainer	10		
P6	x	x	Male	63	Trainer	30		
P7	x		Female		Resident			

User experience

Quantitative Results

The quantitative analysis of the survey data revealed that the overall scores for presence, agency and perceived value of the VR training were moderate to moderately high. Physical presence had the highest medium score $M = 3.64$ (SD = .661) while self-presence scores were slightly below the midpoint of the scale $M = 2.44$ (SD = 1.09) suggesting that participants had a fairly high sense of really being present in an operating room. However, they did not quite feel that their virtual presence was an extension of their real body. Agency scores were moderately high $M = 4.85$ (SD = .945), indicating that participants felt some control over their movements in the virtual environment. Participants scored slightly below the midpoint regarding the experience of adverse events such as nausea, disorientation and dizziness $M = 2.93$ (SD = .894). When asked about the value of the VR training in comparison to physical simulation training with a mannequin, participants scores were slightly above the midpoint level of the scale $M = 3.20$ (SD = .945). **Table 3** shows an overview of the quantitative outcomes.

Table 3. Descriptive Statistics

	N	Range	Minimum	Maximum	Mean	Std. Deviation
MPS total*	5	1.67	1.93	3.60	3.04	.661
Physical presence*	5	1.00	3.20	4.20	3.64	.456
Social presence*	5	2.60	1.40	4.00	3.04	1.090
Self presence*	5	2.20	1.20	3.40	2.44	.817
Agency**	5	2.25	3.50	5.75	4.85	.945
Physical discomfort*	5	2.00	2.00	4.00	2.93	.894
Perceived Value VR Training*	5	2.50	1.50	4.00	3.20	1.037

Notes: * measured on a 5-point Likert scale; ** measured on a 7-point Likert scale,

Qualitative Results

The qualitative analysis of the observational data and interview data provides more contextual information for these quantitative scores and more in-depth information about the user experience and first reaction of towards the VR-scenario training. These insights will be discussed in the following paragraphs.

General user experience

Most participants described the VR-scenario training as an enjoyable experience. They valued the realistic design of the operating room and medical equipment in the virtual environment. However, most participants, described the interaction with the controllers as challenging and something to get used to. As one participant noted:

"I'm not a gamer, so I really can't manage those hand controls." (P6)

Three participants reported mild physical discomfort including nausea and disorientation. One participant indicated that this feeling mostly subsided once she got used to the virtual environment. None of the participants experienced continuous discomfort or had to stop the experience. Some participants also commented on difficulties adjusting the VR glass which led to visibility issues during the simulation. Other technical issues that were noticed included objects "jumping" away and the ability to walk into objects or other avatars in the virtual environment.

Look and feel of the virtual environment & physical presence

Participants were positive about the accuracy and detail of the virtual operating room and medical equipment. When discussing this topic one of the residents said:

> *"Yes, it looked amazing! Really… That cart actually looked just like ours – it was funny to see. That was really well done." (P1)*

However, some aspects such as the size and placements of certain objects was perceived as slightly inaccurate. They also noted that some equipment was missing in the current prototype. Despite these inaccuracies participants experienced a fairly high sense of physical presence which is in line with the survey outcomes. One of the trainers described the experience as follows:

> *"Yes, amazing! I really felt like I was there." (P6)*

Functional interactions, agency & self-presence

Although participants praised the realism of the medical interactions, they also experienced high cognitive effort when performing the tasks in the virtual simulation. Most of these interactions felt somewhat unintuitive and challenging to perform in VR. As one of the residents stated:

> *You can't actually grab anything. Normally, when placing an IV, you hold the hand, like this… and then insert the needle. But that's not possible here — now you have to use buttons. That felt… different."(P4)*

Because of the high cognitive load participants paid less attention to the scenario and the other players. As one of the residents put it:

> *"When you're focused on picking up the syringe, you're so busy with that, that I actually didn't notice anymore whether she [the patient] was... still alive." (P7)*

Concerning agency**,** participants felt not completely in control of their actions. They indicated that their actions sometimes did not match their intention and that their movements lacked precision. They were also unsure if a task was performed correctly. When discussing this topic one of the residents stated:

> *"You feel like you have a bit less control. You press the button and whoop — it goes really fast! Don't overdose!" (P1)*

Several participants reported that they had difficulties grabbing objects or that objects were unintentionally dropped. This lack of control also influence the feeling of being immersed in the VR-scenario. As expressed by the same resident:

> *"At one point, I really wanted to connect the pulse oximeter, but the cart kept moving away or something — and you're just like, I just want to grab it! When it doesn't quite work, that's when you really realize you're in a simulation or VR." (P1)*

Although agency was somewhat limited, the quantitative scores indicated that participants still felt some control of their actions.

When discussing self-presence, participants had a mixed reaction how natural and intuitive their virtual embodiment felt. This is also reflected in the quantitative scores. One of the trainers reported a high degree of self-presence although he found it confusing that only his hands were visible:

> *Absolutely, it felt very natural. That's why I was a bit disappointed there weren't any arms attached — because those really felt like my hands." (P6)*

Another participant stated that being able to walk around without teleporting would benefit the experience of self-presence:

> *The one thing I still think would be useful is being able to actually walk. Right now, you teleport of course, and that still feels a bit… off. I mean, eventually it worked, but I think if you could walk, you'd feel more like, 'I need to get there quickly,' you know?" (P1)*

The limitations that were experienced while interacting in the virtual environment can be partially attributed the fact that participants had no previous experience with VR and had to still get used to the controllers while being in the simulation. The majority of participants were confident that with more practice interactions would become more intuitive and that their sense of agency and self-presence would increase.

Social presence and collaboration

Participants generally reported that they were aware of the other users while they were in the simulation. They valued that they could interact with the other users and tried out small gestures like waving. Verbal communication was possible and became more natural as participants grew more familiar with the VR controllers. However some participants indicated that they were so focused on their own tasks that they paid little attention to the others. Moreover participants could not recognize each as they were represented as

abstract dummy avatars without names of role description. As one of the trainers highlighted:

> *"I was aware of my own hands, but sometimes I saw other hands without seeing a person attached to them. I really missed the realistic presence of the person." (P6)*

Another limitation to better collaboration was the lack of peripheral vision due to the VR glasses. Participants had to deliberately turn their head to see each other. Additionally, participants experienced a audio-visual mismatch: sometime a voice of another user seemed distant while the avatar appeared nearby.

With regard to the social presence of the patient avatar participants valued the realism that is not possible with the traditional mannequins like changes in skin colour with low blood saturation. However, participants noted that the patient avatar was still in cloth which is not usually the case in the given scenario.

This mixed experiences regarding social presence are in line with the quantitative score.

Value for non-technical skills training and future application

Participants view the VR-scenario training as a valuable learning tool for training non-technical skills in a simulated setting. Advantages that were mentioned included the possibility to simulate complex scenario's with a high degree of realism. As highlighted by one of the residents:

> *"I think you can simulate so much more with this than with a mannequin. With a mannequin, you're physically in the same room, but someone has to tell you, 'the mannequin is turning blue.' In VR, you can actually make the patient turn blue. That makes it feel much more realistic, and especially for CRM and communication, people might really start to feel stressed. And from that, you can learn a lot — how you communicate and how you act." (P1)*

Participants also valued the multiplayer feature that allows them to practice together. The option to practice remotely was also viewed as an advantage. However, participants emphasized that residents need time to get familiar with the controllers and practice the interactions before the training could be used effectively.

RECOMMENDATIONS

The participants had several recommendations to further improve the current prototype and the simulation experience:

1. **Practice interactions:** First and foremost, as already became clear in the previous paragraphs, users of the simulation training need the opportunity to practice and get familiar with the controllers and interaction before engaging in a complex scenario training.
2. **Limit teleportation:** Although teleportation was mentioned a one of the more intuitive control features, limiting it would help to increase the feeling of presence and spatial orientation during practice.
3. **Feedback:** Participants highlighted the need for some sort of feedback to confirm that a task is performed correctly, especially given the lack of tactile cues.
4. **Design of the users' avatars:** Participants preferred a more realistic, human-like representations of their avatar en recommended to include the users' names to help them recognize each other.
5. **Add other medical interactions:** To expand the scope of the current prototype participants recommended to expand the current medical interactions and add more such a intubation.
6. **Seamless communication:** Seamless communication was perceived as key to make the VR-scenario applicable for team training. Any delay or in the audio transmission would affect the collaboration and realism of the training.
7. **Remote or on location training:** Regarding the future application of the VR-scenario training, Participants could imagine to use the simulation both remotely and on-site.

DISCUSSION AND CONCLUSION

Discussion

This study explored the user experience and potential value of a VR-scenario for anaesthesiologists in training focusing on non-technical skills such as teamwork, leadership and communication. Our approach was in line with Kirkpatrick's first evaluation level (reaction). For our study we used a combination of qualitative and quantitative approaches provided a broader perspective on user experience.

Overall participants described the VR-scenario as a unique and enjoyable learning experience. Participants valued the realism of the operating room and the medical equipment which was reflected in the moderately high sense of physical presence. The high degree of realism gave them the sense of really being in an actual operating room. Only minor level of physical discomfort was reported. These results suggest that the VR environment was effective in creating a realistic and engaging environment for the scenario training.

Although the quantitative agency scores were also moderately high, qualitative results revealed that agency and self-presence was negatively affected by the interaction design and difficulties with the VR controllers. For many, the interaction design was unintuitive and imposed a steep learning curve, particularly for participants without prior gaming or VR experience. Users reported a high cognitive load while performing medical tasks which sometimes lead to reduced situational awareness and difficulties in collaborating with other team members and attending to the patient cues. Participants also missed some form of feedback on their task performance. These findings suggest that for future development work, we need reiterate on how to transfer fine-motoric medical tasks into intuitive VR interactions and on how to provide feedback without tactile cues. In addition, an onboarding environment should be added to the simulation, where users can familiarize themselves with the VR controllers and practice medical tasks before engaging in the scenario training.

The sense of social presence and the reaction to collaborating with other users was also mixed. Although participants valued the multiplayer function and saw great potential for team training collaboration was currently hindered by the abstract avatar design, limited peripheral vision and occasional audio-visual mismatch. The results suggest that for future development work we need to reiterate on the multiplayer feature and create more alignment between auditive and visual cues and improve the design of the user's avatars

Despite these challenges, participants expressed enthusiasm about the value and future potential of the VR training for developing non-technical skills such as communication and teamwork. Several participants indicated that repeated exposure and an initial familiarization phase would enhance the effectiveness of VR-scenarios in educational settings. Moreover, the multiplayer functionality, the opportunity to simulate complex team-based scenarios with a high degree of realism and the opportunity to practice remotely or onsite were perceived as important strengths of the VR approach.

From an internal validity perspective, several limitations must be considered. The relatively small sample size of seven participants restricts the generalizability of the findings. Furthermore, the participants may not fully represent the diversity of backgrounds and levels of experience present in the broader population of anaesthesiologists. The reliance on self-reported measures introduces the potential for response bias, particularly given the novelty of VR technology. Nevertheless, the use of concomitant qualitative and quantitative data strengthens the study by offering both quantitative benchmarks and contextualized feedback on user experiences.

When placing these findings in the context of the broader VR literature in medical simulation, our results are largely consistent with previous research. Many VR-based medical training studies report high engagement levels but identify usability challenges, particu-

larly related to interface design and physical side effects such as cybersickness (20-22)The emphasis on VR's potential for non-technical skills training resonates with growing calls in the literature for simulation tools that do more than rehearse technical procedures, instead fostering communication, leadership, and teamwork under realistic pressures (23).

The creation of innovative solutions to unprecedented problems amidst unexpected circumstances necessitates a substantial adaptive expertise, which refers to a system's aptitude to adapt to intricate, dynamic, and demanding conditions. Clinical teams encounter significant challenges in exercising adaptive expertise during periods of elevated stress.

Innovation

This study introduces innovation in both methodological approach and educational application. By explicitly applying Kirkpatrick's evaluation model to the early assessment of a VR-based simulation for anaesthesiology, it addresses a gap in the literature where structured evaluation frameworks are often lacking (23, 24). The focus on user reaction (Level 1) provides a foundation for systematic future evaluations targeting learning, behaviour change, and organizational outcomes.

Moreover, the integration of quantitative (VEQ and MPS scales) and qualitative thematic analysis offers a novel, comprehensive perspective on user experience that goes beyond simple satisfaction surveys alone. Previous reviews have identified a predominance of single-method evaluations in VR simulation studies, often focused narrowly on usability or enjoyment without deeper analysis of presence and interaction quality (20, 24).

Finally, this study highlights VR's potential not only for technical skill rehearsal, but for fostering non-technical skills such as teamwork and communication—areas increasingly recognized as critical for clinical performance under pressure. In doing so, it supports the translation of VR simulation methods into non-technical, team-based training, promoting the development of adaptive expertise in clinical teams working in dynamic, high-stress environments.

Conclusion

This study demonstrates that VR-based simulation offers a promising tool for non-technical skills training in anaesthesiology, providing an engaging and realistic learning environment. While users appreciated the immersive design and collaborative potential, challenges related to interaction design, physical comfort, and technical reliability were identified. Addressing these usability aspects will be crucial for maximizing the educational impact of VR simulations. Future studies should expand on these findings by exploring learning outcomes and behavioural changes across larger and more diverse participant groups evaluating higher levels of Kirkpatrick on effectiveness.

Author contributions

K. Hoek, MD, PhD candidate at the Anaesthesiology department of the Leiden University Medical Center and anaesthesiologist. Her research focuses on the educational challenges of acquiring communication skills among healthcare providers. KH had the original idea for the study, contributed to data collection, transcription and analysis. She wrote the original draft, methodology and final article.

M. van Velzen, MD, PhD, is an educationalist, clinical research coordinator, and assistant professor at the Department of Anaesthesiology of the Leiden University Medical Center. She contributed conceptualizing and participated in data validation and review.

E. Sarton, MD, PhD, is the former Head Department of Anaesthesia and former Head Board Division at the Leiden University Medical Center. She's the former director of Education master Medical School and former Chair of Dutch Society of Anaesthesia. Her research evolves around education in medical training. She contributed conceptualizing, data validation and review.

C. Jaschinski, PhD, is a senior researcher at the Research Group Technology, Health & Care and the Saxion Extended Reality Lab at Saxion University of Applied Sciences. Together with KH she designed the study and measurement instruments, contributed to the design of the VR-scenario prototype and performed the data analysis. Together with KH she co-wrote the original draft and final version of the submitted article.

All authors revised and approved this article and meet the ICMJE criteria for authorship.

Competing interests and acknowledgements

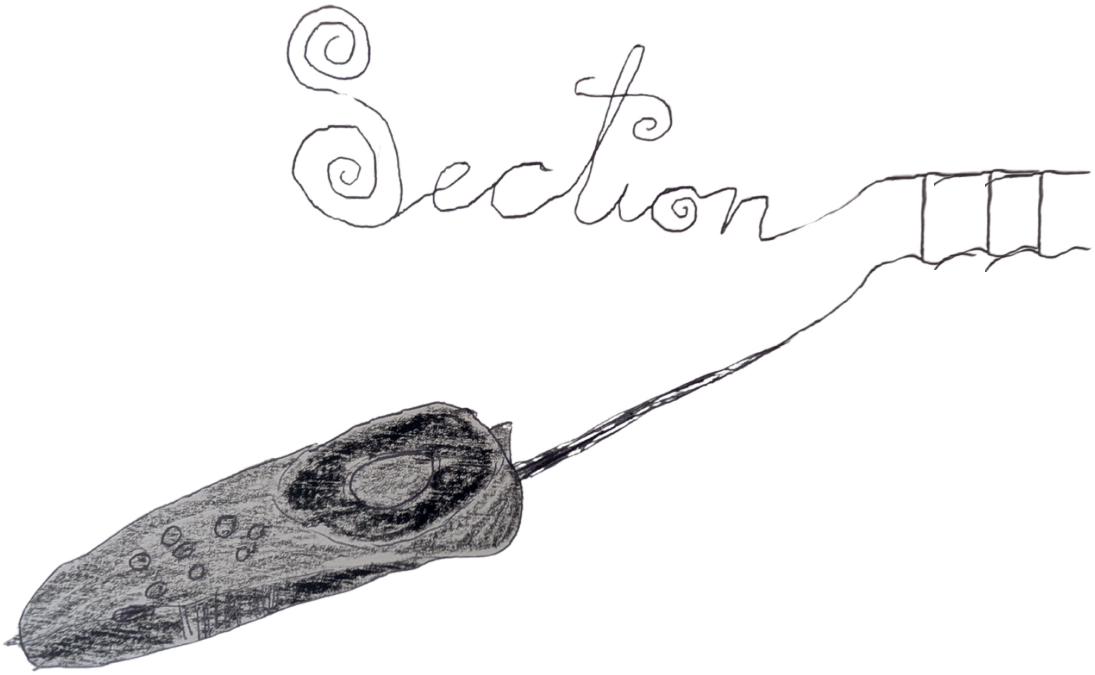
This work was supported by the Tech For Future, Centre of Expertise on research in High Tech Systems and Materials.

We would like to acknowledge Matthijs van Veen, Marloes Bekhuis, Bram Scholten (Saxion Extended Reality Lab) and Maartje Hendriks (Research Group Technology, Health & Care, Saxion), and Naweed Shifai (LUMC) for their valuable contribution to this project.

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Communication for Patient Comfort and Anxiety Reduction

3

A GOOD INTENTION DOES NOT SUFFICE

ARTICLE INFO

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Keywords:

Empathy
Negative suggestions
Patient-centered care
Patient-doctor communication
Positive suggestions
Therapeutic communication

Status:

submitted

ABSTRACT

Spoken words play a powerful yet often underestimated role in shaping patients' experiences. In many low-resource settings, where time, tools, and training may be limited, the words a healthcare provider chooses can still make a world of difference. A calm voice, a thoughtful explanation, or a reassuring phrase may not cost anything—but they can ease fear, reduce pain, and build trust. This commentary highlights how understanding the science behind our words can help create comfort, dignity, and better care—no matter the setting—by exploring how neurolinguistic and neurobiological mechanisms influence patients' perception of pain and comfort and emphasizing the impact of therapeutic communication. Negative language—such as references to pain or negations—can worsen discomfort through nocebo effects, while positive suggestions may enhance treatment outcomes and strengthen the patient-provider relationship. The commentary discusses how the complexity of pain perception is modulated by cognitive and emotional factors such as attention, fear, and expectation. Healthcare providers, often with the best intentions, may inadvertently use language that undermines patient wellbeing. Understanding the implicit effects of language enables more patient-centered communication strategies that can improve outcomes and patient satisfaction. This article advocates for the integration of these insights into clinical training and emphasizes that knowledge of communication science is essential for enhancing therapeutic effectiveness.

INTRODUCTION

Modern medicine advocates patient-centered care, with an understanding that health has changed towards consideration of complex systems in permanent interactions with the environment. It has been well established that the environment of the clinical setting, the cognitive-affective communication of clinicians, and the rituals of administering treatments influence the clinical outcome of patients (1).

Medical situations and procedures are often life-changing events for patients, fragile in unfamiliar surroundings with uncertain outcomes (2). This makes patients susceptible to what a healthcare providers says, or does not say.

In this light, spoken words are powerful and suggestive tools that shape future experiences and perceptions. To illustrate the principles of therapeutic communication, showing the complexity of pain perception, the significant role of cognitive and emotional factors in shaping the patient's pain experience, and demonstrating how negative linguistic suggestions may exacerbate pain and anxiety, consider the following clinical case:

Nathalie, a patient undergoing a vaginal echography with her gynecologist. The procedure is difficult, and Nathalie is in distress and pain. Her gynecologist, intending to encourage her, details the procedure, informs Nathalie of the next steps, tells her it won't hurt that much, that she shouldn't worry, and it will not take much longer.

Healthcare providers highly estimate the importance of communication skills (3). Also, in medical school, generally it is thought patients need to be informed of all details of a procedure. However, alleviating anxiety, stress and pain needs careful consideration of human psychology and pain modulation which will be elaborated in this article.

Pain perception

Pain is defined as 'An unpleasant sensory and emotional experience associated with, or resembling that associated with, actual or potential tissue damage' (4). How the brain recognizes and interprets pain depends on numerous factors and complex mechanisms. For instance, certain stimuli can alleviate pain. A gentle touch can close pain gates by gate control systems, fear and stress activate the entorhinal cortex, insula and anterior cingulate gyrus amplifying the perception of pain(5).

Attention also affects the perception of pain. Every second, thousands of signals enter our brains. We are only aware of an exceedingly small fraction of these signals as our brain filters signals as they come in. Studies using functional MRI have shown that visual and somatosensory stimuli have pain-modulating functions. Simply put, shifting attention leads to less pain.

The peculiarity of pain is expressed in its own complexity. The ultimate pain and lived experience is a result of complex neuronal networks, interactions, and multiple thalamo-corticolimbic connections. Fear, stress, emotions, and attention all influence pain perception. Understanding these mechanisms can provide insight into more effective patient care strategies.

Negative suggestions

The use of linguistics may influence perception. A negative context can enhance nocebo effects. When said: "the injection of this medication may sting", it has been demonstrated that someone's negative expectation induces an exacerbation of pain or anticipatory anxiety and triggers an inflammatory activation of cytokines, making pain transmission easier (5).

A nocebo effect can also be involuntarily created using negation. The human brain is incapable to 'not' think of something. 'Do not think of a pink elephant' makes one immediately think of a pink elephant. A phrase as 'Do not worry' or 'This will not hurt' are examples of negative suggestions, as they imply a negative context and cannot be erased by negation.

Other negative suggestions may include any suggestion of a negative feeling or experience, such as: "Please feel free to call us if you feel any nausea or pain", or "Can you describe your intensity in pain, from no pain at all, to the most excruciating pain you've ever felt"? Aforementioned suggestions allow attention to be shifted to nausea, and pain, enhancing their intensity. Alternatives may be "Feel free to call us if we can do anything for you to improve your comfort" and "Can you describe the intensity of your comfort, from the least to the most comfortable you've ever felt?".

From a neutral to a positive suggestion

Once medication is administered without announcing its effects, its therapeutic actions are known to diminish (1, 6). In the classical paradigm, a placebo effect is assessed by administering either an inactive substance or a fake intervention. However, in the open/hidden paradigm, therapy is not withheld from the patient. Here, the placebo effect emerges from the contrast between the usual therapy's effects (open = drug and expectation effect) and treatment without disclosure (hidden = solely drug effect) (6). Hence, therapy can be potentiated by our words: "I'm giving you morphine" can be transformed into "I'm giving you morphine, a strong medicine that will probably make you feel better". Feeling comfortable and safe can easily be enhanced with our spoken words: "I'm raising the bed rail" can be transformed into "I'm raising the bed rail for your safety and comfort".

From a good intention to a good therapeutic relationship

Important to note is that suggestions may influence patients in an implicit way, that is, without patients consciously realizing its impact. A good intention does not suffice. Knowledge of how neurolinguistic and neurobiological mechanisms affect patient pain perception and comfort can be used by healthcare providers to influence the patients' lived experience.

Linguistic features include the use of positive suggestions, and avoidance of negative suggestions with negations. The choice of words when providing information on therapeutic benefits and potential side effects impact patient's lived experience and clinical outcomes. A good intention becomes a good therapeutic relationship with mutual understanding.

CONCLUSIONS

Spoken words wield significant power in healthcare settings, influencing patient experiences and outcomes. By integrating insights from neurolinguistics and neurobiology, healthcare providers can enhance their communication strategies to foster positive therapeutic relationships and improve patient comfort and pain management. This commentary underscores the necessity of moving beyond good intentions to implementing informed, strategic communication practices that prioritize patient-centered care.

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4A

PATIENT-EMBODIED VIRTUAL REALITY AS A LEARNING TOOL FOR THERAPEUTIC COMMUNICATION SKILLS AMONG ANAESTHESIOLOGISTS: A PHENOMENOLOGICAL STUDY

ARTICLE INFO

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Keywords:

VR
Therapeutic language and communication
Ethnographic phenomenology
Healthcare education
Patient-embodied experience
Proteus-effect

DOI: 10.1016/j.pec.2023.107789

Patient Education and Counseling



Volume 114
ISSN 0738-3991
January 2023
Pages 107789

ABSTRACT

Objective

In medicine, training of effective therapeutic communication skills with creation of rapport is challenging, since communication is often implicitly copied from the professional environment. Therapeutic language and communication are particularly useful in preoperative setting as patients often experience preoperative anxiety. This phenomenological study describes the development of two patient-embodied virtual reality experiences designed to be used as an educational tool for training in communication for anaesthesiologists.

Method

Two patient-embodied VR experiences were developed deploying negative or positive therapeutic communication styles. The experiences were designed from a first-person patient perspective. The authors investigated the lived learning experiences of these experimental patient-embodied VR tools through semi-structured interviews with ten anaesthesiologists adapting a thematic analysis framework.

Results

Interviews revealed acknowledgement of the importance of good communication skills. Overall, participants had not followed any specific training, having learned and adapted their style of communication 'on the job'. Patient-embodied VR was effective for a full immersive experience as participants expressed to have felt as if they had been a patient. Analysis of the reflection on therapeutic communication skills before and after the patient-embodied experiences showed a shift in perception, implying effective immersive Experiential Learning.

Conclusions

This study elaborated the potency of Experiential Learning with VR in therapeutic communication in a preoperative setting. Patient-embodied VR can influence beliefs and values and demonstrated effective as an educative tool.

Practical implications

The findings of this study can contribute to further research and healthcare education programs to use Experiential Learning with patient-embodied VR.

INTRODUCTION

Anaesthesiologists are in charge of preoperative care and acknowledge the importance of communicational skills in the operating room as a cornerstone of their practice (1). In a preoperative setting, good communicational skills become particularly useful as patients often experience preoperative anxiety. Preoperative anxiety describes an adverse state of uneasiness or tension that is secondary to patient worries regarding disease, hospitalization, the planned use of anaesthesia, surgery and the unknown (2). It usually peaks during induction of anaesthesia and is associated with difficulty of induction, an increased need of hypnotic and analgesic medication, a higher risk of emergence delirium and post-traumatic stress disorder amongst others (3-5). Such outcomes, affecting patient well-being and health, gain a more central role in modern medicine and medical education. Hence, modern medicine advocates patient-centered care (PCC), with great contributions to patient reported outcomes such as satisfaction and comfort (6-8).

Nevertheless, there is no general agreement nor regulation in the educational system on how to teach and learn communication skills. Communication skills seem to be acquired 'on the job' greatly depending on implicit contextual factors rather than conventional classes or training. The question arises how to best teach and learn therapeutic communication skills and how to sensitize clinicians about its importance. We hypothesized that a real lived experience of a patient could be a useful learning experience.

In this light, we have used Virtual Reality (VR) to create experiences from the perspective of a patient, referred to as 'patient-embodied VR'. VR technology has become a promising field in modern medical skills training (9-11). This technology substitutes the real world by using a head-mounted display (HMD) that allows users to be fully immersed and experience situations from a different perspective. In virtual interactions, avatars become users' self-representation and can affect people's attitudes, behaviors in an implicit or explicit manner (12, 13) making it potentially a very effective and innovative teaching method. In this article we will elaborate:

1. how patient-embodied VR can simulate a lived experience for immersive educational purposes
2. how we developed two patient-embodied experiences with positive or negative communication styles
3. how patient-embodied experiences may influence believes and attitudes of anaesthesiologists towards therapeutic communication.

METHODS

This prospective exploratory research was carried out at the Leiden University Medical Center (LUMC, Leiden, the Netherlands), a large tertiary academic teaching hospital. The protocol was approved by the Institutional Science Committee and received a certificate of no rejection from the Institutional Review Ethics Committee. Personal data protection and obtaining consent forms from research participants was obtained prior to study start. Data was collected and recorded between February 2019 to February 2020. Participants received no financial compensation.

Conceptual framework

Therapeutic language and communication can be defined as the process of exchanging ideas, thoughts and knowledge between a physician and a patient with the objective to guide a patient's internal and behavioral state towards an anxiety-neutral position (14-18). *Empathy* and *rapport* are two main elements of effective therapeutic language and communication (7, 8). *Empathy* requires the ability to understand and identify another person's internal state, including their emotions and motivations (19). Creating *rapport*, which is the process of establishing a 'connection', relates to collaboration and parity between patient and physician (20).

The conventional approach of 'See one, do one, teach one' lacks a multi-faceted approach needed for the development of these skills (21) and has limited impact on how well physicians communicate with their patients (22). Physicians' communication skills appear to be copied from their professional environment as a "hidden curriculum", rather than explicitly being taught in medical education classes (23). Hitherto, how well physicians communicate seems to be dependent on the specific context by which these skills are required and can be reproduced (24). This concords with the connectionist framework where one may learn through experience (25).

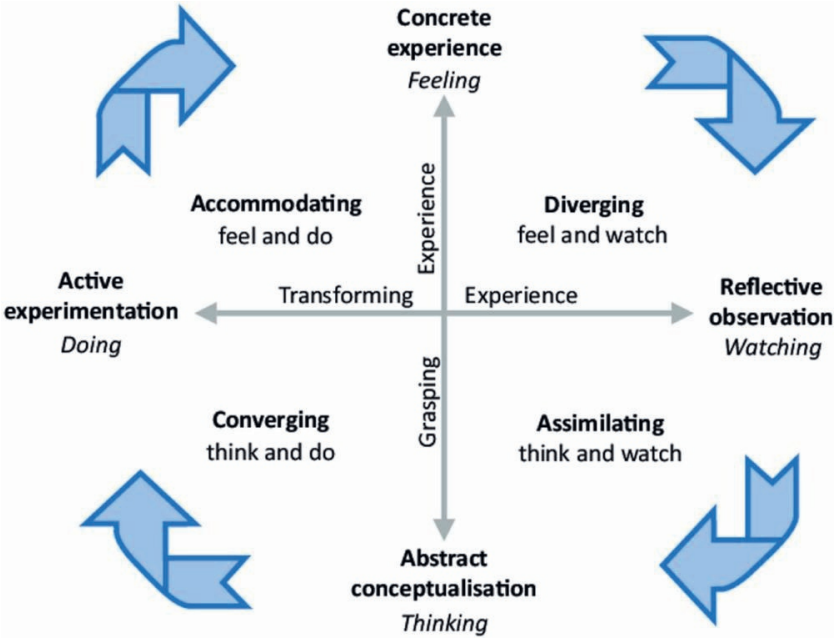


Figure 1. Kolb's Experiential Learning Cycle.

In particular, Kolb's experiential learning cycle describes the internal cognitive processes required to develop new skills and may provide a framework on how to teach and learn therapeutic language and communication (26).

As shown in **Figure 1**, in the four-stage model, a learner must first encounter a concrete experience which may shed light on a certain concept. Next, the learner can reflect on the new experience, conceptualize the experience, and finally actively experiment with newly created or modified concepts. For instance, doctors who became patients due to illnesses were able to gain the perspective of being a patient which consequently increased their sensitivity to patient experience and fostered empathy in their subsequent professional interactions with patients (27-29).

Not every healthcare professional will experience what it feels like to become a patient. Patient-embodied VR can generate an innovative possibility to provide a concrete immersive experience as a patient. This can affect attitudes and beliefs of healthcare providers through the *Proteus effect*. The *Proteus effect* describes the phenomenon where the avatar becomes users' self-representation. In our case, a healthcare providers (user) becomes a patient (avatar). We have hypothesized it can substitute the first phase of the concrete experience of Kolb's learning cycle. In VR, embodiment can increase users' engagement and provide emotional fidelity invoking a sense of *presence* creating realistic emotional and neurocognitive responses (12, 13, 30).

Study design

In this study we have used a phenomenological approach, i.e. understanding the meaning of a lived experience (31). The phenomenon studied here is a VR experience through the perspective of a patient who is prepared to undergo general anaesthesia and surgery, using two different communication styles. We will describe how we developed the patient-embodied VR experiences and how they may add richness through immersive learning. We have conducted semi-structured interviews with anaesthesiologists that underwent the VR experiences to further substantiate the potential of patient-embodied VR and how it can be used as a learning tool.

Patient-embodied VR experience

We have created a patient journey map of a patient who would undergo elective general anaesthesia and surgery. The patient was brought to the preoperative holding area. Standard preoperative procedures were performed and an intravenous cannula was inserted. Preoperative control questions were asked while the patient would wait in a hospital bed before taken to the operating room. An anaesthesiologist would take the patient to the operating room where the journey would end after the last checks with the medical team were effectuated and anaesthetic drugs were given to induce general anaesthesia as shown in **Figure 2**.

For this study, two scripts for patient-embodied VR experiences were written. One experience would display current practice. This experience contained more negative communication styles with limited therapeutic communication skills. For instance, the Preoperative Holding Area Nurse would stand next to the patient while engaging communication with the patient as shown in **Figure 3a** [8]. She would use some negative verbal suggestions such as 'this needle is going to hurt' before needle insertion (32). In the background, other healthcare providers would not salute the patient as the patient entered the preoperative holding area as shown in **Figure 3b** (33). This version would show signs of nonverbal behaviors suggesting the healthcare professionals were in a hurry, paying little attention to the patient with little empathy and/or rapport (7). All adverse effects of medication were also specified ("this medication will sting, and this could hurt a little") (32).

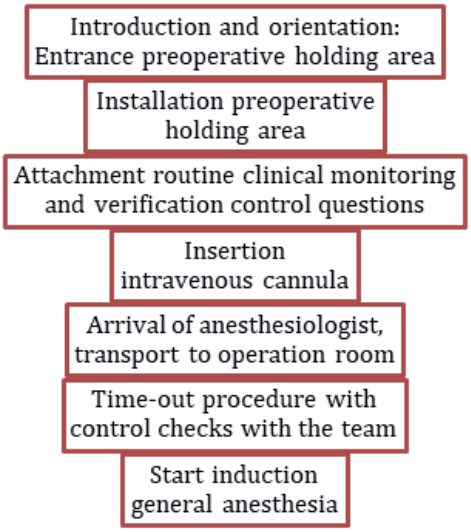


Figure 2. Structure patient-embodied VR experience.

A second version focused on more positive therapeutic communication; for example, asking "are you warm enough" instead of asking if a patient was feeling cold. This version included the use of hypnotic language and patient-centered talking styles to comfort the patient and promote the patient's endogenous ability to reduce pain and stress (34, 35). Nonverbal behaviors were also modified (33, 36). For instance, healthcare professionals would sit next to the patient and make eye contact to confirm they connected and paid attention to the needs of the patient (rapport) as shown in **Figure 3.b**.

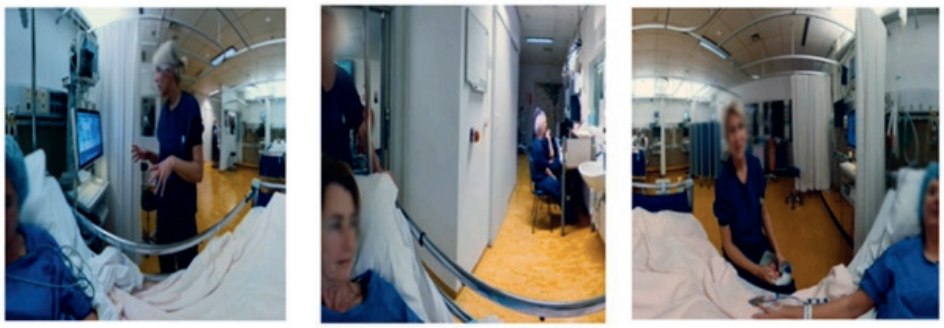


Figure 3. A: (left) Preoperative Holding Area nurse stands next to the patient. 3B (middle): Health care professionals don't salute the patient as she enters the preoperative holding area. 3 C: (right) Preoperative Holding Area Nurse sits next to the patient to ask preoperative questions (identity, known allergies).

Nevertheless, the two versions would only differ slightly, avoiding exaggerated behavior or communicative styles. They would display the same procedures, total duration and actors with only modest adaptations. The negative version would display regular care, with



Figure 4. Example of subtle differences between VR experiences where a HCP needs to rapidly bring blood to the OR for another (bleeding) patient. 4 A (left): positive experience: OR nurse provides no additional information, smiles politely to the patient. 4B: (right): negative experience: OR nurse expresses that he is in a hurry to bring blood, preoperative nurse is concerned.

examples inspired by reality. The positive version displayed an example of how reality could also look like, as a reachable alternative as shown in **Figure 4.**

Differences in attitudes, word choice and behaviors were based on several studies on rapport building and therapeutic language, all combined for these videos (7, 8, 18, 32-35, 37-40). The scripts were validated by two anaesthesiologist-hypnotherapists, with one amongst them independent of the research team.

The patient-embodied VR experiences were filmed with a 360° camera from the perspective of the patient. They were shown to the participants with an Oculus-Go® head mounted device.

Participants and procedures

Anaesthesiologists and residents in anaesthesiology were invited to participate in the study. They were recruited via email or phone between November 2020 and February 2021. Their participation consisted of a semi-structured interview before and after viewing the patient- embodied VR experiences as shown in **Figure 5**. The participants did not contribute to developing the patient-embodied VR experiences, nor did they know its contents beforehand. We chose to show the negative version first, as it displayed current practice.

During the first introductory part of the interview, participants were questioned about their current communication techniques, skills and training. Participants were asked how they perceive patient's preoperative anxiety in general, what they assume the causes and effects are, and how they manage it. General introductory questions were followed up with more in-depth core questions where participants were invited to give personal clinical examples to illustrate and elaborate their answers. The interview was designed to take up to 30 min.

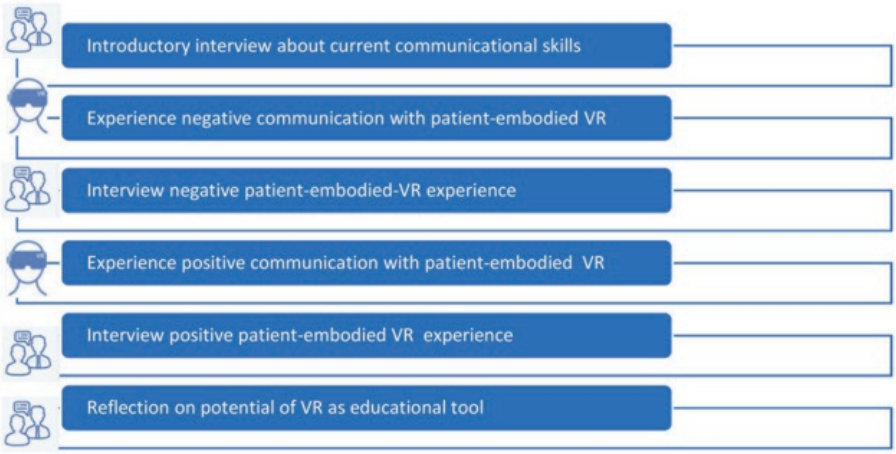


Figure 5. Structure study participation anaesthesiologists.

Next, participants were invited to engage the negative patient- embodied VR experience without being informed about its content beforehand. After completion, participants were asked to describe how they felt during the experience. This part of the interview had a flexible structure where the participant could elaborate on self-reported topics. Detailing questions were asked depending on participants responses. This part was designed to take between 15 and 30 min.

Subsequently, participants were invited to engage the positive patient-embodied VR experience. In a similar manner as the negative experience, participants were asked to describe how they felt during the positive experience. The interview was designed to take between 15 and 30 min.

In the final reflective part of the study, follow up questions could be used to provide further clarification if needed. The participants were asked to compare the negative and positive experience. Did they perceive differences and how did those differences change the clinical encounter? How did the patient-embodied VR experiences affect them and how could they be used as an educational tool. This last part of the interview was designed to take up to 20 min.

Data analysis

Semi-structured interviews were conducted to explore how patient- embodied VR was experienced and how it can be a learning tool in therapeutic communicational skills. Data were retrieved until theme saturation, that is until the researcher was empirically confident a category was saturated, and additional data would not lead to any new emergent input (41, 42).

The interviews were analyzed using an applied thematic analysis with an inductive process, based on the six phases of thematic analysis outlined by Braun and Clarke: data familiarization, code generation, theme development, theme revision, theme definition and report production. A codebook was created as themes were developed by two coders separately before they were discussed together until consensus was reached (43). The analysis continued with the clustering of codes into categories, and then structured and grouped to overarching themes. The final validation of codes against data extracts was undertaken by a third researcher to ensure the consistent representation of categories and themes of the entire data set.

RESULTS

Sample characteristics

Ten anaesthesiology staff members and residents in anaesthesiology participated in the patient-embodied VR experiences and one of the researcher conducted semi-structured interviews until data saturation was obtained. Six (60%) participants were staff members and four (40%) were residents. Five (50%) were female. Demographics are shown in Table 1.

Table 1. Demographic characteristics of the VR development team and study participants.

Participants (10)	Years in practice staff members:	
	5–10 years	5
	> 10 years	5
	Sex:	
	Male	5
	Female	5
	Clinical role	
	Resident	4
	Staff member	6

Qualitative findings of semi-structured interviews

Analysis of the transcriptions resulted in the identification of five major themes. First, perceptions of therapeutic communication before patient-embodied VR are described, followed by the VR experiences and final reflection. Verbatim quotations from the transcripts are included to support themes which emerged from the data. Quotations have been translated from Dutch to English and grammatical structure has been left unchanged for the sake of authenticity.

Perceptions of preoperative anxiety and therapeutic communication before the patient-embodied VR experiences

Participants globally agreed in presumed causes of preoperative anxiety varying between the surroundings of the OR, the fear for the unknown and the more technical aspects of the procedures. Most of the participants indicated that they could recognize preoperative anxiety by observing verbal and nonverbal signs. All participants stated the importance of providing information e.g., answering questions, explaining the procedure, explaining the risks that may come along. Many participants asked questions to their patients and adapted their approach and attitude depending on the patients' answers. They sought to make a connection with their patients by standing close to them, looking them in the eyes, or assuring if the patient wants to proceed with the surgery. None of the staff anaesthesiologists mentioned having received a particular training in communicational skills to comfort a patient. One resident mentioned having classes during medical stud-

ies, however these classes did not contain specific therapeutic linguistic features. An overview with subthemes and verbatim quotations can be found in **Tables 2–6**.

Table 2. Themes and sub-themes

Themes	Subthemes
Presumed causes and effects of preoperative anxiety	Surroundings of the OR Fear for the unknown, the anesthesia, the surgical procedure Information provision Approach Effects of preoperative anxiety on induction, postoperative anxiety and pain, trauma
Recognition of preoperative anxiety	Non verbal signs Verbal signs
Current handling with preoperative anxiety	Information/ elucidate Medication Approach /Personalization
Current training and feedback	Current education concerning therapeutic communication Feedback from staff members Feedback from residents Feedback from patients
VR embodied experience	Negative VR experience Positive VR experience

Table 3. Presumed causes and effects of preoperative anxiety

Surroundings of the OR	"I think the OR, you open a door to another world, people look different, they have other clothes, a mask, there is a lot of medical equipment (5) It's all very impersonal, the holding area especially. We discuss quite some personal and sensitive information where there's not much room voor privacy" (4)
Fear for the unknown, the anesthesia, the surgical procedure	If I would be a patient I would want to know what is going to happen. And also what would be the solution if something happens not the way it's supposed to" (7) "You literally give your live in the hands of someone else, a complete stranger (they don't know me at all!)" (4)
Approach	"I think the team. It matters a lot what team is there, how relaxed or stressed they are." (2)
Effects during anesthesia and recovery	"Stress may be harmful for a patient with heart failure. Being able to reduce stress has therefore a direct function on patient safety." (3) "You can see that when a patient is very wild during the induction they are very fidgety when they wake up." (8) "When a patient is stressed, this effects the autonomous nervous system so the wellbeing…. The more high you start, the lower you fall. So in these regards its medically better if the patient is relaxed when they undergo anesthesia." (8)

Table 4. Recognition of preoperative anxiety

Verbal signs	"Some people when they are nervous they start to talk a lot, to raddle." (2) "You can see it and notice it, often they also express it and say they are afraid." (1)
Non verbal signs	"Facial expressions. Or, even though they say they are calm, their vital parameters tell me otherwise." (1) "I can see it in their eyes. And I appoint it". "I can hardly to anything against the stress if they say they are not stressed. But often it's stress" (2)

Table 5. Current handling with preoperative anxiety

Information	"I ask what they are afraid for. If they are afraid to die, which is often during a high risk procedure, I can hardly say this will not happen because the risk does exist." (1) "I explain we will do our best and make sure the patient wakes up." (8) "Explanation. Every step we take, what we do. Like that. It's like a standard talk you give." (4) "Some information is relevant. Some information is more destined to colleagues. You may rather say "I expect a little blood loss" instead of "I expect 200cc blood loss".(8) "I always tell opiates may cause nausea, dizziness, giddiness. Some things may hurt." (5)
	"I try to explain we really need it. And you can hardly avoid it, I do some tricks to ease. Like: ' Oh, you can say it when it hurts' , and then I check if it's better. But I'm not sure that if you don't say beforehand something is going to hurt it will hurt less." (5)
	"I present myself, tell the patient we'll take good care of him, then we speak with the team members before we start our anesthesia induction. It's a very short moment, and however they will, they will fall asleep anyway." (1)
	"If you're going to hurt someone, and you don't tell them beforehand, I don't think that's fair." (5)
Approach Personalization	"What I always do, consciously, is that I stand very close to the patient to really make contact. Make that connection." (5)
	"I always say: "If you don't want to do this, you don't have to, right?!". (4)
	"I will tell them. "I see your heart rhythm shows you're anxious, but that's not an issue". Or I will take their hand, sometimes you don't need to talk I try to level with a patient, make eye contact, not from a higher position, really look him in the eyes and tell we're gonna take good care of you." (7)
	"I believe the approach is the most important. People feel safe when they are approached in the right way." (3)
	"When they have to sleep, they will sleep. I'm not, just because they are afraid going to change my ways. Expect of course by guiding them." (1)
	"I just take my time. I sit beside the bed, even if it's 6hr30 in the morning or in the middle of the night. I don't care. Especially when I notice someone is afraid, I try to explain what is realistic about this fear and what isn't." (6)
	"I explain this is our comfort zone, this is what we do and where we feel passionate about." (5)
	"I know what suggestive questions are. Like: ' You're not in pain right'? No, you should ask: Are you in pain?" (6)
Medication	"Using medication. It's not always prescribed so I think this is where we may gain something." (8)

Table 6. Current training and feedback

Current training	"We don't really get classes in communication skills. In the OR I'm not really consciously using any special techniques." (7)
	"No, nothing during my studies. I think you kinda need to have it 'in you'…" (6)
	"I think we learn more during our practice." (7)
	"So no, we don't get any classes. So in the OR I'm not very aware of a particular communication technique I would like to use. I don't really apply any tools in the OR."(7)
	"I've had classes in communication, but never since my studies." (2)
Feedback	"Be interested in the patient. Make sure there is calmness in the OR." (4)
	"Well, you don't see your patients after surgery. When they go to sleep being relaxed they also wake up relaxed. But how patients really see or experience this we never here." (7)
	"We work very individually, making it hard to give each other feedback. Sometimes we accompany a resident, but we don't really give feedback. And of direct colleagues I never see how they communicate" (6)

Table 6. Current training and feedback (*continued*)

Feedback	"Yes, that's a good one. No we don't really have a method for this, to give each other feedback." (8)
	"Yes, well it's kind of part of our job. If someone says something very upsetting to the patient, I would definitely say something." (5)

Discussion of the negative patient-embodied VR experience

Participants saw the negative VR experience first. Eight of the participants spoke in the first person while reflecting on the video:

> *"This team was very distant. I don't think I would have gone easily to sleep. No, I don't think any trust is created here." (7)*

In the negative video all participants experienced distance. Three noticed they felt scared, three noted they felt uncomfortable, three explicitly noted a lack of empathy within the medical team. Five participants did not feel 'seen' as a patient with needs and insecurity. One participant said the following:

> *"This team was so distant. I don't think I would have gone under anaesthesia." (7)*

Another participant wanted to call off the surgery: "I almost have the urge to, in this situation, to just go home. Thinking no one listens to me, everyone is doing something else.

> *"Yes, I don't feel safe." (6)*

Participants agreed that aspects of the video were realistic and could have happened in real life.

> *"I recognize a lot of things, (….), The empathic capacity of all parties is very mediocre. They should imagine themselves this is a very special day for me (…), something important is going to happen to me and my bodily integrity." (8)*

An overview with subthemes and verbatim quotations can be found in **Table 7.**

Table 7. VR experience

Negative experience	"This team was very distant. I don't think I would have gone easily to sleep. No, I don't think any trust is created here." (7)
	"It's very impersonal, patients are ignored, a lot of things go wrong." (1)
	"I almost have the urge to, in this situation, to just go home. Thinking no one listens to me, everyone is doing something else. Yes, I don't feel safe." (6) "I recognize a lot of things, (….), The empathic capacity of all parties is very mediocre. .. They should imagine themselves this is a very special day for me (…), something important is going to happen to me and my corporal integrity." (8)

Table 7. VR experience (*continued*)

Negative experience	"I felt very uncomfortable and embarrassed. I also felt like there was no time." (3)
	"This team was so distant. I don't think I would have gone under anesthesia." (7)
	"It felt like you're a production number. Oh, here is a new knee, and this one is for me." (5)
	"They should imagine more that for me this is a special day, that I'm getting all these new impressions and something is going to happen with my physical integrity. That's what's really lacking here. More empathy and compassion." (8)
Positive experience	"There was more calmness, more friendliness. (…) Everyone had attention for the patient." (3)
	"A lot more calm (…) There was clearly a 'information hygiene', this is how it should be done. Friendly, polite, empathic, calm." (8)
	"This felt more relaxed. Yes, absolutely a good feeling. Much better." (4)
	"I was more relaxed. I felt heard and informed. You know what's happening, these persons around me are important. (…) People make contact with me, less noise." (1)
	"They made me feel like I was in good hands." (2)
	"It was more calmer, you felt seen, there was more attention. I think sadly in our daily practice we should do more things." (5)
	"An oasis. Much better, but better relaxation. A world of difference." (8)
	"Much different. They answered questions, there was distraction when the IV was put in, they made contact with me." (2)
	"Yes, this was very relaxing. It felt so good." (5)
	"This was a 180 degrees turn, it was more calm. How people moved, but also the alarms were turned off. More friendliness, being polite to the patient. Like sitting next to the patient instead behind her. There was a hygiene in what information was given to the patient. This is how it should be." (8)

Discussion of the positive patient-embodied VR experience

Participants saw the positive VR experience after they reflected on the negative VR experience. Seven of the participants spoke in the first person while describing the video:

"They made me feel like I was in good hands." (2)

All participants reacted positively on the style of communication in this video. All participants agreed this version to be much more relaxing:

"There was more calmness, more friendliness. (…) Everyone had attention for the patient." (3)

"An oasis. Much better, but better relaxation. A world of difference." (8)

The majority of the participants expressed positive feelings and emotions. Two participants stated they wished their own handling would be more like this positive experience:

"It was calmer, you felt seen, there was more attention. I think sadly in our daily practice we should do things more like this." (5)

One participant did say the style of communication not to be theirs but added this style to be more relaxing. One of the participants expressed this style to be nice but noted it would become 'strange' if exaggerated.

An overview with subthemes and verbatim quotations can be found in **Table 8.**

Table 8. Response to positive experience

Calm/Relax	"A lot more calm (...) There was clearly a 'information hygiene', this is how it should be done. Friendly, polite, empathic, calm."(8) "This felt more relaxed. Yes, absolutely a good feeling. Much better."(4) "I was more relaxed. I felt heard and informed. You know what's happening, these persons around me are important. (...) People make contact with me, less noise."(1) "There was more calmness, more friendliness. (...) Everyone had attention for the patient."(3) "An oasis. Much better, but better relaxation. A world of difference."(8) "Yes, this was very relaxing. It felt so good."(5)
Professional trust	"They made me feel like I was in good hands."(2) "Much different. They answered questions, there was distraction when the IV was put in, they made contact with me."(2) "This was a 180 degrees turn, it was more calm. How people moved, but also the alarms were turned off. More friendliness, being polite to the patient. Like sitting next to the patient instead behind her. There was a hygiene in what information was given to the patient. This is how it should be."(8)

Reflection by participants

Participants were invited to compare the two VR experiences and reflect on how they were affected by them. All participants were able to note differences between the experiences. They agreed the experiences to be realistic, seven participants explicitly said the positive VR experience was more the method they would prefer.

> *"This was 180 degrees turn, more calm. How people moved, but also the alarms were turned off. This is how it should be." (8)*

Four participants noted their body responded to the VR experiences. They noted that their body had reacted to the two videos in a different way:

> *"I felt it. I felt a lot more relaxed". (1)*

A majority of the participants reflected that the videos permitted to see a change in the style of communication and how this affected them, if they would have been a patient:

> *"I question now, it is true that children who go to sleep while they are fighting, also wake up like this, this may also really feel the same for adults." (1)*

"I really believe the communication styles of the video's matter for the lived experience of the patient". (2)

Four participants specifically suggested the use of patient-embodied VR and the training or use of communication skills to be useful:

"I think we should start training people like this. Especially because there are people who don't have affinity with this subject, or people who still have a lot to learn. Especially in the OR, this is very important" (3).

"Sometimes we're thinking about a next patient. But we have to really be aware. Awareness is very good, especially using these kinds of videos. It's a way to create awareness." (9)

Many participants reacted in a positive way on VR to be used in an educational purpose. Learning in a practical way was preferred by a majority of the participants:

"I think we can learn more while doing it". (7)

DISCUSSION AND CONCLUSION

Discussion

With our study we elaborated on how VR can simulate a lived experience in a preoperative setting. Adapting Kolb's Experiential Learning Cycle, embodied VR offers an innovative possibility to provide a concrete experience not easily available in real life. Patient-embodied VR can therefore simulate Kolb's diverging phase to 'Feel and Watch' and its assimilating phase to 'Think and Watch' as shown in **Figure 6**.

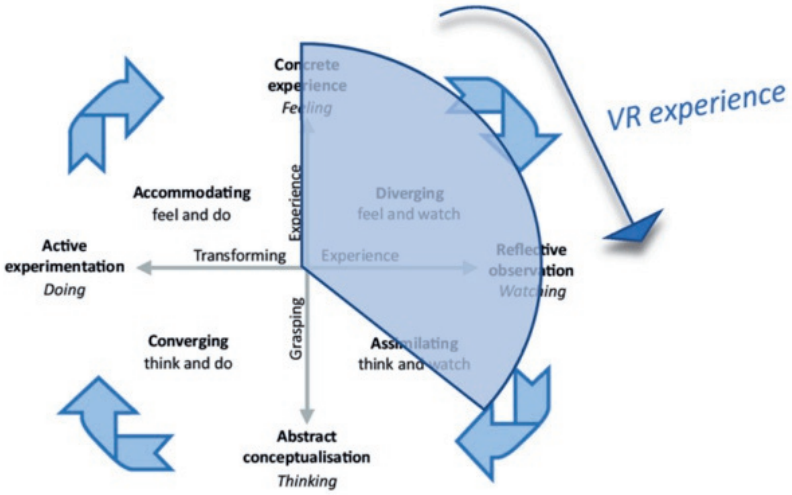


Figure 6. Patient-embodied VR may simulate the first two diverging and assimilating phases: 'Feel and Watch', 'Think and Watch'.

To create the sense of *presence*, immersive storytelling with VR offered an experience where participants could create their own story. For this purpose, the 360^0 VR tools included several actions happening around the patient. Indeed, our VR tool was able to simulate a lived experience in a preoperative setting implying internal validity of our study. Participants reported their lived experiences from a first-person perspective and explained how they had felt a change in their own body.

Finally, we've conducted semi-structured interviews to substantiate how our VR tool may influence the beliefs and opinions of anaesthesiologists. The immersion of the reality of a patient created a shift in perception and understanding of the participants. During the reflective phase of the interviews many participants noted positive effects of therapeutic communication and suggested the start or use of training of these skills. The use of narrative-based medicine had been put into practice contributing to a better understanding of physician's role in communication and handling of preoperative anxiety. The results of our study congruent with other studies that demonstrated that VR affects crucial transformation memory processes (10, 11). The interviews permitted Kolb's second phase of *reflective observation* as shown in **Figure 7.**

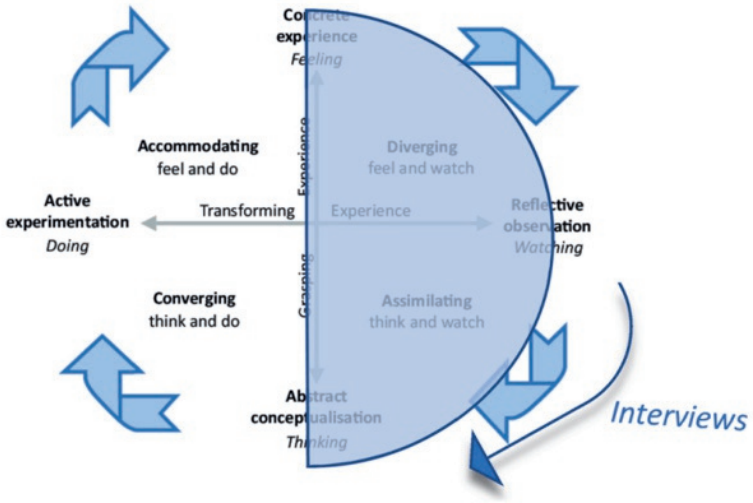


Figure 7. Reflecting during semi-structured interviews may simulate 'Abstract conceptualization'.

Elements indicating generalisability were the concordance of study data concerning preexisting knowledge and beliefs of preoperative anxiety, on communicational skills, and training. Participants seemed to give great importance to the reduction of preoperative anxiety as they all pointed out one or more negative clinical effects of it. Causes and effects cited by the participants accord with previous research concerning preoperative anxiety and rapport-making between healthcare providers and patients (2-5, 44-46).

Likewise, participants elaborated how they would read verbal and non-verbal signs of the patients to be able to adapt their personal approach. They pointed out how distance could occur, especially when they are busy. This concords with other studies in a broader medical context that have already shown patients reporting dissatisfaction derived from a lack of rapport or empathy exhibited by physicians, which often resulted from work exhaustion and the medical culture's emphasis on 'distance', professionalism (47).

Implicatively, participants did suggest the importance of *connection* with their patients. However, specific knowledge and skills on the creation of rapport and other aspects of therapeutic language and communication lacked amongst the participants. Moreover, specific teaching or training in therapeutic communication was insufficient as participants reported no specific courses or methods, nor standardized evaluations or feedback by patients or colleagues. These findings confirm earlier research such as the work of Lave and Wenger as well as Billet who describe how professional acculturation occurs through social processes of on-the-job or situated learning within the workplace sometimes called the 'hidden curriculum' (23, 48-50). It outlines how VR can be used as an educational tool to create awareness and intrinsic motivation to learn more about therapeutic language

and communication. This is in line with studies demonstrating the feasibility of VR to train soft skills and communication in medical education (51, 52).

One limitation of the study might be the interviewing of anaesthesiologists of only one hospital, as clinical setting and contextual factors may differ in another hospital or country. Another limitation might be a certain selection bias as study participation was voluntary, However, we estimate little bias as participants knew very little about the objectives of the interview, they knew nothing of the content of the VR experiences.

CONCLUSION

In conclusion this study elaborated the potency of Experiential Learning with VR in therapeutic communication in a perioperative setting. The patient-embodied VR experiences were experienced by anaesthesiologist participants as if they had been a patient, a setting rarely possible in a real life. Semi-structured interviews revealed that participants were able to distinguish the subtle changes in communication and language. Furthermore, participants have the same knowledge and believes of preoperative anxiety as known in literature. The latter suggests external validity despite a modest sample size.

Analysis of the reflection on therapeutic communication skills before and after the patient-embodied experience showed a shift in perception, implying effective immersive Experiential Learning. As *rapport* is a corner stone of clinical interactions, we believe this methodology may be particularly relevant for stakeholders seeking to improve patient-centered care through therapeutic communication. Patient-embodied VR might be an effective educative tool that can be used in training in therapeutic communication skills.

PRACTICE IMPLICATIONS

The methodology using a VR-embodied experience may indeed be used in a broader context in medical education where 'becoming a patient' is relevant, but difficult to elaborate. In the last decade it has successfully been developed in psychiatry and geriatrics to train healthcare providers to communicate with patients with whom communication is challenging (53, 54).

Earlier research outlined the need of more research on VR implementation in health profession education (9). This research may contribute to fill in this gap of consistent knowledge on how to use VR in medical education as it gives a rich description on the design, development and potential of our VR tool.

However, in our study set-up, not all phases of Kolb's learning cycle were completed. One still needs to converge (*think and do)* and accommodate (*feel and do)*. Further research with these elements is needed to evaluate the effects of the implementation of a training in therapeutic communication with an integrated patient-embodied VR experience.

Research should also examine how these experiences might affect future patient interactions and patient outcomes, including assessing whether training healthcare professionals using a patient-embodied VR approach could lead to subsequent reduction in patient-reported pre- operative anxiety and improved communicational skills.

COMPETING INTERESTS

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Author contributions

Krista Hoek: Conceptualization, Methodology, Software. Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization, Project administration.

Elise Sarton: Conceptualization, Methodology, Formal analysis, Supervision, Validation.

Monique Van Velzen: Conceptualization, Data curation, Supervision, Project administration.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

ACKNOWLEDGEMENTS

Our special thanks go out to all healthcare providers participating in the development of the patient-embodied VR experiences. We are highly thankful to GJ van Geffen for contributing to the writing of the scripts of the patient journey.

We also extend our gratitude to our reviewers to have guided us towards improving our manuscript even further.

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4B

RESPONSE TO COMMENTS ON "PATIENT-EMBODIED VIRTUAL REALITY AS A LEARNING TOOL FOR THERAPEUTIC COMMUNICATION SKILLS AMONG ANAESTHESIOLOGISTS: A PHENOMENOLOGICAL STUDY"

ARTICLE INFO

Authors:

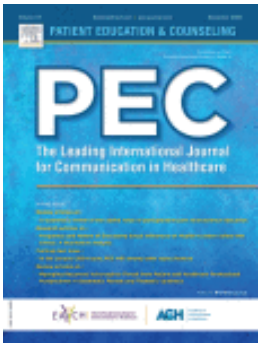
Krista Hoek
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Keywords:

Empathy
Negative suggestions
patient-centered care
Patient-doctor communication
Positive suggestions
Therapeutic communication

DOI: 10.1016/j.pec.2023.107980

Patient Education and Counseling



Volume 117
ISSN 0738-3991
December 2023
107980

ABSTRACT

This correspondence responds to criticisms of the phenomenological approach used in the article 'Patient-embodied VR as a learning tool for therapeutic communication skills among anaesthesiologists: a phenomenological study', defending the methodological choices and interpretive framework.

We express our gratitude to Michael Ting and colleagues for their insightful remarks on our recent article (1). Their comments address critical aspects of phenomenological qualitative research.

The authors raise three comments with respect to the used methods of our study. Firstly, the authors highlight important points on validity of our VR experiences. They express concerns with respect to selection bias and applicability of the scripts, an omnipresent bias that needs to be taken into account interpreting study results and their applicability. Within the immersive scenarios, we deliberately incorporated nuanced shifts in language and interactions, informed by conceptual frameworks and prior scientific investigations as referenced in our manuscript. Notably intricate are patient-physician interactions, a complex interplay of empathetic conduct, sociocultural cues, and rapport often founded on non-verbal cues, surpassing verbal communication (2, 3).

Neurobiological mechanisms can implicitly make one feel at ease or uncomfortable. Patients may not be able to recall specific moments allowing them to identify exact factors contributing to a particular sense of (dis)comfort. As outlined in our manuscript, the ultimate lived experience arises from complex subjective neural networks, interactions, and the intricate web of Cortico-Limbic-Thalamic connections (4, 5). The objective of our study was not to explore the lived experience of patients, but to explore the impact of a lived patient experience on healthcare providers concerning therapeutic communication. Patient perspectives are very valuable and study results of several patient-centered studies have been incorporated in the scripts elevating validity. For the final touch of specific contextual factors of our hospital setting, the narratives and patient journeys have been co-developed by a team of healthcare professionals working in the operating room. They have seen many patients and were able to recall several interesting elements enhancing authenticity of the storyboards and scripts.

Furthermore, the authors raise queries on the long-lasting skill retention among study participants. Our study meticulously established how VR can simulate a real-life experience, adhering to Kolb's Experiential Learning Cycle (6). Yet, as the discussion section of our papers describes, it remains critical to converge *(think and do)* and accommodate *(feel and do)* to complete the learning experience as shown in **Figure 1.** We concur on the necessity for subsequent research incorporating these elements to assess long-term skill retention and its impact on the healthcare environment.

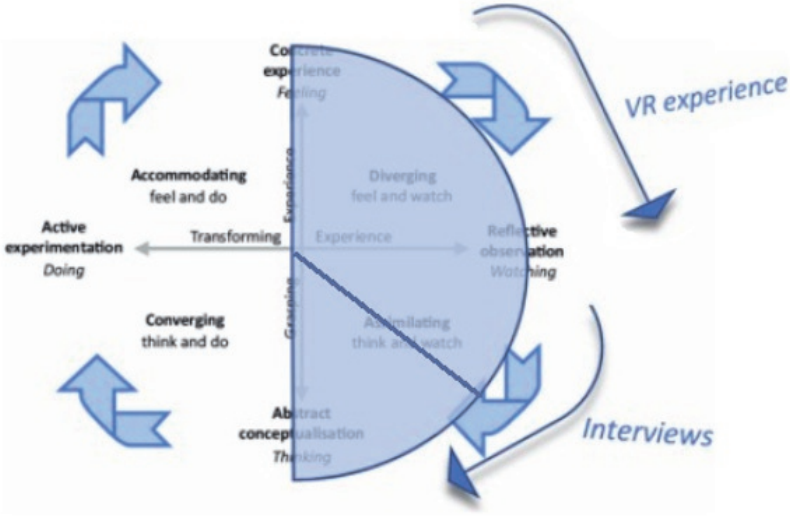


Figure 1. Kolb's Cycle (6) with 4 phases: Diverging, Assimilating, Converging and Accommodating. In the colored section is shown what parts of the cycle have been accounted for during our study (1).

Finally, concerns were raised on the sequence of the VR experiences. Our manuscript delineates how patient-embodied VR can replicate lived experiences and influence the attitudes and convictions of anaesthesiologists regarding therapeutic communication. Our methodological choices aligned with our research questions, beginning with an initial VR experience displaying current standard practices and deliberately lacking content explanations to mitigate influence of availability heuristic. We hypothesized that altering the sequence would amplify confirmation bias, leading participants to actively seek 'negative cues' in the negative experience. We did consider a randomized presentation of VR experiences to our participants, and we believe it would have complicated our thematic analysis given the relatively low number of participants.

We emphasize once more the two versions varied minimally, refraining exaggerated behaviors or communication styles. Both versions entailed the same procedures, duration, and persona with only subtle adjustments. One version portrayed standard care, drawing from real-world examples, while the second version portrayed a potential reality using therapeutic communication styles.

In summary, we believe our findings contribute to the field of educational VR development and we look forward to more exciting research on this topic. The overall aim of this area of development is to uncover patient-embodied VR's potentials and drawbacks, and determine its role in training therapeutic communication in the medical field.

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4C

DEVELOPMENT OF A PATIENT-EMBODIED EXPERIENCE, HOW AND WHY?

ARTICLE INFO

Authors:

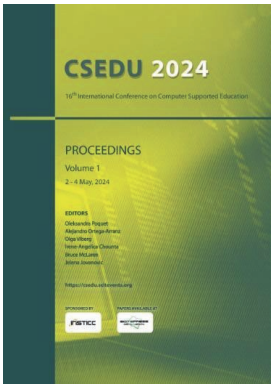
Krista Hoek
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Keywords:

VR
Therapeutic language
and communication,
Ethnographic phenomenology,
Healthcare education,
Patient-embodied experience,
Proteus-effect

DOI: 10.5220/0012755800003693

Serious Games for Education



Volume 1
ISSN 2184-5026
ISBN 978-989-758-697-2
May 2024
Pages 758-764

ABSTRACT

Introduction

The rise of immersive technologies, particularly virtual reality (VR), has significantly impacted medical education. In patient-embodied VR, through VR headsets, learners can embody a patient's perspective, offering a secure and immersive learning encounter. This communication outlines a framework for crafting patient-embodied experiences, drawing from our VR endeavours aimed at enhancing therapeutic communication skills in medical education.

Methods

Our framework includes a development process with consideration of user experience, technical implementation, content creation and validation. Central to content creation is the collaborative construction of a patient journey, involving the involved parties via storyboards and scripts distinguishing direct and indirect actions.

Results

For our patient-embodied experience, the cooperative development of the patient journey, script and storyboard included an initial version created by the main researcher after study of landmark articles on therapeutic communication and fieldwork. Validation was achieved through two group sessions with healthcare providers who consented to participate.

Conclusions and practice implications

The findings and insights presented can contribute to the growing knowledge in the field of educational VR development. They demonstrate the feasibility and potential of leveraging immersive technologies to create engaging and impactful virtual experiences. Hitherto, further validation may evaluate how they influence beliefs and attitudes of healthcare providers towards therapeutic communication.

INTRODUCTION

Medical education has been incorporating elements of experiential learning for several decades, and the specific use of immersive technologies has gained more prominence in recent years. In particular, learning with virtual reality (VR), or immersive virtual environments (IVEs) aligns with the Constructivist Theory, which suggests that learners actively construct their knowledge and understanding of the world by building upon their existing mental frameworks. In an immersive learning environment, learners are given the opportunity to explore, discover, and make meaning from their experiences (1)

In virtual reality (VR), immersive learning incorporates various sensory modalities to enhance *multisensory engagement* enabling embodiment. Embodiment is the possibility in VR to visually substitute a person's real body by a life-sized virtual one, seen from the person's own first-person perspective. In other words, when we place a VR headset on, our virtual bodies momentarily substitute our real bodies, a phenomenon known as the *Proteus effect* (2). Multisensory and motor systems interconnect during cognitive processing. During VR, embodiment can increase users' engagement and provide emotional fidelity invoking a sense of *presence* creating realistic emotional and neurocognitive responses (3, 4).

When using VR as an educational tool, learners have the ability to experience a full 360-degree view, providing them with unrestricted access and freedom to explore their surroundings. This contrasts to traditional video experiences, where the audience's perspective is limited to a fixed viewpoint as depicted in **Figure 1**. The distinctive aspect of VR lies in its participatory nature. In VR, writers, directors, and producers, referred to as builders, do not have the ability to dictate how learners engage with the story. Instead, they can only invite participation, allowing learners to choose where to direct their attention and which aspects of the story to focus on (5). This stands in contrast to conventional storytelling, where a storyteller transmits the narrative to listeners. Traditional videos typically provide viewers a fixed perspective. The screen acts as a window into the world of the video, and viewers can only observe the events and scenes from the specific viewpoint chosen by the director as shown in **Figure 1.**

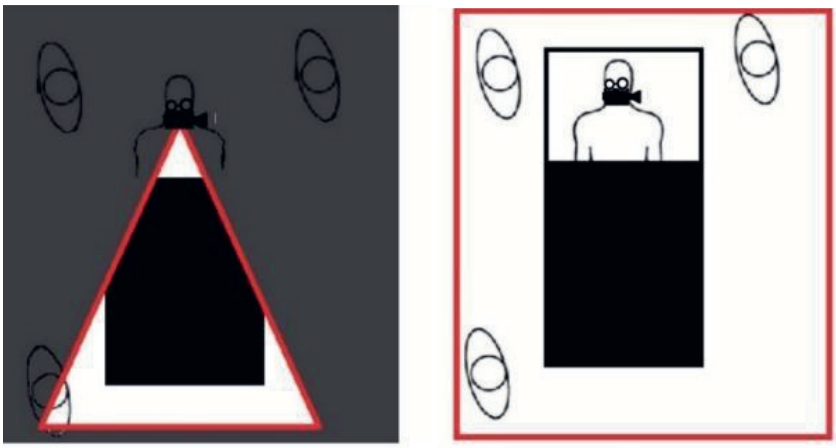


Figure 1. Red outlines show the extent of what a camera can film in 90 vs 360 degrees of freedom.
Left: 90 degrees of freedom of traditional film
Right: 360 degrees of freedom of VR

In healthcare, a growing emphasis on patient-centered care, and consumerism in medicine has exemplified the importance of effective physician-patient communication (6) and the use of IVEs as an educational tool in this context. We will refer to patient-embodied VR as the specific VR application where a learner who puts on the VR headset virtually becomes the patient. Given that this immersive transformation has the capacity to affect self-perception, attitudes, convictions, and conduct in both implicit and explicit ways (2, 4, 7), our hypothesis posits that it holds substantial promise as an exceedingly effective and innovative pedagogical approach in education on communication skills.

An example of the use of patient-embodied VR can be found in our work published recently (8, 9). We developed two patient-embodied experiences to create a possibility for healthcare providers to feel what it is like to become a patient. In these VR experiences, the learner experiences the sequential stages of a patient undergoing elective general anesthesia and surgery, with nuanced shifts in language and interactions. We will describe how we have developed these experiences, and what important lessons we have learned that can be used by researchers aiming to develop-embodied VR experiences.

METHODS

This prospective exploratory research was carried out at the Leiden University Medical Center (LUMC, Leiden, the Netherlands), a large tertiary academic teaching hospital. The protocol was approved by the Institutional Science Committee and obtained a waiver from the Institutional Review Board (NWMO-LUMC).

Informed consent was obtained prior to inclusion, participation was voluntary and privacy rights were in alignment with the Declaration of Helsinki and GDPR guidelines. Data was collected and recorded between February 2019 to December 2020. Participants received no financial compensation.

Prototype iterations were systematically tested in simulated settings, followed by expert debriefings and FMEA. Each cycle informed design enhancements, ensuring usability and training effectiveness. Adjustments continued iteratively until the prototype was deemed optimized. User evaluations revealed that medical interns and clinical educators believed in the potential and usefulness of the VR simulation as a learning tool for CRM.

Encountered challenges included onboarding in the virtual environment requiring participants to familiarize themselves with effective navigation within the virtual space.

Another challenge involved translating clinical needs into programming possibilities outlined by the developers. This continuous need for translation persisted between user requirements and technical capabilities. Integration of simulation with UCD and FMEA facilitated design and redesign of the prototype.

The anaesthesiology department provided full support, and a collaborative partnership was made with another university medical center to facilitate further validation and broader implementation for other institutions enhancing scalability.

Participants and procedures

Healthcare providers working in the OR were invited to participate in the development of the patient-embodied VR experiences. They were recruited between January 2019 and May 2019. The procedure encompassed content creation, content validation, and filming and editing of the VR experiences as shown in **Figure 2**.

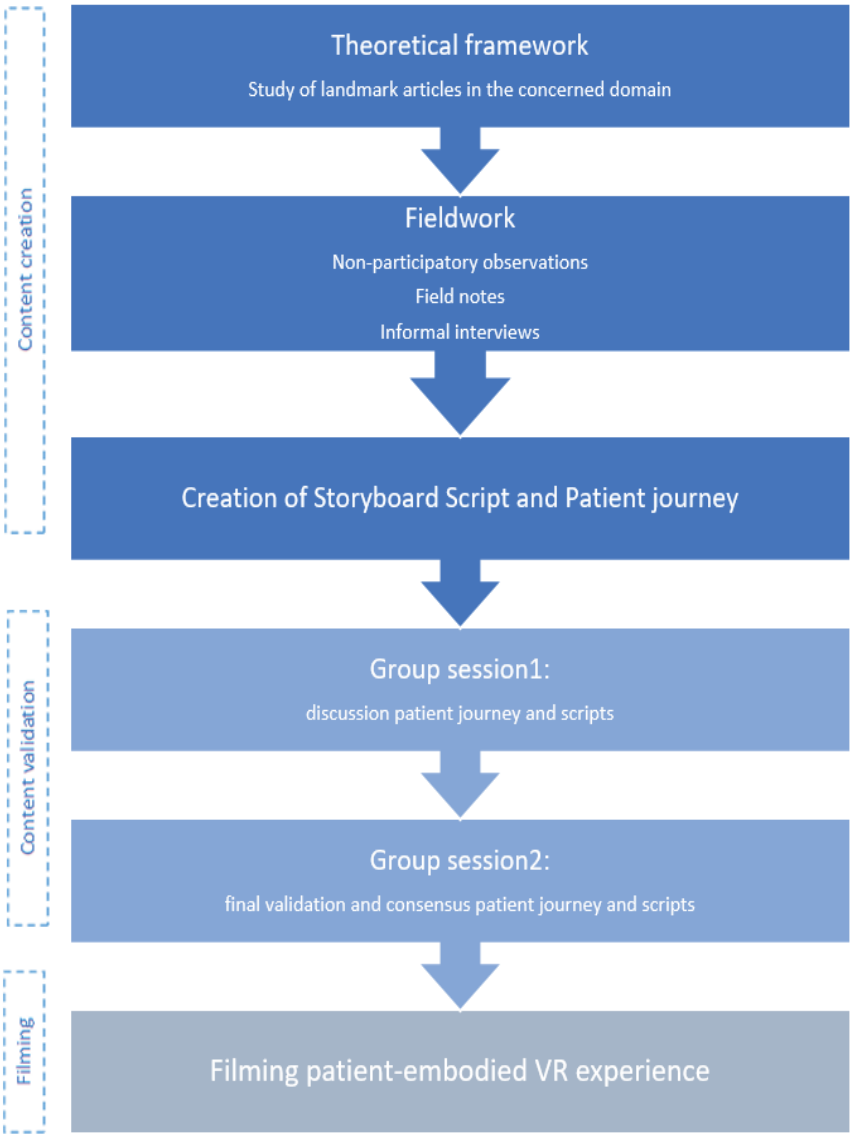


Figure 2. structure of the study participation

Content creation

To create the storyboard and script of the patient journey, a theoretical framework needed to consider the study of landmark articles in the concerned domain. In our case, Landmark patient-centered studies were used to include important aspects of lived patient experiences in preoperative settings (10-18).

Secondly, fieldwork of the researcher (KH) included informal interviews with healthcare providers and patients, along with observations to gather data was used to create an initial script for the patient journeys as shown in **Figure 2.**

Content validation

Group sessions are an adapted tool to validate the storyboard and script (19). In our study, a first group session was held to discuss and adapt the scripts.

Group input such as photographs, focused and selective observation notes, reflective notes and commentaries were used to write a second version of the patient journeys. A second group session implied a final validation where the scripts were discussed and adapted until consensus was reached; that is until the final script was consented by all group members (20) as shown in **Figure 2.**

The specific linguistic features were further validated by an independent hypnotherapist based on validated and relevant research (16, 18, 21-25).

Filming and editing

Asking healthcare providers to play their own role has several advantages as its economical, and the actors may identify themselves very easily with their own professional role. We asked the developers to play their own professional role, e.g. a surgeon would play the surgeon. An anaesthetic nurse volunteered to play the patient, as she had been a surgical patient several times before.

RESULTS

Case study description

Nine healthcare providers participated in the development of the patient-embodied VR experiences. Six were OR nurses, one was a surgeon and two were anaesthesiologist-hypnotherapists. One hypnotherapist who was not affiliated with our hospital did not participate in the filming of the experiences. The majority was female (82%). Demographics are shown in Table 1.

Table 1. Demographic characteristics of the VR development team and study participants

Clinical role	
Anaesthesiologist-hypnotherapist	2
CRNA (Nurse anaesthetist)	2
Preoperative holding area nurse	3
Operating room nurse	1
Surgeon	1
Years of practice	
<1year	1
1-5years	3
5-10years	1
>10years	4
Sex	
Male/Female	2/7

Development of the patient-embodied VR experiences

Between February 2019 and December 2019 two scripts and storyboards were created: the positive and negative patient-embodied VR experience.

Guidelines of several digital platforms were used (5, 26). Filming was performed using a *GoPro*® camera, editing was performed using *Movavi*® enabling the experiences to be available on most common VR headsets. Also, an online Youtube version was uploaded making it possible to view the experience online.

The final durations of the experiences were 12 minutes and 19 seconds for the negative experience, and 10 minutes and 36 seconds for the positive experience.

The story-world needed to be as consistent with reality as possible, using objects, personas, and actions to stimulate the sense of immersive *presence*.

Storyboard and script

We developed a storyboard with the main scenes as shown in **Figure 3** including all direct interactions with the patient.



Figure 3. Storyboard patient-embodied VR experience

We developed a script with 'shadow actions' visible if the learner would look around. An overview of the main differences in setting, direct interactions and shadow actions can be found in **Table 2**.

Table 2. Overview of main difference in setting, interactions and shadow actions

	Negative experience	Positive experience
Setting		
Preoperative holding area	No (distraction) activities for other patients No preventive measures for delirium prevention	Other patients use a tablet or read a magazine Curtains opened, visible clock, noises of monitoring minimalized
Operation room	Radio on Alarms and sounds of continuous monitoring on. Surgical equipment partially displayed	Noises minimalized No visible surgical equipment

Table 2. Overview of main difference in setting, interactions and shadow actions (*continued*)

	Negative experience	Positive experience
Direct interactions		
Contact with preoperative holding area	-Patient is ignored when she requests to go to the toilet -Nurse does not ask any personal questions while she places the IV cannula	-Nurse sits next to the patient -Nurse uses hypnotic distraction methods during the placement of the IV cannula -Nurse responds to the concerns of the patient.
Contact with anaesthesio-logist	Contact with anaesthesiologist with little rapport.	Anaesthesiologist asks personal questions before the patient is taken into the OR
Shadow interactions		
Preoperative holding area	OR nurse passes as the patient is brought to the preoperative holding area, he tells his colleague there is a bleeding in the OR, and he needs to hurry	OR nurse passes as the patient is brought to the preoperative holding area. He holds something in his arms, but is discrete.

Setting

In the positive experience, another patient present is able to read a magazine as shown in **Figure 4**. This is a distraction method that may increase comfort while the patients await their surgery (27).



Figure 4. Positive experience: another patient reads a magazine

Direct interactions

There are changes in attitude of the healthcare providers with or without a direct therapeutic relationship. One example is the communication style of the anaesthesiologist just before the start of the inductive phase of anaesthesia (patient is induced into a state of

unconsciousness and analgesia (pain relief) before the start of the surgical procedure) as shown in **Figure 5**.

In the negative video, the anaesthesiologist administers the medication, however, the communication shows limited effort to establish rapport (8, 17, 28). Furthermore, the potential side effects of the drugs are explicitly mentioned, thereby increasing the likelihood of the patient experiencing these adverse effects (18, 25).

In the positive experience, the anaesthesiologist uses hypnotic linguistic techniques to induce relaxation (24), enhance focus and promote a smooth start of general anaesthesia. The anaesthesiologist sits beside the patient (16).



Figure 5. Anaesthesiologist sits next to the patient, uses suggestive language to induce relaxation

Shadow actions

An example of a suggestion used in the final script was having an OR-nurse pass by to bring blood for the transfusion of another patient to enhance authenticity of the dynamics of the operating theatre. Subtle changes between the experiences are shown in **Figure 6.**

One portrays an OR-nurse that politely smiles to the patients without showing any concerns. The other portrays an OR-nurse that expresses a sense of urgency. He seems bothered, and tells the preoperative nurse he has to deliver blood. The preoperative nurse seems worried.

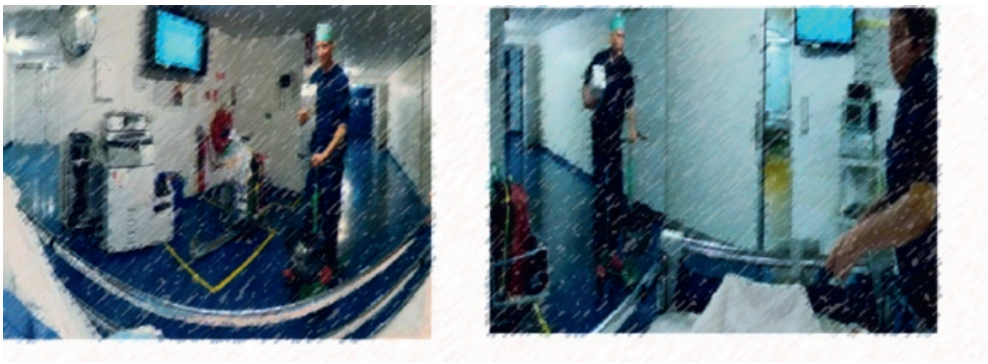


Figure 6. Left: the operating room (OR) nurse remains silent and smiles politely without showing his concerns. Right: the OR nurse conveys a sense of urgency to bring blood to another patient, and the preoperative nurse appears annoyed and worried

DISCUSSION AND CONCLUSION

Discussion

This study describes the development of two patient-embodied VR experiences. The specific linguistic features were validated by an independent hypnotherapist and were based on validated and relevant research (16, 18, 21-25).

Internal validity of the VR experiences was confirmed given that healthcare providers participated in the development of these experiences themselves. Between the two experiences, small changes in setting, interactions and shadow actions would implicitly suggest a more or less welcoming experience. Indeed, the development included the addition of these several elements enhancing authenticity of the VR experiences.

This type of immersive storytelling with VR offers learners a possibility to create their own story in 360°; as they were able to look around freely in VR. Additionally, healthcare providers played their own roles during the filming of the scenes.

Limitations

One of the limitations of the VR experiences lies in the limited interaction within the VR-environment. The learner had the ability to observe their surroundings; however, due to the recorded nature of the experiences, learners were not able to freely move around as they would have in a virtual environment utilizing computer-generated 3D video imagery.

We selected this setting based on the believe that a patient typically finds themselves confined to a hospital bed with limited mobility or free choices. We contend that utilizing a genuine operating theatre and real actors enhances fidelity, thereby intensifying the sense of immersion.

Innovation

The findings and insights presented in this study can contribute to the growing knowledge in the field of educational VR development. They demonstrate the feasibility and potential of leveraging immersive technologies to create engaging, authentic and impactful virtual experiences (8)

CONCLUSION

By using immersive VR technology, one can create an interactive and engaging virtual environment that allows learners to experience a simulated reality, that is the experience of being a patient.

This development process involves careful consideration of user experience, technical implementation, content creation and validation. In our opinion, key elements of the content creation should be based on the cooperative development of a patient journey, with participation of the involved parties using a storyboard and script that distinguishes between direct actions and indirect (shadow) actions.

Future directions and study validation

The findings of this study can contribute to further research and healthcare education programs avid to use experiential learning with patient-embodied VR. We conclude with a call for further research to fully unlock the potential and drawbacks of patient-embodied VR as an educational tool and its usefulness in medical training. Also, further research may examine how patient-embodied VR might affect patient reported outcomes like preoperative anxiety.

Initial validation of our patient-embodied experience consisted of a qualitative study analyzing the lived experience of anaesthesiologists (8). Further validation may include evaluation of the effects of the implementation of a training in therapeutic communication with an integrated patient-embodied VR experience.

ACKNOWLEDGEMENTS

We thank all healthcare providers participating in the development of the VR experiences.

COMPETING INTERESTS

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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5A

IMPLEMENTATION AND EVALUATION OF A THERAPEUTIC COMMUNICATION EDUCATIONAL PROGRAM FOR NURSES: PROTOCOL FOR A MIXED METHOD DESIGN

ARTICLE INFO

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Keywords:

VR,
Therapeutic language,
and communication,
Ethnographic phenomenology,
Healthcare education,
Patient-embodied experience,
Proteus-effect

DOI: 10.2196/65795

Journal of Medical Internet Research



Volume 14
ISSN 1929-0748
June 2025
e65795

ABSTRACT

Background: Admission to a hospital can be a very stressful and anxiety-provoking experience, as patients face many unknowns that can compromise their physical and psychological well-being. Patient-centered care necessitates that healthcare organizations and professionals actively comprehend patients' experiences and values, for which effective training in communication skills is essential. Objective: This study will contribute to this field of research by evaluating a blended therapeutic communication training program.

Methods: The training consists of online e-learning, followed by a virtual reality patient-embodied experience during a 1-day didactic training with experiential small groups. Theory on therapeutic communication is taught, focusing on how to use rapid rapport techniques and hypnotic and suggestive language to facilitate empathy. This is combined with practical exercises, ensuring an active learning process. By integrating these diverse blended learning training methods, the program aims to enhance nurses' communication skills, ultimately improving patient care. Applying the Kirkpatrick model for training evaluation, this prospective study will use a convergent mixed methods study design, integrating both qualitative and quantitative data. Qualitative data will include fieldwork, as well as individual and focus group interviews with the participating nurses. Quantitative data will include questionnaires that include the first two levels of the Kirkpatrick model and that are validated for this purpose.

Results: On February 8, 2024, we received permission from the authorizing body (Institutional Science Committee and NWMO Committee) to start our study. Data collection started in April 2024 and was completed by the end of 2024.

Conclusions: This study will systematically evaluate the effectiveness of therapeutic communication training in the acute admission ward for patients who require emergency treatment. The results will yield insights into the feasibility and acceptance of the implementation of therapeutic communication training among nurses in an acute admission ward in the Netherlands.

INTRODUCTION

Admission to a hospital can be a very stressful and anxiety-provoking experience, as patients face many unknowns that can compromise their physical and psychological well-being. Hospitalization exacerbates patients' emotional reactions and may impede their ability to cope with and adjust to this new environment (1). Especially in the dynamic and acute setting of the acute admission ward, patients are susceptible to anxiety, stress, and pain (1, 2). In the acute admission ward, many medical procedures, such as invasive exams and surgery, are notorious for causing preprocedural anxiety and stress, with a prevalence varying between 11% and 80% of all adult patients undergoing surgery (3, 4). By amplifying the body's stress response and sensitizing the nervous system, preoperative anxiety is associated with more postoperative pain, chronic pain, and lower satisfaction scores (5-9).

Landmark studies on patients' experiences and values describe that anxiety and stress come from the fear of the unknown, the uncertainty of treatments and their side effects, and the loss of control (3, 10). Patient-centered care necessitates that healthcare organizations and their professionals actively comprehend patients' experiences and values (11-14). To establish high-quality and effective communication within this framework, effective training in communication skills is essential. It may assist healthcare providers in managing anxious and painful patients.

Despite its recognized importance, communication skills are not consistently or systematically taught in medical and nursing education. There is no general agreement or regulation in the educational system on how to teach and learn communication skills. Communication skills seem to be acquired 'on the job', greatly depending on implicit contextual factors rather than conventional classes or training (15). The question arises of how to best teach and learn therapeutic communication skills and how to sensitize its importance. We hypothesize that a real lived experience of a patient could be a powerful learning experience, allowing healthcarere providers to develop a deeper, more empathetic understanding of the patient's perspective (16, 17). Furthermore, we hypothesize that this understanding fundamentally aids in learning therapeutic communication.

Therapeutic communication can be defined as a way of communicating with awareness of and positive influences on contextual factors (18-20). Spoken words are potent and suggestive tools that can shape future experiences and perceptions. In addition, communication includes paraverbal elements such as voice pitch, pacing, tone, and volume. Nonverbal aspects such as eye contact and body language also play a significant role in shaping perceptions of the receiver. These elements are crucial for establishing rapport between individuals during interactions. *Rapport*, defined as a close and meaningful relationship with mutual understanding, involves both verbal and nonverbal communication

(21, 22). Incorporating elements of therapeutic communication can improve patients' knowledge and understanding, foster trust, enhance self-care skills, increase treatment adherence, provide comfort, and aid in managing emotions, all of which are essential for health and well-being (23, 24).

While various communication training programs exist, there is limited research on the effectiveness of short, blended-learning approaches that integrate virtual reality (VR)-based experiential learning to enhance therapeutic communication. This study aims to address this gap by evaluating the impact of a one-day blended-learning therapeutic communication training program. The training combines electronic learning (e-learning), VR patient-embodied experience, and didactic training with experiential small groups, providing an innovative approach to skill acquisition

The main objective of this study is to evaluate the impact of our therapeutic communication training for nurses in the acute admissions ward of a tertiary hospital using Kirkpatrick's 4-level training evaluation model (25, 26) as shown in **Figure 1**. Our research questions are derived from the first two levels:

Level 1: How do participants feel about therapeutic communication training?

Level 2: Did participants learn about therapeutic communication?

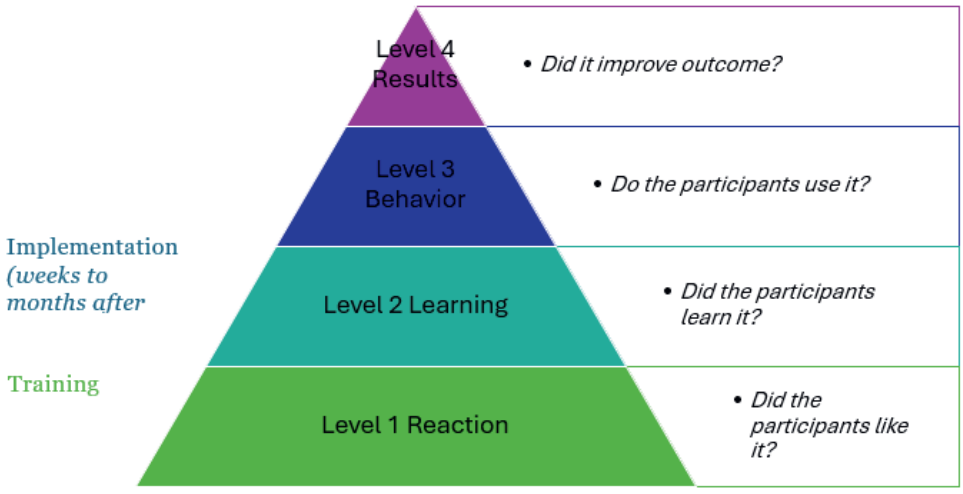


Figure 1. Kirkpatrick four-level training evaluation model

METHODS

Setting and Participants

This prospective study will be conducted at the acute admission ward of the LUMC Hospital, a tertiary teaching hospital in the Netherlands. In the acute admission ward, patients who need emergent care or treatment can be admitted for a short stay. The protocol was approved by the Institutional Science Committee as well as the non-WMO committee and will adhere to Good Clinical Practice (GCP) regulations.

To be eligible for the study, participants must daily communicate with patients or their relatives as part of their daily duties, speak proficient Dutch (local language) to be able to complete the surveys, and participate in an interview. Nurses leaving the ward within a year were excluded. For the quantitative analysis, nurses of a general ward will also be invited enhancing statistical power with a greater number of participants. In both wards, all eligible nurses were invited to participate in the TC training during working hours, and they were invited through email to participate in the study. Participants will not receive any compensation and signed an informed consent form before the start of the study. Pragmatically, the interviews will take place during working hours, inviting nurses on call on the day of the interview. To include broad data, interviews are planned during day and evening shifts on different days of the whole week.

This study will not directly involve patients in the development of the TC training, as it was designed based on established literature on patient stress and anxiety as well as previous research on the development and validation of VR-embodied experiences (16, 17).

The primary objective of this study is to evaluate the effects of the training on nurses, focusing on their perceptions and learning outcomes. Direct patient involvement in this stage would require a substantial shift in study design and ethical considerations, particularly concerning data collection from patients.

Study Design

A convergent unblinded mixed method study design in which qualitative and quantitative data are used in multiple phases and merged and analyzed equally for an interactive approach (27).

Qualitative and quantitative investigations will take place before and after the implementation of the TC training at the acute admission ward. Additional quantitative data is retrieved at a general ward.

Qualitative research, and in our case ethnography, has an important role in better understanding the social factors influencing medical and scientific routines (28). A qualitative

researcher will perform fieldwork and immerse themselves in the research population for an extended period, studying insiders' perspectives, behaviors, and culture. Qualitative outcome measures will include nonparticipatory observations, individual interviews, and focus group interviews with healthcare providers. During fieldwork, we aim to be naturalistic and nondirective, stepping back from action and minimalizing interference with regular care (29, 30).

For quantitative data analysis, data saturation will be pursued (31). For quantitative outcomes, our pragmatic feasible objective is to include at least 50% of all nurses, which amounts to 20 nurses of the total 40 nurses working in the acute admission ward, and 20 of the 40 nurses in the general ward.

Intervention

Therapeutic Communication Training

The TC training was developed based on landmark patient-centered studies and included important aspects of lived patient experiences (5-8, 19, 32-35). The trainer is a hypnotherapist and anesthesiologist with extensive teaching experience currently working at the Leiden Universitair Medisch Centrum (LUMC) hospital.

The blended TC training program includes several components, including online and offline elements, and an overview can be found in **Appendix 1**.

(1) Online e-learning: an online training module covering the basics of therapeutic communication.

(2) VR patient-embodied experience: this immersive experience enables nurses to feel firsthand what it is like to be a patient, enhancing empathy and insight. The VR experience shows the patient journey of a woman who will undergo knee surgery. She was brought into the preoperative holding area, given an IV drip, and driven to the OR. The video ended when the anesthesiologists induced general anesthesia. During the video, the healthcare providers do not apply therapeutic communication practices, show little empathy or personalized care, and give quite a few negative suggestions during the encounters. A more detailed description of the VR experience can be found in our recent work on patient-embodied VR experiences (16, 17).

(3) 1-Day didactic training: this in-person session of a maximum of 10 participants features experiential small-group activities, reinforcing the concepts learned online and in VR. The theoretical foundation of the training focuses on therapeutic communication techniques such as rapid rapport building and strategic word choice using hypnotic language. Techniques such as reframing, mirroring, and positive suggestions are emphasized while

avoiding the nocebo effects of negative language and expectations. Practical exercises ensure an active learning process, enabling nurses to apply these techniques effectively in their interactions with patients.

Quality Assurance

We hypothesized that the implementation of the TC training program would require more than an initial TC training. To facilitate the full implementation process, nurses, researchers, quality advisors, and communication experts will work together to optimize the implementation process, as shown in **Figure 2** and detailed below.

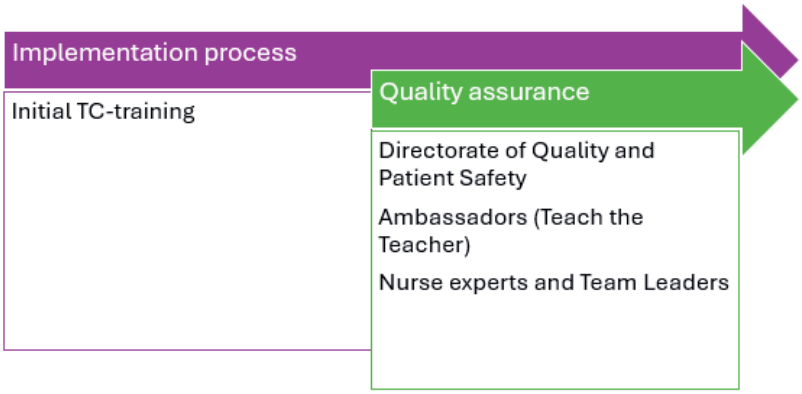


Figure 2. Implementation process

Directorate of Quality and Patient Safety

To ensure the quality of the learned knowledge of TC communication, the Directorate of Quality and Patient Safety and the Communication Department of the Hospital will be involved throughout this research project. They will meet regularly with the nurse experts and team leaders of the ward to evaluate the implementation process.

Teaching the Teacher

We hypothesized that it would be necessary to have "TC-ambassadors" on the ward to be able to answer questions, plan clinical bedside lessons, and perform practical exercises. Recruitment of the TC ambassadors will start after all nurses in the acute admission ward follow the training. After an initial briefing, an invitation will be sent to participate in "Teach the Teacher training" to become a TC ambassador. Team leaders will have the final choice of selection of these ambassadors. This training will be provided by the Radboud Academy, a partner institution of the Nijmegen Academic Medical Centre. During this course, participants will learn to obtain more in-depth knowledge on therapeutic communication, as well as the didactic competencies needed to become an ambassador of the TC program.

Outcomes and Measures

Qualitative Outcomes and Measures

We have adhered to Consolidated Criteria for Reporting Qualitative Research (COREQ) criteria for our qualitative outcomes including, among others, fieldwork, as well as individual and focus group interviews among the participating nurses before and after the training has taken place (36). The interview guide can be found in **Appendix 3**. Interviews will be audio-recorded, transcribed verbatim, anonymized, and then safely stored.

Focus group interviews are used to interview a small number of demographically similar people in social, psychological, and public health science (37). During the interviews, nurses will be asked about their perceptions, attitudes, opinions, and views regarding therapeutic communication. Group members are free to talk and interact with each other. Instead of a researcher individually asking group members questions, focus groups will be used to observe group interactions to explore and clarify the beliefs, opinions, and views of participants. During these interviews, the interviewer will take notes and record the discussion for subsequent notetaking to learn from the group. The building of the a priori template and analysis was performed by the principal investigator (KH). For practical reasons, if it is not possible to conduct a focus group interview, individual interviews will be held to gather further data.

The interviews were conducted by research interns (NK and CK), and the researchers (MVV and KH), all with extensive experience in qualitative research. Interviews after the intervention will not be performed by KH, as she is the trainer of the TC-trainer, and this might induce biases. All interviewers introduced themselves initially and did not know the participants before the commencement of the study.

Quantitative Outcomes and Measures

Quantitative outcomes include questionnaires on current knowledge of therapeutic communication, as well as validated training analysis questionnaires following the Kirkpatrick analytical model (26), and will be conducted as shown in **Figure 3.**

Kirkpatrick level 1 Reaction: What are Participants' Reactions to TC Training?

This questionnaire will be sent out after the training, including themes such as educational goals, trainees' preparation, the use of new teaching and learning methods, the use of learning tools, teaching environment, teacher assessment, and teacher characteristics on a 5-point Likert scale from very weak to excellent and can be found in **Appendix 4**. (25).

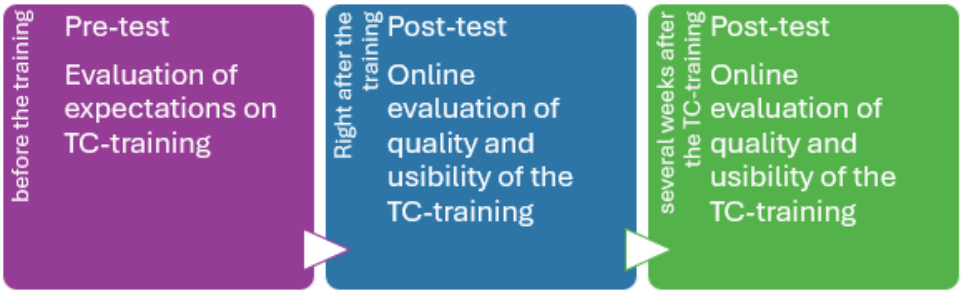


Figure 3. Data collection of quantitative data

Kirkpatrick level 2 Learning: Knowledge of Therapeutic Communication

For the purpose of this study, a standardized Nursing Education Program Implementation and Analysis (NEPIA) questionnaire was developed to evaluate knowledge of therapeutic communication. This questionnaire included five multiple-choice questions, with one or more correct answers, and can be found in Multimedia **Appendix 4**. This questionnaire was conducted and validated by a pilot of ten nurses to evaluate the clarity of the questions. Their responses will not be taken into account in further analysis. This questionnaire aims to respond to Kirkpatrick's second level: "Learning". What is the impact of TC training on participants' self-efficacy regarding therapeutic communication?

Data Analysis

All data will be kept in password-protected files with limited user access on protected hospital network drives and collected in the electronic data capture system Castor EDC. For quantitative data analysis, SPSS 25 (IBM Corp) for Windows will be used. Chi-square tests, independent *t* tests, and Mann–Whitney U tests will be used to test differences before and after training.

Qualitative analysis will be performed using template analysis (38) in ATLAS.ti (Lumivero).

Initial themes for the interviews can be found in **Appendix 3**. During the initial coding, a critical reflection will be performed (KH, MVV). If needed, themes are modified, or additional themes are added to ensure that the themes fit the data and that the data are not selectively analyzed to fit the themes. The initial analysis provided information for further participant selection and coding. Performing iterative data collection and analysis to guide decisions will improve the dependability of the results (39). The template will be further developed by applying it to the full data set. The building of the a priori template and analysis of the interviews will be performed by the principal investigator (KH). We decontextualize the data to identify descriptions and cluster them into discrete categories. Overall, we aim to structure these experiences, and additional changes might be made to the template; more interviews might be needed. Qualitative data will be retrieved while

pursuing data saturation; that is, until we are empirically confident, additional data will not lead to any new emergent input (31, 40).

Ethical Considerations

The protocol was approved by the Institutional Science Committee and received a waiver from the institutional review board. The study will adhere to GCP regulations. Written informed consent was obtained from all participants. Participants received no financial compensation. Data will be anonymized.

RESULTS

On February 8, 2024, we received permission from the authorizing authorities (Institutional Science Committee NWMO Commissie divisie 1) to start our study. Data collection started in April 2024 and concluded at the end of 2024. We expect to publish our results in 2025.

DISCUSSION

Overview

This study evaluates the effectiveness of a one-day blended-learning therapeutic communication training for nurses, integrating e-learning, VR patient-embodied experience, and didactic small-group training. Using Kirkpatrick's evaluation framework, we aim to assess whether this structured format enhances nurses' communication skills, specifically measuring their reaction (Level 1) and learning outcomes (Level 2). We anticipate that the training will be feasible, well-received, and effective in improving nurses' understanding and application of therapeutic communication techniques. If successful, this study could demonstrate the value of short, immersive training models in clinical education, particularly in fast-paced hospital environments.

Existing research underscores the importance of therapeutic communication in reducing patient anxiety and pain perception; however, most training programs are time and resource-intensive and often lack immersive experiential components. Our one-day format, enriched with VR-based patient embodiment, addresses these gaps by providing a scalable, high-impact intervention. Previous studies on therapeutic communication training have not consistently incorporated technology-driven experiential learning, making this approach unique in its accessibility and potential for broader hospital-wide adoption.

A key strength of this study is its mixed method design, ensuring a comprehensive evaluation of both subjective participant experiences and measurable learning gains. In

addition, the blended-learning approach, including VR, offers a realistic, patient-centered perspective that may enhance the long-term retention of communication skills.

Another strength of this study is the opportunity to attend the TC training during working hours, enabling all nurses to participate. The team leaders of both wards will make an effort to accommodate this in the scheduling.

A limitation of this study is that only short-term learning outcomes are assessed, leaving a long-term impact on patient care remaining to be evaluated.

Dissemination

We intend to present our results within our hospital and advocate for implementation in other wards, and if possible, hospital-wide. To enhance the dissemination process, we will use social media platforms and in-house press releases. Furthermore, we aim to publish the results of this study in appropriate peer-reviewed, open-access journals to ensure they are accessible to clinicians, researchers, educators, and other relevant stakeholders within healthcare organizations, including patients. Furthermore, dissemination through social media and institutional press will support a wider engagement within healthcare communities.

Future Implications

In the case of proven effectiveness of therapeutic communication training and implementation, future research should be conducted evaluating Kirkpatrick's level 4 training: the improvement of patient outcomes. Finally, our results may be useful for other health care institutions and implementation researchers when planning or implementing therapeutic communication skills training.

CONCLUSION

This study systematically evaluates a short, immersive therapeutic communication training program by using blended-learning methods, including VR-based patient-embodied experiences, we aim to determine its feasibility and effectiveness in improving communication skills. If successful, this training model has the potential to enhance patient care, influence hospital-wide training initiatives, and serve as a blueprint for scalable communication education programs in healthcare settings.

ACKNOWLEDGMENTS

The researchers would like to acknowledge the healthcare professionals who will participate in this research. We thank them for their time and effort in contributing to this project. R. Heemskerk, Y. Huinen, N. van Schagen, and J. Schilstra have made significant contributions that have enabled the planning of our project. The medical work environment and implicit rationing of care will be respected during this study. We also thank research interns C. Kwendé (Master of Anthropology) and N. van der Kwaak (applied Psychologist), both with extensive experience in qualitative research, who will assist in conducting this study. This study was funded by Verpleegkundige Vernieuwing (Nursing Innovation), an initiative that supports nurses in building a future-oriented work and learning environment. A project group was established to submit the funding application, and the program selected this project following an internal review.

Data Availability

The datasets used and/or analyzed during this study are available from the corresponding author upon reasonable request. The original audio files were unavailable due to privacy restrictions.

Authors' Contributions

K. Hoek had the original idea for the study and contributed to the conceptualization, investigation, methodology, project administration, supervision, data collection, data curation, and formal analysis.

L. Suur contributed to conceptualization and recruitment project administration and management.

M. van Velzen assisted with conceptualization, data curation, formal analysis, investigation, resources, software, supervision and participated in data validation and review & editing.

E.Y. Sarton has evolved around education in medical training. She contributed to conceptualization, project administration, supervision, visualization, data validation and review& editing

Conflicts of Interest

K. Hoek is the trainer and developer of the TC training.

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APPENDIX 1

TC-training

The training will take place between April and August 2025, one to three times per month. Two additional training days will be scheduled for any participant who was not able to follow the training on the planned date.

The TC-training will consist of the following:

->E-learning: this e-learning will be available with a personalised link 2 weeks prior to the physical training. It takes about 30-45 minutes to complete the e-learning. The e-learning deploys key insights of therapeutic communication. It encompasses the explanation of important terminology such as placebo, nocebo, negative and positive suggestions, reframing, and *rapport*.

->VR-embodied experiences. There will be 2 VR-embodied experiences available and shown on the day of physical training. The description and validation of these VR-experiences can also be found in our earlier published work (16, 17).

->physical training with a first part of theoretical knowledge and frameworks, landmark research. This is followed with hands-on training using mirroring rapport techniques and applying therapeutic communication skills with reframing in small groups.

Timeline:

E-learning: 30-45 minutes

Physical training: 5.5 hours (with 45 minutes pause included), and two VR-experiences (each around 12 minutes).

APPENDIX 2

The NEPIA questionnaire, Kirkpatrick's level 2:

Question 1: Which statement is correct?

a. Pain leads to an increase in inflammatory markers in the blood.

b. The brain can open or close pain gates and thus modulate pain.

c. A high degree of stress leads to the suppression of the entorhinal cortex, thereby reducing pain perception.

d. Shifting attention can increase pain perception.

Correct: A, B

The brain can open or close pain gates and thus modulate pain. An increase in inflammatory markers is a consequence of stress, not pain. These are very closely related. However, not every (minor) pain prick will cause increased inflammatory markers. How the brain recognizes and interprets pain depends on various factors and complex mechanisms. Pleasant stimuli (e.g., a gentle touch) can close pain gates (gate control), and the brain can also open pain gates, as seen in the feeling of a 'broken heart.' A high degree of fear and stress leads to the activation of certain areas in the brain (entorhinal cortex, insula, and anterior cingulate gyrus), enhancing pain perception. Studies using functional MRI have shown that visual and somatosensory stimuli have pain-modulating functions. Simply put shifting attention results in less pain.

Question 2: You are administering a painkiller. Which action will ensure the medication works best? Choose the best answer.

a) Administer the medication without providing any additional information.

b) Say that this is a very effective medication and the patient will likely feel better.

c) Say that you see the patient is in pain and this will help.

d) Say that you don't think this medication will work well against the pain.

Correct: B

Say that this is a very effective medication, and the patient will likely feel better. Here, you are giving two positive suggestions: you trust the medication, and you indicate that the patient will feel better. The third answer is less effective because it focuses on the patient's pain, emphasizing a negative feeling, which is unnecessary.

Question 3: What promotes coping-stimulating behaviour? Choose the best answer.

Coping: the way someone deals with problems and stress

a. Distraction techniques

b. Lots of empathy

c. Commentary

d. Apology

Correct: A

Distraction techniques. Distraction techniques promote coping-stimulating behaviour. Conversely, too much empathy, commentary, or an apology reduces coping-stimulating behaviour because these focus on negative feelings.

Question 4: Which statement is correct? Choose the best answer.

a. Empathy always has a positive effect on a patient's comfort.

b. Implicit factors, such as the colour or temperature of the environment, affect a patient's experience.

c. Anxiety is a detrimental mechanism that activates limbic structures.

d. I should always give a warning before inserting an IV.

Correct: B

Implicit factors, such as the colour or temperature of the environment, affect a patient's experience. Atmosphere can be influenced unnoticed by background noises, smells, and colours. The third answer is incorrect because anxiety is not always detrimental. Although anxiety activates limbic structures and triggers the sympathetic autonomic nervous system, causing physiological effects like tachycardia and tachypnoea, these are stress responses. The last answer is incorrect because a warning can cause anticipatory stress and increased pain. For example, when inserting an IV, it is better to ask the patient to keep their arm still or consider distracting them by asking a question at the moment of insertion (e.g., what did you have for dinner last night?).

Question 5: Which statement about the placebo effect is correct?

a. The placebo effect only works mentally.

b. Placebo effects can be harmful.

c. In a randomized study, there are no placebo effects.

d. Placebo effects can be unconscious.

Correct: D

Placebo effects can be unconscious. There are implicit or explicit placebo effects, with implicit effects being unconscious. Placebo effects can have biochemical and physiological impacts. Even in randomized studies, there can be (implicit) placebo effects.

Course evaluation Kirkpatrick level 1:

Improving the quality of continuing education requires your constructive and insightful comments and recommendations. Please help us provide effective training conditions by answering the following questions accurately.

Name of the training course: Basic Therapeutic Communication Training (TC-training)

Date of the course: [Enter the date here]

Please fill in your answer by choosing between:
1: very poor/little
2: somewhat poor/little
3: sufficient
4: somewhat good/much
5: very good/much

Instructor Assessment	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
Academic proficiency of the instructor					
Lecturing method and the ability to transfer the concepts to learners					
Ability of the instructor in class management					
Use of active teaching methods and engaging the learners					
Ability to respond to the ambiguities and questions of learners					
Frequency of using practical examples during teaching					
Course content assessment	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
Effectiveness of the contents of the course in increasing your knowledge					
Relationship between training course and your organizational needs					
Up-to-datedness of the contents of the course					
Quality of teaching in the training course					
Course support assessment	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
Your satisfaction with the duration of the course					
Desirability of educational location and environment					
Brightness and light in the classes					

Course support assessment	excellent	Very good	Intermediate	weak	Extremely weak
Ventilation and adequacy of cooling/heating system					
Catering and reception					
Treatment of authorities toward you					
Overall satisfaction	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
Satisfaction of the quality of workshops					
Satisfaction of the way of conducting workshops					

APPENDIX 3

Interview guide

Topic List for Before the Training (set to take between 15-45 minutes)

Topic	Question
Demographics (Round of questions - all at once)	- What is your name? - How old are you? - How long have you been a nurse/medical professional?
Pain	- What do you typically use to evaluate a patient's pain? How do you 'see' that a patient is in pain? - Is this a standard at LUMC? - Follow-up: What do you think about this? - What do you think are the most effective methods to assess pain? - What is the role of doctors in assessing/treating pain? Do they do things differently? - What are your experiences with the Central Pain Team?
Registration	It happens that the registration of NRS scores is not filled in, especially for the second measurement after a high NRS score. Why is this? Does it ever happen that a pain score does not match how a patient seems to experience the pain? How do you handle this?
Anxiety	- What do you typically use to assess a patient's anxiety? How do you 'see' that a patient is anxious? - Is there a standard at LUMC (similar to pain scores, but for anxiety)? What do you think about this? - How do you deal with an anxious patient? - What do you think are the most effective methods to assess (to 'see') anxiety? - What is your role in assessing/treating anxiety? What is the role of the doctor? Is there a difference?
TC (Not yet completed)	- What do you already know about the TC course? - Do you know why the TC course is being introduced? - What are your expectations of this course? - What would you like to learn during the course?

Topic List after the Training (set to take between 15-45 minutes)

Topic	Question
Demographics (Round of questions - all at once)	- What is your name? - How old are you? - How long have you been a nurse/medical professional? - Have you completed the TC training?
TC Training	- What did you think of the TC training? - To what extent do you think you can apply TC communication? Do you have an example? - Did the training meet your expectations? (Explain why/why not) - Do you need additional training at this time?
Pain	- During the TC training, it was discussed to evaluate pain and anxiety with a comfort score (NRS comfort), with a checkbox does the patient need more pain relief. Do you agree with this? - Do you have any other suggestions to improve pain registration?
Free	- Do you have any other points regarding pain, anxiety, and therapeutic communication that you would like to discuss?

5B

THERAPEUTIC COMMUNICATION, A NURSING EDUCATIONAL PROGRAM, IMPLEMENTATION AND ANALYSIS, A MIXED METHODS DESIGN

ARTICLE INFO

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Keywords:

VR,
IVEs,
Medical Education,
Immersion,
Hidden Curriculum,
Etiquette,
Operating Room,
Transition,
Clerkship,
Experiential Learning,
Workplace-based Learning

Status:

submitted

ABSTRACT

Background

Hospital admission can provoke significant anxiety and stress, impacting patients' well-being. Effective therapeutic communication is crucial to mitigate these effects. This study evaluated a blended learning program designed to enhance nurses' therapeutic communication skills, incorporating e-learning, virtual reality (VR), and in-person training.

Methods

Using Kirkpatrick's evaluation model, we applied a convergent mixed methods design. Quantitative data were gathered via pre- and post-training questionnaires, and qualitative data were collected through group interviews. The training included an e-learning module, a VR simulation of patient-embodied experiences, and a 1-day interactive workshop.

Results

Quantitative pre- and post tests results demonstrated significant improvements in knowledge scores, affirming training efficacy. Qualitative findings revealed high satisfaction rates and increased sensitivity in patient interactions. Key themes included enhanced empathy and strengthened team dynamics. Participants valued the practical relevance of the training.

Conclusion

Our findings highlight the feasibility and acceptance of therapeutic communication training. This program has the potential to improve quality of care and foster collaborative practices. Future studies should explore long-term implementation and patient outcomes.

INTRODUCTION

Hospital admission is often stressful for patients, driven by fear, treatment uncertainty, potential side effects, and loss of control, all of which can affect their physical and psychological well-being (1, 2).

This emotional stress can hinder patients' ability to adapt, especially in acute admission wards (3, 4). Invasive procedures and surgeries often cause preprocedural anxiety, affecting 11–80% of adult patients (1, 5). Anxiety amplifies the stress response, leading to more postoperative pain, chronic pain, and lower patient satisfaction (6-10).

Patient-centred care requires healthcare professionals to understand patients' experiences and values (11-14). High-quality communication within this framework depends on effective training, which helps providers manage anxious and distressed patients.

Therapeutic communication involves intentional use of verbal, paraverbal (e.g., tone, pace), and nonverbal cues (e.g., eye contact, body language) to positively influence interactions and context (15-17). These elements are key to building *rapport*—mutual understanding through meaningful connection (18, 19). Incorporating such skills can improve patient understanding, trust, self-care, adherence, emotional regulation, and overall well-being (20, 21).

Despite its importance, therapeutic communication is not systematically taught in medical or nursing education, and no standard approach exists for its instruction (22). Skills are often learned informally on the job, shaped by context rather than structured training. This raises the question of how best to teach and emphasize its value.

We hypothesize that experiencing care from a patient's perspective fosters empathy and supports learning therapeutic communication (23, 24). While many training programs exist, few evaluate scalable blended-learning approaches incorporating VR. This study addresses that gap by assessing a one-day program combining e-learning, patient-embodied VR, and small-group didactic training.

The main objective of this study is to evaluate the impact of our therapeutic communication training for nurses in the acute admissions ward of a tertiary hospital utilizing Kirkpatrick's four-level training evaluation model (25, 26), as shown in **Figure 1**. Our research questions are derived from the first two levels:

Level 1: How do participants feel about therapeutic communication training?

Level 2: Did participants learn about therapeutic communication?

The second objective of this study was to analyse current communication methods, in particular those evolving around pain, stress, and comfort of patients.

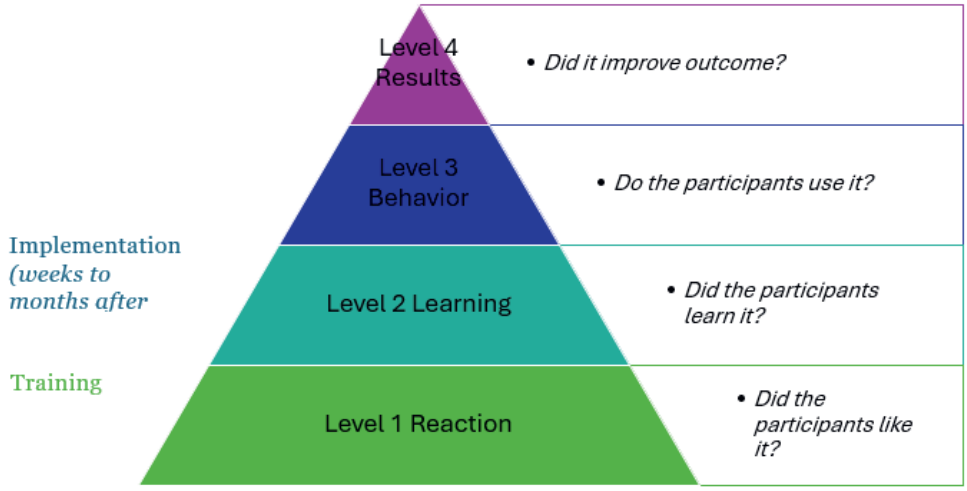


Figure 1. Kirkpatrick four-level training evaluation model

DESIGN

Setting and participants.

This prospective study was conducted at two wards in the Leiden Universiteit Medisch Centrum (LUMC) hospital, a tertiary teaching hospital in the Netherlands. One acute admission ward, one general ward. The protocol was approved by the Departmental Science Committee and received a waiver to be performed by the Institutional Review Ethics Committee (METC Leiden the Hague Delft, Leiden, the Netherlands) following GCP regulations. Personal data protection and consent from the research participants were obtained prior to data collection. The data were collected and recorded between March 2024 and September 2024.

Eligible participants were nurses who regularly communicated with patients or relatives, spoke Dutch fluently, and were available for interviews. Nurses leaving the ward within a year were excluded. To increase statistical power, nurses from a general ward were also invited. All eligible nurses received email invitations and could attend the training during working hours. No compensation was provided, and all participants gave informed consent. Interviews were conducted during day and evening shifts with nurses on duty.

Patients were not involved in developing the TC training, which was based on literature and prior VR training research (23, 24). The study focused on nurse outcomes; involving

patients would require a substantial shift in study design and ethical considerations, particularly concerning data collection from patients.

Study design

A convergent unblinded mixed method study design in which qualitative and quantitative data were used in multiple phases and merged and analysed equally for an interactive approach (27). Qualitative and quantitative investigations took place before and right after the TC training at the acute admission ward. At the general ward, only quantitative data collection was retrieved.

For quantitative outcomes, our pragmatic feasible objective is to include at least 50% of all nurses, which amounts to twenty nurses of the total forty nurses working in the acute admission ward, and twenty of the forty nurses in the general ward.

Intervention

Therapeutic Communication Training

The TC training was developed based on landmark patient-centered studies and included important aspects of lived patient experiences (6-9, 16, 28-31).The trainer was an anaesthesiologist and researcher (KH) with extensive teaching experience currently working at the LUMC hospital.

The blended TC training program included several components, with online and offline elements, and an overview can be found in **Appendix 4**.

1) Online E-Learning: an online training module covering the basics of therapeutic communication, activating eventual prior knowledge
2) VR patient-embodied experience: This immersive module allows nurses to experience the patient journey from the inside. It follows a woman undergoing knee surgery, from the preoperative area to anaesthesia induction. Healthcare providers in the video display minimal empathy and use negative suggestions, illustrating poor communication. Further details are available in our earlier work (23, 24).
3) 1-Day didactic training: This in-person session of a maximum of ten participants featured experiential small group activities, reinforcing the concepts learned online and in VR. The theoretical foundation of the training focuses on therapeutic communication techniques such as rapid rapport building and strategic word choice using hypnotic language. Techniques such as reframing, mirroring, and positive suggestions are emphasized while avoiding the nocebo effects of negative language and expectations. Practical exercises ensured an active learning process, enabling nurses to apply these techniques effectively in their interactions with patients.

Prior to its use in the current study, the TC training was piloted, tested, and refined with input from over 30 nurses in a separate department at LUMC strengthening content and delivery of the final TC training format.

Outcomes and measures

2.4.1 Qualitative outcomes and measures

Qualitative outcomes include, among others, individual and focus group interviews with the participating nurses of the acute admission ward before and after the training has taken place as shown in **Figure 3**. The interview guides can be found in **Appendix 3**.

Focus group interviews were used to interview a small number of demographically similar people in social, psychological and public health science (32). During their shift, nurses were invited to participate in an interview during working hours by our researchers. During these interviews, nurses were asked about their perceptions, attitudes, opinions and views regarding therapeutic communication. Group members were free to talk and interact with each other. All interviewers introduced themselves and their role initially and did not know the participants personally before the commencement of the study. During these interviews, the interviewer took notes and recorded the discussion for subsequent note-taking to learn from the group. Constructing the a priori template and analysis was performed by the principal investigator (KH). For practical reasons, when it was not possible to conduct a focus group interview, individual interviews were held to gather further data. The interviews were conducted by research interns (NK and CK), and the researchers (MvV and KH). Interviews after the intervention were not performed by KH, as she was the trainer of the TC training and this could have induced response biases.

Quantitative outcomes and measures

Quantitative outcomes included questionnaires on current knowledge of therapeutic communication, as well as validated training analysis questionnaires following Kirkpatrick analytical model (26), all conducted as shown in **Figure 2**.



Figure 2. Data collection before and after the TC training

Kirkpatrick level 1 Reaction: What are participants' reactions to TC training?

This questionnaire was sent out after the training, including themes such as educational goals, trainees' preparation, the use of new teaching and learning methods, the use of learning tools, teaching environment, teacher assessment, and teacher characteristics on a 5-point Likert scale from very weak to excellent and can be found in **Appendix 2** (25).

Kirkpatrick level 2 Learning: Knowledge on therapeutic communication:

For this study, a standardized Nursing Education Program Implementation and Analysis (NEPIA) questionnaire was developed to evaluate knowledge of therapeutic communication. This questionnaire included questions leading up to a total point of 8, and can be found at **Appendix 1**. This questionnaire was conducted and validated by a pilot set of 10 nurses to evaluate the clarity of the questions without prior knowledge of TC. Their responses were not considered in further analysis. This questionnaire aimed to respond to Kirkpatrick's second level: "Learning". What is the impact of TC training on participants' self-efficacy regarding therapeutic communication?

Data analysis

All data were kept in password-protected files with limited user access on protected hospital network drives and collected in the electronic data capture system Castor EDC.

For quantitative data analysis, SPSS 25 (IBM Corp) for Windows was used. Chi-square tests, independent t tests and Mann–Whitney U tests were used to test differences before and after training, as appropriate.

We have adhered to Consolidated Criteria for Reporting Qualitative Research (COREQ) criteria for our qualitative analysis. Data analysis was performed using template analysis using Atlas.Ti (Lumivero) (33). Initial themes for the interviews can be found in **Appendix 3.** The *a priori* template was built by the principal investigator (KH). During the initial coding (KH, MvV), a critical reflection was performed. If needed, themes were modified, or additional themes were added to ensure that the themes fit the data and that the data were not selectively analysed to fit the themes. The initial analysis provided information for further participant selection and coding. The template was further developed by applying it to the full data set. Qualitative data were retrieved pursuing data saturation; that is, until we were empirically confident that additional data would not lead to new emergent input (34, 35).

In this mixed method study, quantitative and qualitative data used in distinct phases were merged and analyzed convergently (36). The decision to employ multiple methods was pragmatic, as relying on a single method could have led to an incomplete understanding. This triangulation strategy tested the validity of the data through convergence among different sources (37).

RESULTS

Sample recruitment

All 40 nurses working in the acute admission ward were invited to participate in the TC training, all 41 working in the general ward were invited. Of the 82 nurses invited, 74 accepted participation in this study. Of these nurses, 42 completed all questionnaires (22 and 20 respectively), and 22 only partially. 42 participants completed the e-learning. Details are also shown in **Figure 3**.

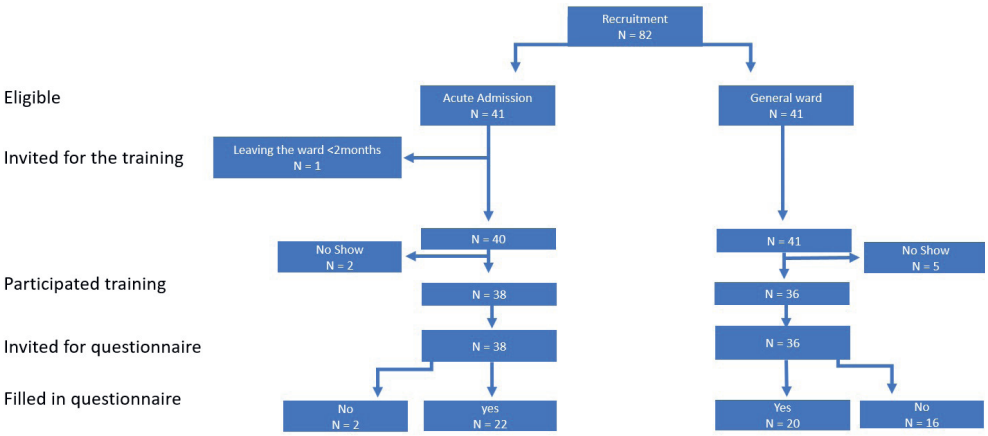


Figure 3. Flow chart

Demographic characteristics can be found in **Table 1.** The qualitative analysis of participants on the acute admission ward included 2 individual interviews, 7 focus group participants, and 43 open question questionnaires before training. After training, there were again 2 individual interviews and an increased focus group of 10 participants. Two participants participated in an interview before, and after the training.

Table 1. Demographic characteristics participants quantitative analysis

Characteristics*	
Age (years)	
Mean ± SD	39±12.9
Gender	
Male	2
Female	42
Relevant working experience (years)	15±13
Work section	
Acute admission ward	40
General ward	35

Table 1. Demographic characteristics participants quantitative analysis (*continued*)

Characteristics*	
Previous professional experience with any VR device	
Yes	10
No	30

*Participants were allowed to leave questions blank, resulting in an incomplete overview of demographic characteristics

Findings from qualitative analysis

Concurrent focus group and individual interviews were conducted, with distinct participant compositions, ensuring independence of the collected data. Field notes and observations were recorded and archived by the researchers (KH, LS, MvV). The quotes extracted from these discussions were translated from Dutch to English, preserving the original grammar structure to maintain authenticity. Verbatim transcript quotes were used to support the development of the thematic framework emerging from the data.

Analysis of before the training

The qualitative analysis of pre-training data resulted in 4 main themes and 9 subthemes as shown in Table 2. These qualitative data served the purpose of answering the second objective of this study being to analyse current communication methods, in particular those evolving around pain, stress, and comfort of patients.

Table 2. Overview of Main Themes, Subthemes before the training

Main Themes	**Subthemes**
Communication Practices and Challenges	Automated and Routine Communication
	Lack of Reflection and Awareness
	Efficiency vs. Sensitivity
	Established Communicative Norms of Nursing
Impact of Communication Style on Patient Care	Unintentional Insensitivity
	Task-Oriented Communication
Pain Assessment and Measurement	Challenges with Pain Measurement Tools
	Limitations of Standardized Pain Assessment Tools
Need for Structured Communication Training	Lack of Structured Training
Expectation of training	Obligatory nature
	Attitude towards training

Communication Practices and Challenges

Participants frequently described their communication as habitual and automatic, often influenced by routine and the pressures and requirements associated with a busy clinical environment.

Automatic and Routine Communication

Participants discussed how certain phrases became habitual, particularly in fast-paced environments. These automated responses often occurred without much reflectional thoughts. One participant mentioned,

> *"It's like my words are on autopilot. When I'm busy, I don't even realize I'm using the same phrases over and over again" (002, individual interview).*

Another said:

> *"I always say the same thing when starting a procedure. It's just automatic" (009, individual interview).*

Lack of Reflection and Awareness

Some participants noted that they did not consciously reflect on how their communication might impact patients. A participant reflected,

> *"We don't really stop to think about how we're communicating with patients. It's all just very quick and instinctive" (005, focus group).*

Another participant added,

> *"I think we should be more mindful, but we're often just focused on getting through the day" (007, focus group).*

Efficiency vs. Sensitivity

Participants acknowledged that their communication often prioritized efficiency over sensitivity, particularly during time-sensitive tasks.

> *"When we're busy, we focus on getting things done fast. It's not that we don't care, but we don't always have time to be as sensitive as we should" (008, focus group).*

Another participant said,

> *"I try to be efficient, but sometimes that means I'm not as compassionate as I'd like to be" (003, individual interview).*

Established Communication Norms

Participants highlighted the longstanding norms and routines that shaped their communication styles, many of which had been ingrained over years of practice. One participant explained:

> *"We've been communicating this way for years, and it's hard to break those habits" (001, individual interview).*

Another noted:

> *"It's the way we've always done it, and changing that isn't easy" (004, focus group).*

Impact of Communication Style on Patient Care

Participants discussed how their task-oriented and habitual communication styles impacted their interactions with patients, often resulting in unintended consequences for patient care.

Unintentional Insensitivity

Several participants acknowledged that their communication could sometimes come across as harsh or insensitive, even though it was not intended that way.

> *"I've realized that I might come off as insensitive without meaning to, especially when I'm focused on getting things done" (006, individual interview).*

Another participant remarked,

> *"It's easy to sound short with patients when you're thinking about the task and not the person" (009, focus group).*

Task-Oriented Communication

Task-oriented communication was frequently mentioned as a strategy to get through busy shifts efficiently. One participant explained,

> *"When you have so many tasks to complete, the focus is on getting through them quickly. You can't always stop to explain things thoroughly" (010, individual interview).*

Another added:

> *"It's all about efficiency. Sometimes we focus on the task more than the patient's feelings" (005, focus group)*

Pain Assessment and Measurement

Participants noted challenges with the current tools used for pain assessment, particularly the Numerical Rating Scale (NRS), and the limitations of standardized pain assessment practices.

Challenges with Pain Measurement Tools

Participants expressed dissatisfaction with the NRS, noting that it did not always capture the full extent of patients' pain experiences. One participant explained,

> *"The NRS only gives me a number, but I don't always feel that the number reflects what the patient is really going through" (010, focus group).*

Another participant noted,

> *"I feel like the NRS is too simplistic for some patients. They might rate their pain, but I still don't understand the full picture" (007, individual interview).*

Limitations of Standardized Pain Assessment Tools

Beyond the NRS, participants voiced concerns about standardized pain assessment tools in general, noting that they often failed to capture the complexity of pain experiences.

> *"The scales are helpful, but they don't give us everything we need to know about a patient's pain. There's more going on than just what can be measured by numbers" (011, individual interview).*

Another participant remarked,

> *"These tools don't capture the emotional aspects of pain, and that's a big part of what patients experience" (006, focus group).*

Need for Structured Communication Training

Participants recognized the need for more structured training in communication skills.

Lack of Structured Training

Participants noted that formal communication training was lacking, which left them relying on instinct and professional experience. One participant stated,

> *"We have never really had training on how to communicate better. It has always just sort of happened naturally" (008, focus group).*

Another participant added:

> *"I think structured training would help us a lot. We're just doing our best with what we know" (005, individual interview).*

Expectation of training

Obligatory nature

In the open questions of the questionnaire on expectations, sixteen participants out of the eighteen, mentioned the obligatory nature of the training.

Attitude towards training

In the open questions of the questionnaire, generally all participants expressed an open attitude:

> *"Approach it with an open mind; on our ward, pain is often difficult to manage, for example, in cases of mucositis." (participant 046).*

Analysis after the training

The analysis after the training resulted in 5 main themes and 9 subthemes as shown in **Table 3.**

Table 3. Overview of Main Themes, Subthemes after the training

Main Themes	**Subthemes**
Satisfaction with Training	Engagement and Interaction
	Relevance and Sufficiency
Applicability and Challenges in Practice	Implementation and Practical Challenges
	Coping Mechanisms
Communication Practices and Challenges	Automatic and Habitual Communication
	Reflective and Sensitive Communication
Pain Assessment and Measurement	Current Limitations in Pain Measurement
	Openness to Innovative Assessment Methods
Impact on Team Dynamics	Enhanced Collaboration and Support

Satisfaction with Training

Participants expressed overall satisfaction with the training, particularly appreciating the interactive elements, the use of VR, and the relevance of the training to their daily practice.

Engagement and Interaction

Participants highlighted how the interactive nature of the training, especially the use of VR, made it more engaging. One participant shared,

> *"The VR part of the training really pulled me in. It made the whole experience more engaging, and I found myself paying closer attention" (22, individual interview after training).*

Another said,

> *"Using the VR glasses made the learning feel more real. I was fully immersed, which helped me focus more" (29, focus group after training).*

Relevance and Sufficiency

Participants noted that the training content was relevant to their daily work and found it sufficient to address their needs. One participant commented:

> *"I could use what I learned the very next day. It was really relevant to my daily interactions with patients" (54, focus group after training).*

Another added,

> *"The training was practical, and I think it's enough for what we face regularly in our work. It fits well with our needs" (30, focus group after training).*

Applicability and Challenges in Practice

Participants recognized the practical applicability of the training, although they faced certain challenges in consistently implementing the new techniques in their routine practices.

Implementation and Practical Challenges

While participants saw the value of the training, they encountered difficulties applying the new communication methods during busy shifts. One participant noted:

> *"It's hard to always apply what we learned when things are moving fast. I sometimes forget to use the techniques during peak hours" (9, focus group after training).*

Another mentioned:

> *" The skills are helpful, but when the ward is hectic, it's easy to fall back into old ways" (69, focus group after training).*

Another added,

> *"It's tough to always stay mindful of the training when under pressure. Sometimes I just do what feels easiest in the moment" (30, focus group after training).*

Coping Mechanisms

Participants reported using coping mechanisms, such as humor, to manage the stress of incorporating new techniques into their work flow. One participant explained:

> *"When things are stressful, I sometimes joke with patients to ease the tension, even though I know I should be applying the training techniques more carefully" (54, focus group after training).*

Communication Practices and Challenges

Participants discussed both the improvements in their communication practices following the training and the ongoing challenges, especially when faced with habitual communication styles.

Automatic and Habitual Communication

Despite the training, participants admitted that automatic communication patterns still persisted during busy times.

> *"Even after the training, when things get really busy, I notice I still use the same phrases I've always used. It's like muscle memory" (29, focus group after training).*

Another shared:

> *"It's hard to break those automatic habits, especially when time is tight" (009, focus group after training).*

Reflective and Sensitive Communication

However, participants also noted an increase in reflection and sensitivity in their communication after the training.

> *"I'm much more conscious of how I speak to patients now. I think about how my words might affect them, whereas before, I didn't give it much thought" (69, focus group after training).*

Another added,

"The training really made me stop and think about the way I approach difficult conversations with patients. I'm more careful with my words" (22, individual interview after training).

Established Communication Norms

Participants expressed challenges in changing the established communication norms within their teams, even after completing the training. One participant remarked,

"It's tough to implement the new methods when the rest of the team is still doing things the old way. It feels like I'm the only one trying to change" (54, focus group after training).

Another said,

"The communication style in our department has been the same for years. Getting everyone to adopt new approaches is harder than I expected" (30, focus group after training).

Pain Assessment and Measurement

Participants were open to using new methods of pain assessment and recognized the limitations of the current tools they were using.

Current Limitations in Pain Measurement

Participants acknowledged that the training exposed the limitations of the NRS and other pain assessment tools, which do not always capture the full extent of a patient's experienced pain.

"The NRS is good for a quick check, but I've realized it doesn't tell me everything. Sometimes the patient's pain is more complex than a number can show" (54, focus group after training).

Another participant shared,

"There are times when the NRS just isn't enough to understand what the patient is really feeling" (69, focus group after training).

Openness to Innovative Assessment Methods

Participants expressed enthusiasm for integrating new methods of pain assessment that aligned with therapeutic communication principles. One participant noted,

"I'm excited to try out the new pain measurement techniques we learned in training. I think they'll help us get a more accurate understanding of our patients' pain" (9, focus group after training).

Another commented,

"The new methods we learned make a lot of sense. I think they'll improve how we assess pain and communicate with patients about it" (29, focus group after training).

Impact on Team Dynamics

Participants observed positive changes in teamwork and communication within their teams after following the training, which improved collaboration.

Enhanced Collaboration and Support

Participants noted that the training fostered better communication and support within their teams.

"Since the training, I feel like we communicate more openly as a team. We talk more about patient care and share ideas" (69, focus group after training).

Another participant shared,

"The training helped us come together more. I feel like there's more support from my colleagues when it comes to applying what we learned" (9, focus group after training).

Findings from quantitative analysis

Kirkpatrick level 1 (reaction)

This questionnaire included themes such as course content, course support, and overall satisfaction. Fourty-four participants completed this questionnaire with scores ranking from 0 to 5 points. Average scores of all themes were high, with a mean score of 4.3. The highest scores were obtained for satisfaction with the way the workshop was conducted (mean 4.6), and ability of the instructor in class management (mean 4.7). All participants graded a 4 or higher on general satisfaction with the quality of the training, and the way it was conducted. More than eighty percent of all participants rated 4 or higher the relevance of the training to their work, the likelihood of applying the gained knowledge from the training in their daily work, and to what extent they would recommend the training to colleagues.

More than 90 percent of the participants responded with satisfied or highly satisfied to the question to what extent the course met their expectations. Also, more than eighty percent responded 4 or higher on general satisfaction with the quality of the training, as well as the way it was conduced.

Course content and course support also received high rankings with global scores of 4 and 5. A complete overview of all results can be found in **Appendix 4**.

Kirkpatrick 2 (learning)

For this purpose, a pre-posttest was performed ranking from 0 to 8 points. A total of forty-two participants completed only the pretest with a median score of 5.0, (IQR 2.0). Forty-three completed only the posttest with a median score of 7,0 (IQR 1.0). There is a significant improvement in scores between these groups ($U = 361$, $p < 0.00001$). Of all participants, twenty-eight completed both pre and post tests, and their test results also improved significantly ($W = 24$, $p = 0.00016$).

Integration of Quantitative and Qualitative Findings

The results indicate feasibility of the implementation of a therapeutic communication training. The integration of the quantitative and qualitative findings evoke a convergence between the two data sets as they both underscore positive impacts of the therapeutic communication training program.

Quantitatively, the significant improvement in knowledge scores from pre- to post-training evaluations highlights a measurable enhancement in nurses' understanding and application of therapeutic communication techniques affirming Kirkpatrick's level 2. Qualitative data, with themes as improved communication practices and increased sensitivity in patient interactions show an agreement of data sets.

The qualitative findings highlight how the training fostered improved team dynamics and a supportive environment. These insights align with the high satisfaction rates and the perceived applicability of the training, as reflected in the quantitative data, affirming Kirkpatrick's Level 1 evaluation.

DISCUSSION AND CONCLUSION

Discussion

This study systematically evaluated the acceptance and feasibility of therapeutic communication according Kirkpatrick's evaluation model confirmed through both qualitative and quantitative assessments (research question 1).

The qualitative analysis, which revealed themes such as enhanced satisfaction with training, improved team dynamics, and more reflexive communication practices, underscores the program's impact on nursing staff.

Quantitatively, the significant improvements in knowledge scores from pre- to post-training as per Kirkpatrick's second level of training evaluation, validate the effectiveness of the training. The integration of VR and didactic elements likely contributed as reported by participants.

Existing research underscores the importance of therapeutic communication in reducing patient anxiety and pain perception; however, most training programs are time and resource intensive, and often lack immersive experiential components. Our one-day format, enriched with VR-based patient embodiment, addresses these gaps by providing a scalable, high-impact intervention. Previous studies on therapeutic communication training have not consistently incorporated technology-driven experiential learning, making this approach unique in its accessibility and potential for broader hospital-wide adoption.

In our study, combining quantitative and qualitative methods provided a deeper understanding by revealing complementary insights. By using triangulation, we explored the phenomenon from multiple perspectives, leading to a more comprehensive and nuanced analysis. The additional retrieval of quantitative data in another ward improved power, external validity, and and reliability of quantitative results.

Another strength of this training is the opportunity to attend the TC training during working hours, enabling all nurses to participate which is seen in the high participation rate. The team leaders of both wards have made considerable efforts to accommodate this in the scheduling. Hence, we were able to limit selection and response biases.

A recognized limitation of this study is its confinement to a single hospital. The results, despite being informative, may not reflect the experiences of healthcare professionals in other hospitals, given clinical and contextual differences between institutions and countries.

Quite unexpectedly, the qualitative data reported participants already using elements learned during the TC training, indicating effectiveness on Kirkpatrick's level 3. With the interviews conducted in the days following the training, this was not something we had anticipated. Further research will be conducted to elaborate more extensively on this matter.

As mentioned, we hypothesized that the implementation of the TC training program would require more than an initial TC training to reach higher levels of learning. For this quality assurance, the Directorate of Quality and Patient Safety and the Communication Department of the Hospital were involved throughout this research project. They met regularly with the nurse experts and team leaders of the ward to evaluate the implementation process. Furthermore, we hypothesized that it would be necessary to have 'TC-ambassadors' on the ward to be able to answer questions, plan clinical bedside lessons and perform practical exercises. The effects of these measures to assure long-term implementation and learning outcomes remain to be evaluated.

Innovation

This study introduces several innovative elements in the design and implementation of a therapeutic communication training program for nurses, which distinguishes it from traditional communication training approaches in healthcare settings.

The use of patient-embodied VR simulations is a cornerstone innovative feature of this training program. By immersing nurses in the patient's perspective (Protheus effect), the VR component enhanced empathetic understanding by providing a visceral, impactful learning experience that traditional didactic methods often fail to achieve (38). This approach helped nurses appreciate the psychological and emotional dimensions of patient care crucial for effective therapeutic communication.

Blended Learning Approach: The program's blended learning format—integrating online e-learning, VR experiences, and in-person training—offered an innovative approach to healthcare training. By incorporating diverse learning styles and multiple channels of engagement, this method enhanced learning flexibility, allowing participants to interact with certain elements at their own pace and convenience (39).

CONCLUSION

This study has systematically evaluated the effectiveness of a therapeutic communication training program for nurses, adopting the framework of Kirkpatrick's evaluation model. Through both quantitative and qualitative analyses, we confirmed that the training significantly enhanced nurses' communication skills—critical in managing patient care effectively.

The study demonstrated notable improvements in knowledge regarding therapeutic communication, verified through pre- and post-training assessments as defined by Kirkpatrick's second level. In addition, qualitative data highlighted increased satisfaction with the training, improvements in team dynamics, and the adoption of more reflective communication practices among participants. Such outcomes illustrate the practical benefits of applying innovative educational tools like VR as cited by participants.

Our results may be useful for other healthcare institutions and implementation researchers when planning or implementing therapeutic communication skills training or using patient-embodied VR experiences. In addition, qualitative data from this study suggested a potential effect at Kirkpatrick's third level (behaviour change). Future research should further investigate Kirkpatrick's Level 3 and Level 4 outcomes, assessing whether participants apply therapeutic communication techniques in practice and whether patient outcomes improve.

Declarations

Competing interests

KH declares herself to be the trainer and developer of the TC training.

Funding

This study was funded by Verpleegkundige Vernieuwing (Nursing Innovation), an initiative that supports nurses in building a future-oriented work and learning environment. A project group was established to submit the funding application, and the program selected this project following an internal review.

Authors' contributions

K. Hoek, MD, PhD candidate at the Anaesthesiology Department of the Leiden University Medical Center and anaesthesiologist. Her research focuses on the educational challenges of acquiring communication skills among healthcare providers. KH had the original idea for the study and contributed to the data collection, transcription and analysis. She did not conduct interviews after the training to limit any bias. She wrote the original draft, methodology and final article.

L. Suur is a nursing expert at The Center For Unplanned Admission (CVOO) of the Leiden University Medical Center. She contributed to conceptualization and recruitment project management.

M. van Velzen, MD, PhD, is an educationalist, clinical research coordinator, and associate professor at the Department of Anaesthesiology of the Leiden University Medical Center. She contributed to data collection, conceptualization, data validation and analysis, and review.

E. Sarton, MD, PhD, is an anaesthesiologist and full professor, the former Head Department of Anaesthesia and Headboard Division at the Leiden University Medical Center. She is the former director of Education Master Medical School and former Chair of the Dutch Society of Anaesthesia. Her research has evolved around education in medical training. She contributed to conceptualization and participated in data validation and review.

All authors revised and approved this article and met the ICMJE criteria for authorship.

ACKNOWLEDGEMENTS

The researchers would like to acknowledge the healthcare professionals who will participate in this research. We thank them for their time and effort in contributing to this project. R. Heemskerk, Y. Huinen, N. van Schagen, and J. Schilstra have made significant contributions that have enabled the planning of our project. The medical work environment and implicit rationing of care will be respected during this study. We also thank research interns C. Kwendé and N. van der Kwaak, who assisted in conducting this study.

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APPENDIX 1

The NEPIA questionnaire, Kirkpatrick's level 2:

Question 1: Which statement is correct? (0.5pt per right answer, 2pt in total)
a. Pain leads to an increase in inflammatory markers in the blood.
b. The brain can open or close pain gates and thus modulate pain.
c. A high degree of stress leads to the suppression of the entorhinal cortex, thereby reducing pain perception.
d. Shifting attention can increase pain perception.
Correct: A, B
The brain can open or close pain gates and thus modulate pain. An increase in inflammatory markers is a consequence of stress, not pain. These are very closely related. However, not every (minor) pain prick will cause increased inflammatory markers. How the brain recognizes and interprets pain depends on various factors and complex mechanisms. Pleasant stimuli (e.g., a gentle touch) can close pain gates (gate control), and the brain can also open pain gates, as seen in the feeling of a 'broken heart.' A high degree of fear and stress leads to the activation of certain areas in the brain (entorhinal cortex, insula, and anterior cingulate gyrus), enhancing pain perception. Studies using functional MRI have shown that visual and somatosensory stimuli have pain-modulating functions. Simply put: shifting attention results in less pain.

Question 2: You are administering a painkiller. Which action will ensure the medication works best? Choose the best answer. (1pt)
a) Administer the medication without providing any additional information.
b) Say that this is a very effective medication, and the patient will likely feel better.
c) Say that you see the patient is in pain and this will help.
d) Say that you don't think this medication will work well against the pain.
Correct: B
Say that this is a very effective medication, and the patient will likely feel better. Here, you are giving two positive suggestions: you trust the medication, and you indicate that the patient will feel better. The third answer is less effective because it focuses on the patient's pain, emphasizing a negative feeling, which is unnecessary.

Question 3: What promotes coping-stimulating behavior? Choose the best answer. (1pt)
Coping: the way someone deals with problems and stress
a. Distraction techniques

b. Lots of empathy
c. Commentary
d. Apology

Correct: A

Distraction techniques. Distraction techniques promote coping-stimulating behavior. Conversely, too much empathy, commentary, or an apology reduces coping-stimulating behavior because these focus on negative feelings.

Question 4: Which statement is correct? Choose the best answer. (1pt)

a. Empathy always has a positive effect on a patient's comfort.
b. Implicit factors, such as the color or temperature of the environment, affect a patient's experience.
c. Anxiety is a detrimental mechanism that activates limbic structures.
d. I should always give a warning before inserting an IV.

Correct: B

Implicit factors, such as the color or temperature of the environment, affect a patient's experience. Atmosphere can be influenced unnoticed by background noises, smells, and colors. The third answer is incorrect because anxiety is not always detrimental. Although anxiety activates limbic structures and triggers the sympathetic autonomic nervous system, causing physiological effects like tachycardia and tachypnea, these are stress responses. The last answer is incorrect because a warning can cause anticipatory stress and increased pain. For example, when inserting an IV, it's better to ask the patient to keep their arm still or consider distracting them by asking a question at the moment of insertion (e.g., what did you have for dinner last night?).

Question 5: Which statement about the placebo effect is correct? (1pt)

a. The placebo effect only works mentally.
b. Placebo effects can be harmful.
c. In a randomized study, there are no placebo effects.
d. Placebo effects can be unconscious.

Correct: D

Placebo effects can be unconscious. There are implicit or explicit placebo effects, with implicit effects being unconscious. Placebo effects can have biochemical and physiological impacts. Even in randomized studies, there can be (implicit) placebo effects.

Total: 0 to 6 points

APPENDIX 2

Course evaluation Kirkpatrick level 1:

Improving the quality of continuing education requires your constructive and insightful comments and recommendations. Please help us provide effective training conditions by answering the following questions accurately.

Name of the training course: Basic Therapeutic Communication Training (TC training)
Date of the course: [Enter the date here]

Please fill in your answer by choosing between:
1: very poor/little
2: somewhat poor/little
3: sufficient
4: somewhat good/much
5: very good/much

Questions added to validated questionnaire:

Workshop Satisfaction	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
Satisfaction with the quality of the workshop/training					
Satisfaction with the way the workshop was conducted					
Relevance and Application	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
How relevant and useful do you think this was for your work?					
How likely are you to apply this training in your daily work?					
Recommendation and Expectations	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
To what extent would you recommend this course to a colleague?					
To what extent did this course meet your expectations?					

Validated questionnaire

Instructor Assessment	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
Academic proficiency of the instructor					
Lecturing method and the ability to transfer the concepts to learners					
Ability of the instructor in class management					
Use of active teaching methods and engaging the learners					
Ability to respond to the ambiguities and questions of learners					
Frequency of using practical examples during teaching					
Course content assessment	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
Effectiveness of the contents of the course in increasing your knowledge					
Relationship between training course and your organizational needs					
Up-to-datedness of the contents of the course					
Quality of teaching in the training course					
Course support assessment	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
Your satisfaction with the duration of the course					
Desirability of educational location and environment					
Brightness and light in the classes					
Ventilation and adequacy of cooling/heating system					
Catering and reception					
Treatment of authorities toward you					
Overall satisfaction	**excellent**	**Very good**	**Intermediate**	**weak**	**Extremely weak**
Satisfaction of the quality of workshops					
Satisfaction of the way of conducting workshops					

APPENDIX 3

Interview guide

Topic List for Before the Training

Topic	Question
Demographics (Round of questions - all at once)	- What is your name? - How old are you? - How long have you been a nurse/medical professional?
Pain	- What do you typically use to evaluate a patient's pain? How do you 'see' that a patient is in pain? - Is this a standard at LUMC? - Follow-up: What do you think about this? - What do you think are the most effective methods to assess pain? - What is the role of doctors in assessing/treating pain? Do they do things differently? - What are your experiences with the Central Pain Team?
Registration	It happens that the registration of NRS scores is not filled in, especially for the second measurement after a high NRS score. Why is this? Does it ever happen that a pain score does not match how a patient seems to experience the pain? How do you handle this?
Anxiety	- What do you typically use to assess a patient's anxiety? How do you 'see' that a patient is anxious? - Is there a standard at LUMC (similar to pain scores, but for anxiety)? What do you think about this? - How do you deal with an anxious patient? - What do you think are the most effective methods to assess (to 'see') anxiety? - What is your role in assessing/ treating anxiety? What is the role of the doctor? Is there a difference?
TC (Not yet completed)	- What do you already know about the TC course? - Do you know why the TC course is being introduced? - What are your expectations of this course? - What would you like to learn during the course?

Topic List after the Training

Topic	Question
Demographics (Round of questions - all at once)	- What is your name? - How old are you? - How long have you been a nurse/medical professional? - Have you completed the TC training?
TC Training	- What did you think of the TC training? - To what extent do you think you can apply TC communication? Do you have an example? - Did the training meet your expectations? (Explain why/why not) - Do you need additional training at this time?
Pain	- During the TC training, it was discussed to evaluate pain and anxiety with a comfort score (NRS comfort), with a checkbox: does the patient need more pain relief. Do you agree with this? - Do you have any other suggestions to improve pain registration?
Free	- Do you have any other points regarding pain, anxiety, and therapeutic communication that you would like to discuss?

APPENDIX 4

Full overview quantitative results

Evaluation training						
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**	**Variance**
Satisfaction with the way the workshop was conducted	43	4	5	4,63	,489	,252
How relevant and useful do you think this was for your work?	43	3	5	4,33	,715	,239
How likely are you to apply this training in your daily work?	43	3	5	4,21	,773	,511
To what extent would you recommend this course to a colleague?	43	3	5	4,67	,566	,598
To what extent did this course meet your expectations?	43	3	5	4,40	,623	,320
Academic proficiency of the instructor	43	3	5	4,56	,548	,388
Lecturing method and the ability to transfer the concepts to learners	43	3	5	4,65	,529	,300
Ability of the instructor in class management	43	3	5	4,72	,549	,280
Use of active teaching methods and engaging the learners	39	3	5	4,46	,555	,301
Ability to respond to the ambiguities and questions of learners	35	3	5	4,40	,651	,308
Effectiveness of the contents of the course in increasing your knowledge	43	3	5	4,30	,638	,424
Relationship between training course and your organizational needs	43	3	5	4,19	,588	,406
Up-to-datedness of the contents of the course	43	3	5	4,35	,650	,346
Quality of teaching in the training course	43	3	5	4,47	,592	,423
Your satisfaction with the duration of the course	43	3	5	4,12	,662	,350
Desirability of educational location and environment	42	2	5	3,95	,623	,439
Brightness and light in the classes	43	2	5	3,81	,699	,388
Ventilation and adequacy of cooling/heating system	43	1	5	3,42	,957	,488
Catering and reception	33	2	5	4,18	,808	,916
Treatment of authorities toward you	32	3	5	4,28	,683	,653

6

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

ARTICLE INFO

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Keywords:

Virtual reality,
Therapeutic communication,
Healthcare education,
Patient-embodied experience,
Mixed method methodology,
Music medicine,
Preoperative anxiety

Submitted

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).

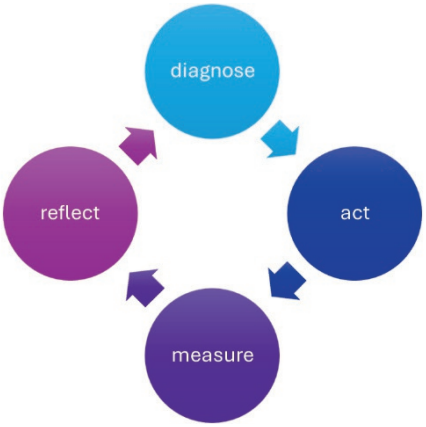


Figure 1. Four stages of PAR and participatory action research.

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**).

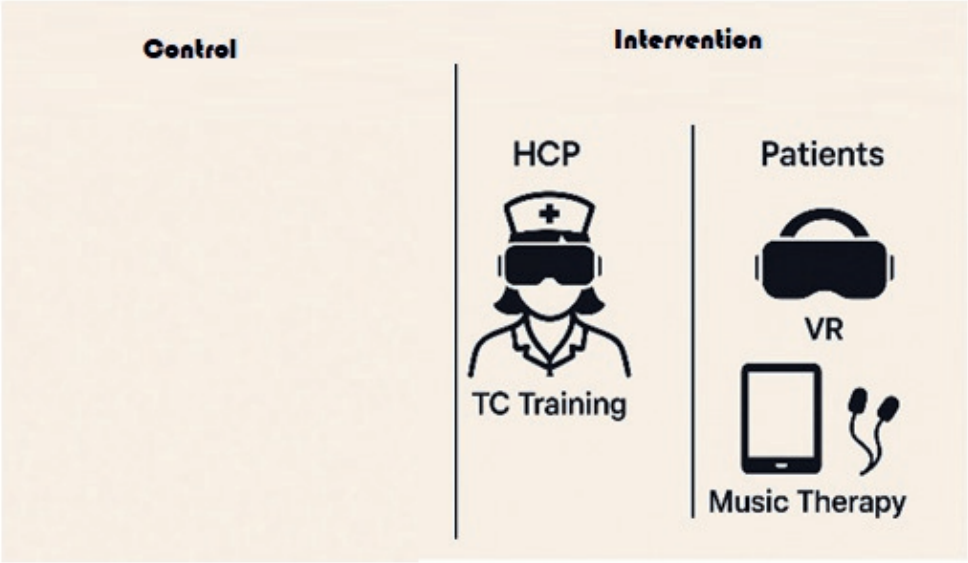


Figure 2. Three study interventions. For healthcare providers: TC training. For patients: VR or Music Therapy. HCP, healthcare professionals. VR, virtual reality. TC, therapeutic communication.

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**.

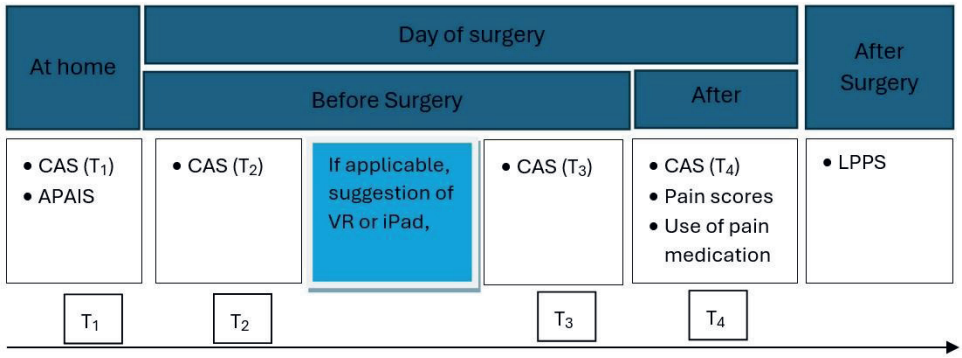


Figure 4. Collection of quantitative data. CAS scores = comfort (1-10), anxiety (10-1) and satisfaction (1-10) scores. T1, remotely before day of surgery; T2, at arrival on holding; T3, after intervention on holding before surgery, T4, post-surgery on recovery/PACU; PACU, post anesthesia care unit. APAIS, 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.

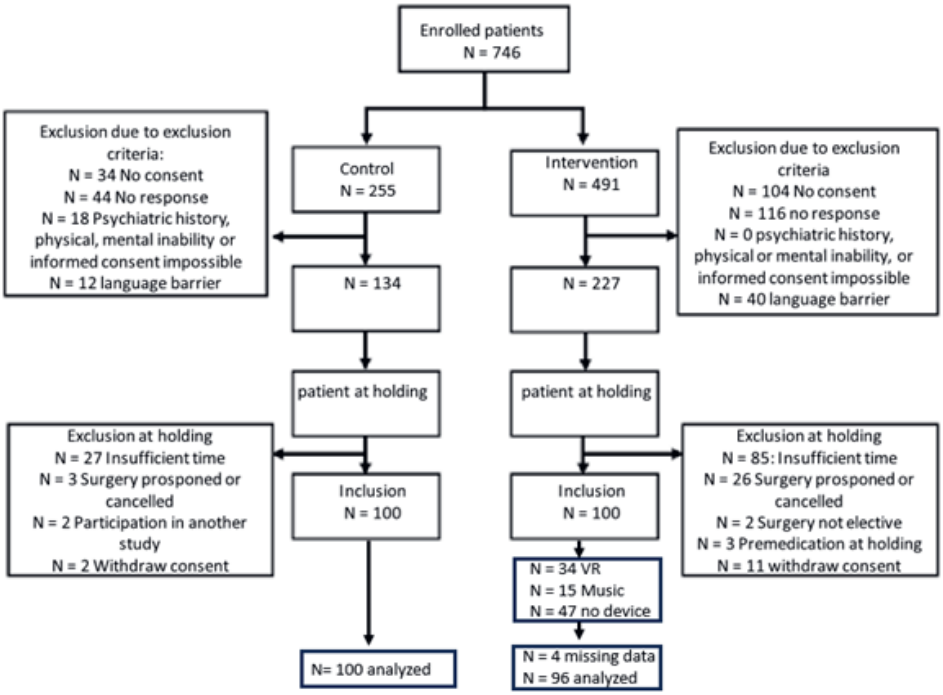


Figure 5. Flow diagram.

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.

ACKNOWLEDGEMENTS

The researchers would like to acknowledge the HCP and patients who participated in this research. We thank them for their time and effort in contributing to this research project. The nurses' work environment and implicit rationing of nursing care were respected during this study. In addition, we would like to thank students Ivar Bouwman and Sofyan Mandil for their contributions to this project.

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

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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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.

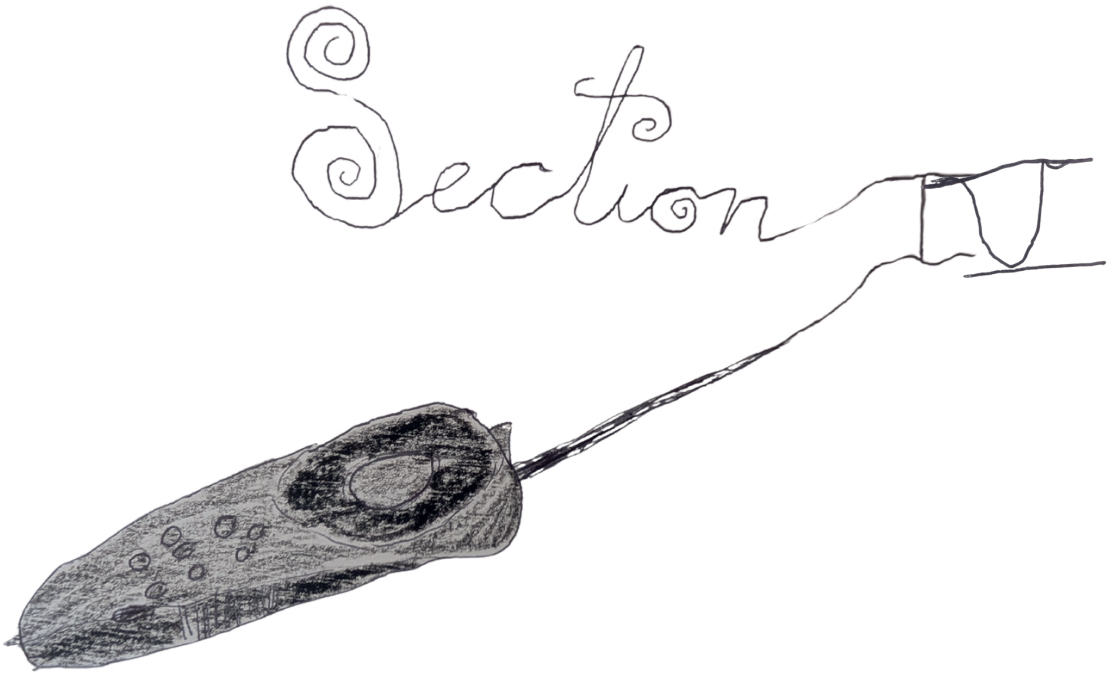
How should we approach future patients?

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).*



Communication and Team Culture in the Operating Room

7

NONVERBAL ELEMENTS OF RAPPORT DURING ENDOSCOPIC PROCEDURES – A VIDEO ETHNOGRAPHIC STUDY

ARTICLE INFO

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Keywords:

rapport,
therapeutic communication,
endoscopy,
video-ethnography,
nonverbal communication

DOI: 10.21203/rs.3.rs-4562058/v1

Submitted

ABSTRACT

Background

Patients undergoing gastrointestinal endoscopy often experience anxiety, physical exposure, and reduced agency, making rapport particularly important in the peri-procedural phase when patients may be unable to speak or move freely. While nonverbal behaviors are known to support rapport in traditional one-to-one consultations, far less is understood about how these behaviors function in the fast-paced, team-based environment of an endoscopy unit. This study examines how healthcare professionals use nonverbal behaviors to build rapport with patients immediately before sedation.

Methods

We conducted a descriptive video-ethnographic study in a tertiary academic endoscopy department. Using ceiling-mounted cameras, we recorded eight elective endoscopic procedures and analyzed the period from patient entry into the room until loss of responsiveness under sedation. Data consisted of synchronized video and audio recordings, fieldnotes, and reflexive memos. A reflexive thematic analysis approach was used to identify patterns of nonverbal behaviors contributing to rapport.

Results

Across the dataset, clinicians demonstrated four clusters of nonverbal behaviors contributing to rapport: eye contact and gaze; comforting physical touch; open or receptive postures; and deliberate positioning relative to patient eye level and proximity. These behaviors were used dynamically in response to patient cues—including anxiety, hesitancy, or physical stillness—and supported moments of attunement between clinicians and patients despite the presence of masks, monitoring equipment, and procedural demands. Although most rapport-related behaviors occurred in dyadic moments, team members also coordinated implicitly through shared positioning and supportive actions.

Conclusions

In the pre-sedation phase of endoscopy, nonverbal behaviors play a central role in establishing rapport, possibly reducing patient anxiety, and enhancing perceived safety. Unlike standard consultation settings, clinicians in endoscopy must adapt their behaviors to patient immobility, limited facial visibility due to masks, and a multi-professional workflow. These findings highlight the need for communication training that addresses nonverbal rapport-building in technical, procedure-driven environments.

KEY MESSAGES

What is already known about this topic:

- Rapport enables effective communication among healthcare providers and patients and is crucial for patient involvement in bowel cancer screening programs.
- Nonverbal elements play an important role in enabling rapport and enhancing patient experience.
- Current knowledge on nonverbal communication for rapport mostly concerns one-to-one interactions and may not be applicable to the endoscopy department.

What this study adds:

- This video ethnographic study was able to identify key elements of periprocedural nonverbal communication techniques within the endoscopy department associated with the creation of rapport.
- The nonverbal elements included eye contact, postural open body positions, physical touch such as a soothing touch and body lean, which were also observed in one-to-one doctor–patient interactions.

How this study might affect research, practice or policy:

- This study identified key elements of periprocedural nonverbal communication techniques within the endoscopy department associated with the establishment of rapport.
- This knowledge may contribute to further development of educational programs with the objective of enhancing communication skills.
- The fit with the literature on rapport making in a one-to-one interaction between healthcare providers and patients supports the transferability of our findings to the environment of the endoscopy department.

INTRODUCTION

Modern medicine is constructed, among other things, on the groundwork of Cartesian body-mind dualism, implying a distinction of what takes place in the mind juxtaposed to what happens in the body (1). Dualism still dominates biomedical analytical methods and lays the groundwork for positivism, which means a logical thought based upon unbiased, impersonal and empirical observations and measurements (2). Healing by technological interventions became the gold standard, and randomized controlled trials (RCTs) were judged as the only legitimate means of measuring their effectiveness (3-5).

Currently, our understanding of human beings and their health has changed toward the consideration of complex systems in permanent interactions with the environment. The clinical setting, the cognitive-affective communication of clinicians and the rituals used to administer treatments influence the clinical outcome of patients (6). In general, the benefits of effective physician–patient communication are clear, and most healthcare professionals acknowledge the importance of improving patient–physician relationships (7, 8). Contextual factors encompass the combination of different psychological, social and physical elements characterizing a therapeutic encounter and influencing the lived experience of a patient (6, 9-11). A negative therapeutic context involving negative sensory and social stimuli may negatively affect patient-reported outcomes such as patient satisfaction. There is empirical evidence that contextual factors, such as pain and anxiety, impact clinical outcomes and influence the use of analgesic and anxiolytic medication (9-11).

In particular, during endoscopy, patients may feel in an inferior position, emphasizing the importance of effective communication skills among endoscopy staff (12). This experience of feeling inferior or exposed has also been described in recent qualitative work, underscoring that comfort, vulnerability and communication are tightly linked in endoscopic care.

Rapport is the close and meaningful relationship between people; an understanding of one other point of view implicates verbal and nonverbal involvement (17, 18). The use of elements of therapeutic communication can increase patients' knowledge and understanding, enhance trust and self-health skills, increase adherence, provide comfort and facilitate the management of emotions that are key to patients' health and wellbeing (16, 19). Rapport seems to be highly relevant for patients in more stressful clinical contexts, such as gastrointestinal endoscopies (20). Endoscopy is therefore an appropriate setting for examining nonverbal behaviors that contribute to rapport, particularly because patients may not be able to rely on their own nonverbal cues once positioned for the procedure.

Colorectal cancer is the third most common cancer worldwide, and its prognosis relies heavily on early diagnosis (21). Early detection, by colonoscopy, holds significant societal importance. Patient experience is a critical factor in determining patient involvement in bowel cancer screening programs and has an impact on whether patients choose to attend repeat disease surveillance procedures (22). More broadly, patient experience before sedation is a determinant of perceived safety and willingness to return for future procedures, underscoring the importance of rapport-building behaviors.

Although extended literature exists on the nonverbal elements of the creation of rapport in healthcare providers and patient interactions, this research generally focuses on communication in a one-on-one interaction during a medical interview or in an examination room (23-30). Far fewer studies have examined how rapport is built nonverbally in dynamic, procedure-driven environments involving multiple clinicians and limited patient agency.

The aim of the current study was to analyze the nonverbal elements used to create rapport by healthcare providers working at the endoscopy department.

For this purpose, we recorded video footage from healthcare providers interacting with patients undergoing elective endoscopy under sedation. An overarching study sought to investigate the effects of training in therapeutic language and communication among healthcare providers and patients. However, the present analysis is descriptive only and does not examine training-related effects.

The research question was as follows: Which nonverbal communication techniques are used by healthcare providers to create rapport in the perioperative setting of an endoscopy department?

Our secondary research question was as follows: How do the nonverbal behaviors we observed compare with what is already known from one-to-one rapport-building literature?

METHODS

This research was carried out at Leiden University Medical Center (LUMC), a large tertiary academic teaching hospital situated in Leiden, the Netherlands. The protocol was approved by the Institutional Science Committee, which received a waiver to be performed by the Institutional Review Ethics Committee (METC Leiden the Hague Delft, Leiden, the Netherlands) and adhered to GCP regulations. Written informed consent was obtained from all participants. Participants received no financial compensation. The data were collected and recorded between May 2021 and June 2022. Recordings started when the patient entered the operating room and were analyzed until the sedation practitioner started deep sedation. Because the focus of this study was explicitly on the pre-sedation phase, no data were collected after patients became unresponsive.

Study design

The present exploratory research used an ethnographic phenomenological approach. Ethnographic research can provide insight into the behaviors, thoughts, behaviors, norms and feelings of a group (31). Video ethnography of healthcare providers interacting with patients undergoing an endoscopic procedure (gastro- or colonoscopy) was used to study patterns of behavior, insiders' perspectives, (nonverbal) communication, and actions in a natural setting over a period of time (32). The researchers (HZ, KH) immersed themselves in the research population for an extended period of time, observing behavior, and making field notes while interacting minimally with the healthcare providers, adapting a go-along ethnographic approach (33). The researchers were nondirective and naturalistic; they did not express preferences, stepped back from action, and attempted not to interfere with regular care. Following the data collection, a reflexive thematic analysis was performed to convert the range of retrieved data into reliable units. The data were retrieved without sampling size and pursuing data saturation; that is, until the researchers were empirically confident, additional data would not lead to any new emergent input (34, 35).

Participants and consent

The study included sedation practitioners, endoscopists, nurses and patients. Hospital staff were recruited via e-mail or informal medical gatherings from the endoscopy department. At these gatherings, healthcare providers were informed about the research project with the aim of recruiting as many healthcare providers as possible. Initially, they were informed that videos were taken to analyze anxiety among patients, without specifying that the videos would also be useful for analyzing the behavior of healthcare providers.

All participants first signed an informed consent form. This approach was taken to minimize any potential changes in behavior among healthcare providers and was approved by the institutional review board. Halfway through the study, all healthcare providers were fully informed about the research questions and therapeutic communication training. They then signed a second consent form, reaffirming their agreement to participate in the study. Staged disclosure was used only to reduce Hawthorne effects; all participants ultimately received full information before the study period ended.

Patients were recruited via telephone or e-mail. All recruited subjects agreed to participate, and all enrolled patients signed an informed consent form. The participants were informed of all the research questions and objectives of the study from the start of the study. Only the period before deep sedation was analyzed; patients remained responsive during the entire analytical window.

At the start of each day, the researcher ensured that all healthcare providers had signed the informed consent forms or would ask the healthcare provider to do so if they had not previously consented. Failure to secure consent would result in the cancellation of recording and study participation for that day; the latter never occurred.

Video ethnography and reflexivity

The preparation of the data collection involved checking the video equipment and environment. The existing camera of the endoscopy room was chosen for pragmatic reasons. These cameras, situated at the ceiling, were able to film the whole endoscopy room from a large angle. Additionally, a camcorder would have made a 'Fly on the Wall' approach more challenging (36), as it is far more visible for all participants.

The researchers (KH, HZ) did not work in the perioperative department and used a transcendental approach, putting aside their own knowledge and theories during the retrieval of qualitative data (37). The transcendental approach, largely developed by Husserl, is a philosophical approach to qualitative research methodology seeking to understand human experiences (38); "description is to be performed from a first person point of view, to ensure that the respective item is described exactly as is experienced, or as intended, by the subject" (39). In this regard, promptly, researchers prepare any reflexive notes. Additionally, all the researchers kept fieldnotes and regularly discussed their experiences within the research team.

Video data allowed repeated viewing, enabling deeper visual analysis of nonverbal behaviors including gaze, positioning, posture, and touch, which could not be captured through audio transcription alone.

Data analysis

Qualitative content analysis was used to reveal themes and categories using ATLAS.ti software. The validation criteria of qualitative research, such as generalizability, reliability, and verifiability, were used (35). The data were transcribed verbatim, and identifiers were removed to preserve the confidentiality of the transcripts. All the data were kept in password-protected files with limited access to protected hospital network drives. Transcription included all audible speech; however, video served as the primary data source, particularly for encoding gaze, posture, body positioning, and physical touch. Nonverbal behaviors were coded directly from video, not inferred from transcripts.

The data were analyzed using an applied thematic analysis with an inductive process based on the six phases of thematic analysis outlined by Braun and Clarke (40): data familiarization, code generation, theme development, theme revision, theme definition and report production (40). A codebook was developed as themes emerged by two coders independently (KH and HZ) before they were discussed together until consensus was reached. The analysis continued with the clustering of codes into emergent categories and then structuring and grouping into overarching themes. The final validation of the codes against the data extracts was completed by the researchers (KH, ES) to ensure consistent representation of the categories and themes of the entire dataset, ensuring data generalizability. The overarching study also used other types of data that will not be described in this article.

RESULTS

Sample characteristics

The analyzed video tapes included sedation practitioners, endoscopists, nurses and patients. The demographic data of the healthcare providers before and after the training were comparable. Most healthcare providers were female and worked in the endoscopy department as endoscopy nurses. The details are shown in **Table 1.** All the patients had previously undergone an endoscopy; the majority were female, with mean ages of 65 (female) and 45 (male) years, as shown in **Table 2.**

The total taping time ranged between 15 minutes and 5 hours, for a total of almost 16 hours. Analyses were performed from the moment the patients entered the endoscopy room until sedation started and the patient did not respond to the cues.

Table 1. Demographics of healthcare providers

	Before (4 cases)	After (4 cases)
Nurse/Endoscopists/Sedation Practitioner	9/4/4	8/3/4
Male/Female	3/14	5/10

Table 2. Patient demographics

	Before (4 cases)	After 4 cases)
Sex (female)	100%	50%
Age (range)	45 (34 - 64)	65 (56 - 76)
Colonoscopy/Gastroscopy/Both	2/1/1	4/0/0
Previous endoscopy	4	4

Reflexivity

Before the commencement of the study, the researchers performed fieldwork by walking alongside the endoscopy nurses, sedation practitioners, and endoscopists to be able to blend in with the team. Additionally, this approach created a more naturalistic posture for the researchers, as shown in the fieldnote below:

> Fieldnote 1 August 2021, HZ
> "At first, I did not know the significance of all the monitoring present, nor did I know where to stand at some moments of the procedure."

Along the way, the researchers (KH, HZ) considered themselves more and more as 'Insiders' as the fieldnote below states:

> Fieldnote 2 July 2021, KH
> "I had a good day today. I can see the team knows who I am now, and what the purposes are of the study. It makes me feel more relaxed, as they seem to think of me, more like a member of the team."

Themes and subthemes

The analyses resulted in the identification of 4 major themes divided into 9 subthemes, as shown in **Table 3**, **Figure 1, and Figure 2**. The nonverbal techniques and gestures used to create rapport in our study included facial expressions, physical touch, postural changes, and body position. We decided to analyze the data before and after the implementation of TLC training to obtain a wider sample. We observed signs of the presence of rapport

and a lack of rapport in both cohorts; however, for the purpose of this study, we did not compare the two cohorts.

Each theme reflects observable, repeated patterns of behavior representing interactional processes in which clinicians actively responded to patient cues. Themes were therefore defined by their *relational function* rather than by the isolated behavior alone.

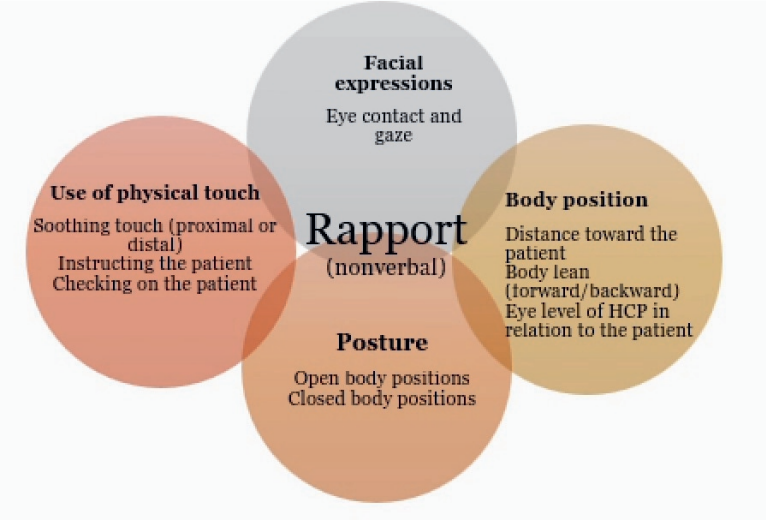


Figure 1.1. Themes and subthemes in a Venn diagram



Figure 1.2. Word cloud of themes and subthemes according to their appearance and importance throughout the dataset.

Table 3. Themes and subthemes in making rapport

1.Facial expressions	1.1Eye contact and 1.2 Gaze
2.Use of physical touch	2.1 Soothing touch 2.1.1 proximal 2.1.2. distal 2.2 Instructing the patient 2.3 Checking on the patient
3.Posture	3.1 Open body positions 3.2 Closed body positions
4.Body position	4.1 Distance toward the patient 4.2 Body lean (forward/backward) 4.3 Eye level of HCP in relation to the patient

3.4 Facial expressions

Eye contact is defined as the extent to which a healthcare provider investigates the patient's face and can be critical for enhancing rapport (23). The eye contact in the video recordings varied from 'brief' eye contact episodes from a few seconds to 'sustained' eye contact from almost a whole minute, where a healthcare provider is constantly following the patient's facial expressions and movements. Two examples of differences in eye contact are presented below:

Example 1 – 'brief' eye contact (video 8, SPS 5, patient 8)
Arriving at the OR the patient lays in the hospital bed with the head end up, facing the sedation practitioner who is reviewing the patient's chart at the opposite end of the hospital bed. As the patient begins to tell the sedation practitioner their story of a previous bad experience of the last hospital visit, the sedation practitioner is seen walking across the OR looking for something, not looking toward the patient who continues the story. The patient is expressing their feelings of anxiety and narrating things that could go wrong during the procedure. While the sedation practitioner is preparing, occasionally looking directly at the patient, their responses consist of "yeah?" and "hmm okay" or sometimes even saying nothing at all.

Example 2– 'sustained' eye contact (video 4, doctor 4, patient 4)
Arriving at the OR, the patient lays in the hospital bed with the head end up, facing the doctor, nurse, and sedation practitioner. The doctor walks toward the patient, greets the patient, proceeds to ask several safety questions, moves to the right side of the patient to face the patient at a comfortable distance, makes eye contact with the patient and listens attentively by nodding the head up and down. The patient begins to express their feelings of anxiety and says they are not feeling very well. The doctor verbalizes they are in good hands. Furthermore, the doctor steps one step closer toward the patient, bends their upper body a little toward the patient and touches shortly the

arm of the patient, while making directly eye contact. The interaction continues with doctor 'looking' and 'listening' to patient; and the patient 'looking' and 'talking' to the doctor.

In our data, sustained eye contact appeared to function as a signal of availability and attentiveness, helping patients feel seen and acknowledged. In contrast, brief or absent eye contact often coincided with patient narratives that remained unsupported or unreciprocated, reducing the likelihood of rapport formation.

Physical touch

The use of physical touch varied from checking the patient to instructing the patient and soothing the patient. Checking the patient was mostly used to determine whether the patient was still responsive after the start of deep sedation. We defined 'instructing the patient' as every touch that functions as an instruction or guidance. Finally, soothing was defined as a touch not used for the abovementioned purposes, with the purpose of soothing, of enhancing patient comfort.

All the videos were checked on the patient, and the patient was instructed about the patient during the initial phase of the start of deep sedation, as described previously **Figure 3**.

Soothing touches were often seen as a reaction to the behavior of the patient. For example, in **Figure 3**, the patient was seen fumbling with her fingers. This was followed by a physical palpation by the endoscopist.

Soothing touch functioned as a bidirectional regulatory cue, often used when patients displayed visible anxiety or bodily tension.



Figure 2. Examples of nonverbal elements of rapport

Posture

The observed postural behaviors included opening and closing the body. Body openness was defined as the absence of folded arms or crossed leg positions (41), also seen in **Figure 3**.

The closed body positions included the folded arms shown in **Figure 3**. Additionally, frequent akimbo positioning of the arms was observed, with hands on the hips and elbows turning outward, as shown in **Figure 3**.

Open postures tended to occur during greeting, reassurance, or explanation and aligned with moments in which patients appeared more verbally engaged. Closed or akimbo postures often coincided with task-focused behavior and reduced relational attunement. While not inherently negative, these postures appeared to limit opportunities for rapport.



Figure 3. Examples of nonverbal elements of rapport

Body position

Body position was used differently throughout the observation period. The physical distance toward the patient was often reduced at moments when patients expressed signs of anxiety, as in the example of **Figure 2** where the endoscopist positioned themselves closer to the patient who was fidgeting her fingers. Often, healthcare professionals use a forward body lean toward the patient.

Finally, healthcare providers positioned themselves differently in relation to the eye level of the patients. As the patients laid on the operating table, they were placed in a standard operational position. However, in 6 out of the 8 videos, healthcare providers kneel down to reach the same eye level as the patient (**Figure 3**).

Body positioning often involves **sequential coordination**. When one clinician leaned forward or lowered themselves to the patient's level, others tended to pause their activity or adjust their position to avoid crowding the patient. These micro-adjustments suggest that rapport-building in endoscopy emerges not solely from one-to-one interaction but from a collective.

DISCUSSION AND CONCLUSION

Discussion

This video ethnographic study was able to identify key elements of periprocedural nonverbal communication techniques within the endoscopy department that are associated with the creation of rapport (18, 23-28). To our knowledge, this is the first study to examine nonverbal communication techniques in a periprocedural setting, such as in the endoscopy department.

Eye contact in the video recordings varied from brief eye contact episodes from a few seconds to sustained eye contact from almost a whole minute, during which a healthcare provider constantly followed the patient's facial expressions and movements. The importance of eye contact has been described by Gorawa as critical for enhancing rapport (23). It serves as a salient factor in therapeutic communication improving adherence.

The use of physical touch was also observed as a frequent tool used by healthcare providers, varying between checking the depth of sedation, instructing the patient and touching for a soothing purpose. Touch can be perceived as comforting and healing (27) and is often performed by healthcare providers when a patient shows signs of anxiety or pain.

Posture analysis revealed the use of open and closed body positions. Open body positions commonly indicate and facilitate rapport and empathy. In contrast, closed body positions such as the use of arms in the akimbo position have been described as imperious, cold and immodest, hindering the creation of rapport (26). Last, body positioning, such as leaning forward, is often perceived as more empathic (24). Looking down on a patient can be intimidating; frequently sitting down or kneeling down may be used to enhance connection (25).

Findings from our data confirm the literature on nonverbal elements for the creation of rapport in wider medical settings, such as one-to-one interactions between a doctor and a patient (23, 24, 42, 43).

Classic one-to-one doctor–patient communication commonly involves two people interacting with each other without a facemask. This leads to more elaborate distinctions in facial expressions. In our study, due to sterility issues during endoscopic procedures, the facial expressions of healthcare providers were partly invisible due to the use of face masks, limiting analysis to eye contact and gaze only in our study.

We clarify that the nonverbal behaviors identified did not function as isolated techniques but formed interactional sequences aimed at supporting patient comfort. For example, clinicians frequently combined eye contact, forward lean, and brief soothing touch when

patients expressed anxiety, suggesting that rapport-building is a multi-modal process rather than a single behaviour.

Additionally, although the results appeared primarily dyadic, several episodes demonstrated that rapport in endoscopy is influenced by **team choreography**. When one clinician leaned forward to reassure a patient, others often paused, stepped back, or adjusted positioning to avoid crowding the patient. These subtle coordinated behaviours indicate that rapport-building is embedded in team flow rather than individual performance.

While eye contact, open posture, touch, and proximity are widely described in general medical communication, the context of endoscopy amplifies their importance: patients lie supine, may already feel physically exposed, and have limited capacity to use their own posture or movement as communicative tools. Thus, clinicians' nonverbal responsiveness may serve as a compensatory relational mechanism in a setting where the patient's expressive freedom is constrained.

That said, achieving matching positioning and body postures naturally seems to be more challenging, given that the patient is lying down on the operating table while healthcare providers need to be in an upright position to perform the endoscopic procedure and provide sedation. Interestingly, as often observed in these videos, healthcare providers tend to mirror and adapt their body positions when they deem this necessary for their connection with the patient.

Moreover, given that many endoscopy units—especially in Northern Europe—perform procedures without sedation, we acknowledge that our findings reflect a subset of endoscopy practice. In unsedated contexts, patient facial expression and body movement would likely be more observable, and rapport-building dynamics may differ. Therefore, transferability applies primarily to sedated or pre-sedation endoscopy sequences.

Notably, complex interactions and continuous processes exist between healthcare providers and patients. Crucial components of nonverbal communication, such as eye contact, body posture and position and the use of physical touch, may be interpreted differently among patients depending on contextual factors such as cultural background, sex, and age. For example, acceptance of comforting touch depends on the location of the touch, familiarity with healthcare providers and sex (27). Eye contact and gaze are interpreted differently between Western and Arabic or Asian cultures (28).

Two researchers were present during the data collection, adapting go-along ethnography (33), a choice of a transcendental approach during the data analysis based on the epistemological assumptions of the Husserlien approach, thus enhancing the internal validity of our findings. The data on which this study is based involved several months of

fieldwork, carried out by the researchers, using a video ethnographic method. Video footage enhanced our research, as the data could be observed repeatedly, at greater depths, providing new insights (44). Employing thematic analysis of the qualitative data permitted identification, analysis and reporting of patterns within the dataset, facilitating the creation of a rich description of the subject matter. Following the standards of qualitative research, validation criteria, such as generalizability, reliability, and verifiability, were used (35).

Nonetheless, video analysis is susceptible to social desirability bias. At first, healthcare professionals may adapt their behavior knowing that they are filmed (Hawthorne effect). Nonetheless, as time passes, people tend to return to natural behavior (45). Video ethnography is a discrete and nondirective technique for recording naturalistic everyday behavior in clinical settings. It is useful to obtain firsthand insights into how healthcare professionals account for patient comfort in ways other methods may not detect. It has ecological validity, that is, it has a predictive relationship with behavior in a real-world setting (46).

Conclusion

This paper provides a thorough description of the nonverbal techniques employed to create rapport. Observations included facial expressions, postural changes, physical touch and body positioning. The fit with the literature on rapport making in a one-to-one interaction between healthcare providers and patients supports the transferability of our findings to the environment of the endoscopy department.

In conclusion, providing comfort and facilitating the management of emotions are key to patients' well-being, and the findings of this study may contribute to further research and programs with the objective of enhancing the therapeutic language and communication skills of healthcare providers in a broader setting.

To increase conceptual coherence, we clarify here that our conclusions pertain specifically to **nonverbal behaviors contributing to rapport**, rather than to therapeutic language more broadly. Our findings highlight how clinicians working in highly technical procedural environments can rely on subtle nonverbal behaviors to enhance patient comfort and relational safety, particularly in the vulnerable pre-sedation phase.

Future directions

Our findings indicate the potential transferability of nonverbal rapport elements observed between the classical consultation context and the endoscopy department. However, our study did not quantify these elements, presenting an intriguing opportunity for future investigation using an objective coding scheme to systematically classify and measure these nuances.

Second, the video cameras were not positioned close enough to capture or encode microexpressions on the faces of the participants. Additionally, the study of microexpressions requires coders to have professional knowledge of action unit coding (47), which might be an interesting field of future research in this context.

Additionally, the incorporation of video-reflective ethnography represents a promising avenue for future exploration. Utilizing this technique in the perioperative setting, such as in the endoscopy department, could offer a more comprehensive and nuanced understanding of rapport dynamics, providing valuable insights into the intricacies of these interactions.

Future studies should also examine unsedated endoscopy populations, where patients' own nonverbal behaviors may be more accessible, allowing a fuller analysis of interactional reciprocity. Comparative research across sedated and unsedated settings would help refine understanding of context-dependent rapport-building practices.

Declarations

Ethics approval and consent to participate and publication

The protocol was approved by the Institutional Science Committee, which received a waiver to be performed by the Institutional Review Ethics Committee (METC Leiden the Hague Delft, Leiden, the Netherlands) and adhered to GCP regulations. Written informed consent was obtained from all participants.

Data availability

The datasets used during and/or analyzed during the current study are available from the corresponding author upon reasonable request. Video footage and original audio files are unavailable due to privacy restrictions.

Competing interests

The authors declare no competing interests.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. We have no competing interests to declare.

Contributions

KH had the original idea for the study. She wrote the original draft, methodology and final article. ES and MvV contributed to the conceptualization. HZ and KH contributed to the data collection. HZ and KH transcribed and analyzed the data. ES and JB contributed to

supervision and editing of the manuscript. All the authors have read and approved the final manuscript.

Aknowledgements

The researchers would like to acknowledge the healthcare professionals and patients who participated in this research. We thank you for their time and effort in contributing to this research project. The medical work environment and implicit rationing of care were respected during this study.

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Consent to Publication

All patients and healthcare providers who participated during this study were informed and consented study participation and publication. Persons identifiable in the Figures have been informed and signed a consent for publication form after reading the manuscript.

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8

A VR EXPERIENCE EXPOSING THE HIDDEN CURRICULUM OF THE OPERATING ROOM: A CASE STUDY

ARTICLE INFO

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Keywords:

VR,
Medical Education,
Immersion,
Hidden Curriculum,
Etiquette,
Operating Room,
Experiential Learning,

DOI: 10.1007/978-3-031-88705-5_1

Intelligent Human Computer Interaction



Volume 15557
29 May 2025
Pages 3-17

ABSTRACT

Introduction

The rise of immersive technologies, particularly VR, has significantly impacted medical education. During the COVID-19 pandemic, medical students faced a dearth of exposure to the clinical environment, notably the operating room, which impeded their learning. Vital habits acquired through physical presence and implicit learning were notably lacking. This paper delineates the development of a dual VR experience, offering insights into the unspoken norms and hidden curriculum of the OR from a first-person perspective.

Methods

Our set-up included a development process, incorporating considerations of user experience, technical implementation, content creation, and validation. Content creation involved the collaborative delineation of how medical students navigate their initiation into the OR, engaging stakeholders through storyboards and scripts.

Results

The script and storyboard were initially conceptualized by the principal researcher following an in-depth study of landmark articles on the hidden curriculum and field observations. Validation was performed through group discussions with an expert panel comprising medical students, OR assistants, surgeons, anaesthesiologists, and educators.

Conclusions and practice implications

The findings and insights presented herein contribute to the growing knowledge domain of educational VR development. They underscore the feasibility and potential of harnessing immersive technologies to cultivate engaging and impactful virtual experiences.

INTRODUCTION

Clinical skills learning during the preclinical years serves the purpose of equipping medical students with essential clinical competencies (1). These include skills in clinical examination, mastering basic medical procedures, refining history-taking techniques, and enhancing clinical communication abilities. By integrating CSL into the early stages of medical education, students have the opportunity to familiarize themselves with crucial aspects of patient care before entering the clinical setting.

However, alongside formal instruction, there is often an overlooked yet influential aspect of medical education known as the hidden curriculum (2). First developed by Hafferty in 1994, the hidden curriculum encompasses the influences within the organizational and cultural fabric of medical institutions that shape students' learning experiences (2). While formal education focuses on explicit learning objectives, the hidden curriculum imparts implicit messages through everyday practices, norms, and interactions within the medical community. These implicit learning patterns underscore the importance of ample opportunities for experience in clinical settings. Where the hidden curriculum encompasses a wide range of implicit lessons and values, the *etiquette* of a work environment refers to the expected behaviors and norms within a particular workspace.

Increasing levels of burnout among medical students have raised concerns, emphasizing the need for educators to grasp contemporary junior doctor perspectives during their transition from school banks to the work floor (3). Managing challenges and transitions stimulates learning, but understanding these perspectives is crucial for preparing and supporting medical graduates.

Unfortunately, logistical challenges compounded by a high number of medical students seeking clerkships in popular specialisms such as surgery and anesthesiology may lead to waiting lists for placements in the OR, further hindering medical students' access to essential hands-on experiences.

The COVID-19 pandemic worsened existing challenges. For logistical and hygienic reasons, medical students are often prohibited from participating in hospital rotations and operating room (OR) experiences, leading to the cancellation of clerkships and hands-on clinical training opportunities (4). This disruption highlighted the importance of innovative approaches to clinical skills acquisition.

Medical education has increasingly embraced experiential learning as a means of enhancing clinical skill acquisition. Immersive technologies, particularly virtual reality (VR), have gained prominence in this regard (5-9). VR aligns with Constructivist Theory, positing that learners actively construct knowledge by building upon existing mental frameworks (10,

11). In immersive VR environments, students engage in hands-on exploration, facilitating deeper understanding and meaning-making from their experience. Moreover, VR-based immersive learning offers unique advantages by leveraging various sensory modalities to enhance engagement and *embodiment*. Through the phenomenon of embodiment, VR users can visually substitute their real bodies with life-sized virtual representations, experiencing scenarios from a first-person perspective. This concept, known as the *Proteus effect*, enables users to momentarily inhabit virtual personas, fostering a heightened sense of presence and emotional immersion (12). The integration of multisensory and motor systems during VR experiences further enhances cognitive processing, leading to realistic emotional and neurocognitive responses (13, 14). For instance, individuals who embody avatars with physically attractive features tend to engage in more confident and assertive behavior within the virtual space, mirroring the perceived traits of their avatars (15). This explains how a VR-embodied experience may be more influential than simply watching a video.

Considering the challenges posed by traditional clinical training methods, VR represents a promising solution. Unlike conventional approaches, VR transcends spatial and temporal constraints, allowing medical students to access immersive learning experiences remotely. By simulating scenarios akin to those encountered in the OR, VR offers students invaluable exposure that is critical for their future medical careers.

This paper delineates the development of a dual VR experience, offering insights into the unspoken norms and hidden curriculum of the OR from a first-person perspective. It was part of a blended learning project in which an existing e-learning module was enhanced.

METHODS

This prospective exploratory study was carried out at the Leiden University Medical Center (LUMC, Leiden, the Netherlands), a large tertiary academic teaching hospital.

Informed consent was obtained prior to inclusion, participation was voluntary, and ethics and privacy rights were in alignment with the Declaration of Helsinki and GDPR guidelines, respectively. Data collection and development were conducted between July 2020 and February 2021. Participants received no financial compensation for participation.

Participants and procedures

Participants were asked to join in crafting the dual VR experiences after an initial email invitation describing the research project followed by an in-person meeting with eligible participants. Involvement included tasks such as crafting content, ensuring its accuracy, and filming and refining the VR experiences, as outlined in **Figure 1**. The participants

included a panel of medical students, OR assistants, surgeons, anesthesiologists, and educators.

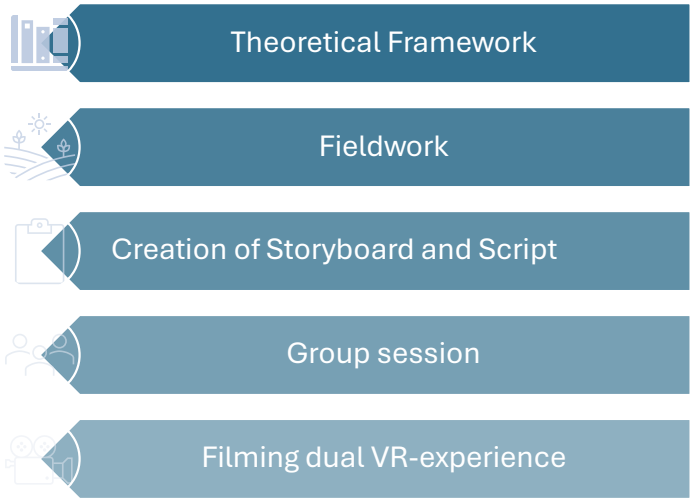


Figure 1. Structure of the study

Theoretic Framework and Content Creation

To construct the storyboard and script depicting the typical journey of a new medical student who starts working at the OR center, we began by establishing a theoretical framework grounded in seminal literature within the relevant field. Specifically, we drew upon landmark qualitative and quantitative studies depicting typical challenges of medical students debuting their careers in the OR, as well as articles on the hidden curriculum in this specific context (3, 16-19).

As Surmon et al. (2016) state, possible negative influences on the preparedness of medical students may involve a) uncertainty, b) disconnection, and c) feeling a part of the team (18). Uncertainty and insecurity of medical students in terms of what is expected of them occur frequently. In earlier studies, students cited the existence of unwritten rules or a hidden curriculum lacking familiarity with the clinical environment (20). Disconnection between the preclinical and clinical curricula contributes to challenges in the preparedness of medical students. As students often feel unsure of hierarchy and how professionals work together, these preoccupations may impede feelings as a part of the team. Throughout content creation, efforts were made to expose medical students to elements of the *etiquette* and hidden curriculum that potentially mitigate these negative influences.

As demonstrated by the work of Laraia et al. (2024), healthcare providers working in the operating room express concerns that students adopt a too passive role, lack situational awareness regarding when or when not to ask questions, and may lack understanding of sterility and the operating room workflow (19). A schematic overview of these themes as described by Laraia et al. (2024) from the OR can be found in **Figure 2** (19).

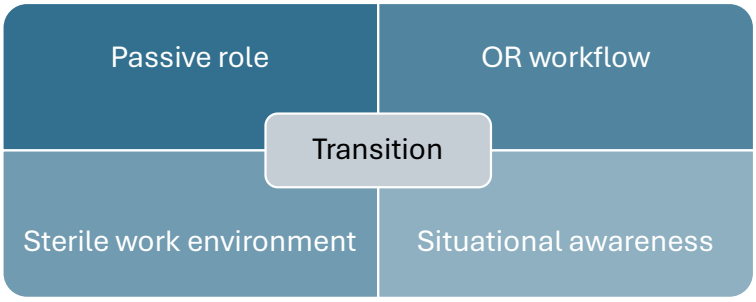


Figure 2. Schematic overview of thematic barriers impeding the transition to the clinical environment

Furthermore, the researcher (KH) engaged in fieldwork comprising informal discussions with healthcare providers, educators and medical students supplemented by observational data collection. This approach facilitated the development of an initial script outlining medical student journeys.

Two VR experiences were to be developed: one in which a colleague medical student fails to adhere to a rule or follow OR *etiquette*, and the other portraying a colleague medical student who respects the rules and *etiquette* of the OR. The specific communication styles, attitudes and professional conduct of the OR needed to be shown, exposing important elements of the hidden curriculum of the OR implicitly. The two VR experiences differed only slightly, requiring the learner to focus and decipher how these differences would impact a workday. We decided on the epistemological assumption to let the learner *feel* these differences, rather than explaining them, by adhering to constructivist theory (11).

Content validation

Group sessions are an adapted tool for validating storyboards and scripts (21). Group input, such as photographs, focused and selective observation notes, reflective notes and commentaries, was used to write and adapt the medical student journey, which was used for final validation until a consensus was reached; that is, until the final script was obtained, all group members provided consent (22).

The specific learning objectives were verified once more by the educators during a final session.

Filming and editing

Requesting that healthcare providers portray their own roles offers several benefits, including cost-effectiveness and easy identification with their professional responsibilities. We tasked the participants with embodying their respective professional roles; for instance, a surgeon would portray the role of a surgeon, a medical student was asked to play a medical student, and so forth. An anaesthetic nurse volunteered to play the patient, as she had already been a patient in our hospital before.

The shooting of the VR-experiences was done with a *GoPro®* camera. Editing and stitching were performed using *PTGUI®*, a panoramic image stitching software, as well as *Pano2VR®*, a virtual tour software that converts 360° into interactive experiences.

RESULTS

Participants and procedure

Seven healthcare professionals participated in the development of the VR-experiences. This included one OR- assistant, two surgeons, two anaesthetic nurses, and two anaesthesiologist. Two medical students participated, as did two educationalists and one VR cameraman/editor, as shown in Table 1. Participants were invited to participate during the development process of the VR experiences, including content creation, validation through a group session, and filming of the VR experiences.

Table 1. Demographics

Role	Number
Medical student	2
OR assistant	1
Anaesthesiologist	2
Surgeon	2
Anaesthetic nurse	2
Educationalist	2
VR cameraman and editor	1

Development of the VR-experiences

Data collection and development were conducted between July 2020 and February 2021. The final durations of the experiences were seven minutes and 32 seconds and seven minutes and 26 seconds, respectively. The narrative environment required consistency with reality, employing objects, characters, and actions to enhance the feeling of immersive *presence*.

A blueprint framework was written describing the purpose of the project, the current education, the learning objectives (cognitive, affective, psychometric), the priming of prior knowledge, and when the education was deemed to be successful, as shown in **Figure 3** and detailed in **Annex 1**.

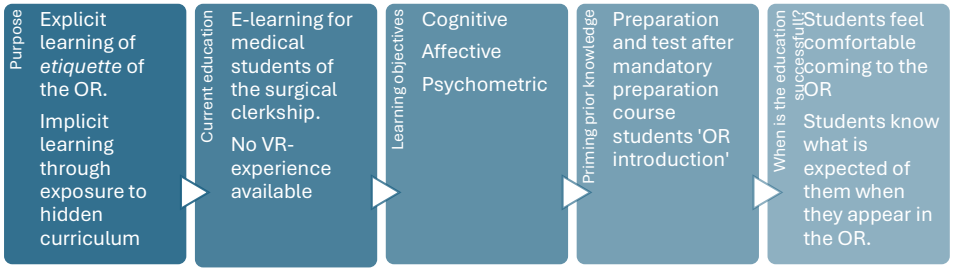


Figure 3. Blueprint of 1) purpose, 2) current education, 3) learning objectives, 3) priming before knowledge and 4) educational success

Script and Storyboard

The fieldwork and group sessions further specified the themes, as shown in **Figure 2**, into specific examples to be used for the storyboard, as described below.

Passive role

As students seem lost and do not seem to show any initiative, in the first experience, the medical student interpreted this passive role by not asking any questions, whereas in the second experience, the student actively asked the surgeon if and how he might participate during the procedure.

OR workflow

Students may enter or exit the OR at unfortunate moments, such as team briefing, debriefing or anaesthesia induction. In the first experience, the medical student enters during induction and is corrected by the anaesthesiologist afterwards. In the second video, the medical student awaits the end of induction before entering the OR.

Sterile work environment

Healthcare professionals express dissatisfaction with respect to sterility among medical students. In the first experience, the medical student enters during a prosthetic surgical procedure, a procedure where door movements need to be as limited as possible. He touched the sterile working space by accident. In the second video, the medical student asks for the right information and changes his schedule to be able to stay for another surgical nonprosthetic surgery. Additionally, in the second video, the medical student assures the correct distance from the sterile working space.

Situational awareness

Introducing themselves needs to be done at the right moment without interrupting healthcare providers. The same applies to asking questions, which healthcare providers encourage, provided that the clinical situation permits. In the first video, the medical student tries to introduce himself after entering the operating room, while the induction of anaesthesia has already started, interrupting this process. In the second video, the medical student enters the room, checks if the clinical situation is 'under control' before introducing himself, and asks how he might assist.

The storyboard provides an overview of the different scenes, as shown in **Figure 4**. The full script of the dual VR experiences is available in **Annex 2**.

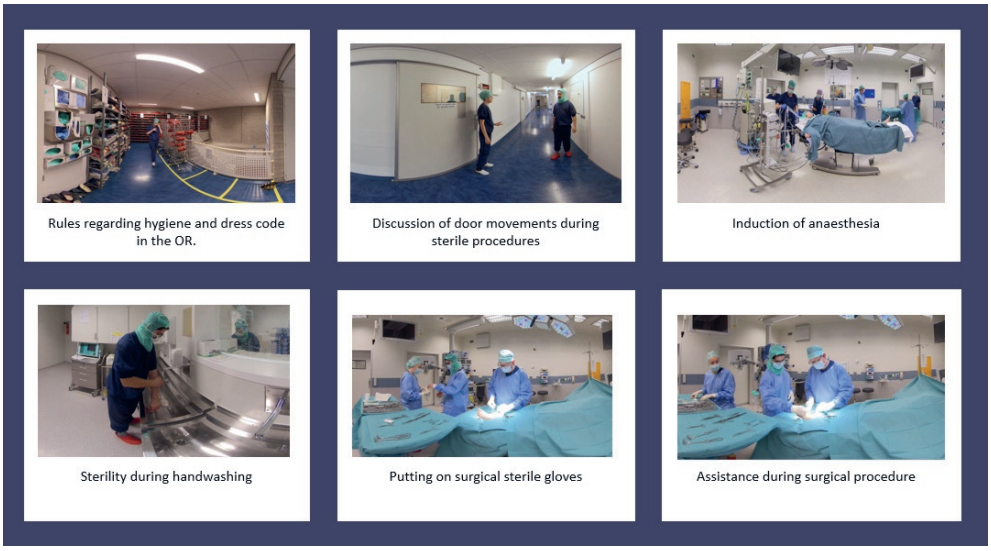


Figure 4. Storyboard of different scenes of the VR experiences

An overview of the main differences in interactions and shadow actions between the two experiences can also be found in Table 2. We crafted a script featuring 'shadow actions' that were observable when the learner shifted his or her gaze. Table 2 provides an overview of the key distinctions in setting, direct interactions, and shadow actions.

Table 2. Overview of the main differences in interactions and shadow actions

	First experience	Second experience
Interactions		
Entrance OR	Colleague medical student 1 forgot to take out earrings.	Respect of dress code of the OR.
Operation room	Colleague medical student 1 was refused access to an OR where prosthetic surgery was performed Colleague medical student 1 enters OR during anaesthesia induction	Colleague medical student 1verifies OR program beforehand Colleague medical student 1 checks entering the OR after anaesthesia induction
Transitional space OR	Colleague medical student 2 disrespects hand washing procedures	Colleague medical student 2 respects hand washing procedures
Shadow actions		
Entrance OR	Other healthcare professionals pass through the entrance of the OR	
Operation room	Anaesthesiologist and anaesthetic nurse intubate the patient, adapt monitoring and positioning of the patient OR nurse 1 starts prepping the patient. OR nurse 2 starts handing over sterile equipment as needed	

DISCUSSION AND CONCLUSION

Discussion

This manuscript describes the development of a dual VR experience for medical students in the OR. Through concrete Experiential Learning, medical students may *feel* what it is like to start working in the OR, preparing themselves for this important transition. As medical students commonly describe this transition as mentally, physically, and emotionally demanding, this dual VR experience may ease this transition, positively affecting their preparedness (16, 17).

We deliberately incorporated nuanced shifts in language and interactions, informed by conceptual frameworks and prior scientific investigations, as referenced in our manuscript. Moreover, the participation of healthcare providers, medical students, and educationalists further enhanced the internal validity of the experiences.

Explicit learning objectives of *etiquette* included respecting the dress code, presenting themselves appropriately upon entering the operating room, and being mindful of entrance and exit, as well as door movements, in relation to specific moments of anaesthesia and surgery. Additionally, respecting an appropriate distance from coworkers who are working in sterile conditions was emphasized. The implicit learning objectives of the hidden curriculum included the communication style of the OR and the professional conduct, roles and attitudes of different healthcare providers working in the OR.

The development of this dual VR experience was based on certain epistemological and methodological assumptions. For instance, we chose 360-degree videos with real humans instead of computer-generated images to make the video look as realistic as possible. However, this impeded interactions with the virtual environment. Learners have the ability to observe their surroundings; however, due to the recorded nature of their experiences, learners are not able to freely move around as they would in a virtual environment utilizing computer-generated 3D video imagery.

Additionally, one assumption underlying this project was that the dual VR experiences, created using 360-degree video, could effectively mimic real-life operating room experiences, which are known to ease the transition from academic learning to clinical practice (20). While 360-degree videos offer a high degree of realism by featuring real people and settings, this approach also introduces limitations. Unlike fully interactive VR environments, 360-degree video restricts the ability of learners to interact with the environment or make choices within the scenario. As a result, students may observe OR dynamics but cannot practice decision-making or physical interactions as they would in a fully immersive, interactive VR setting. This trade-off between realism and interactivity is an important consideration for future iterations of this training method.

Future directions

The results of this study have the potential to enhance ongoing research and healthcare education initiatives aiming to integrate experiential learning via VR.

Additional validation could involve assessing the first-hand experiences of medical students who engage in dual VR, along with evaluating the impact of integrating this dual VR experience into the introductory course of medical students' first surgical clerkships. Future studies should also examine the scalability of VR experiences across different medical fields and training levels.

After further validation, this education could be utilized for Bachelor's and Master's students in Clinical Technology, as well as integrated into the Bachelor of Medicine curriculum for students receiving education in the OR during their studies. Subsequently, it could be made accessible to all hospital employees who spend time in the OR as part of their job duties. Moreover, this education could be offered through the corporate training learning management system.

Conclusion

Utilizing immersive VR technology enables the creation of an interactive and captivating virtual environment, providing learners with the opportunity to engage with simulated realities. In this particular case study, medical students can immerse themselves on a typi-

cal day in the OR, where they encounter explicit etiquette and implicitly learn about the hidden curriculum of the OR.

The logistical and hygienic challenges that hinder the transition from school desks to the work floor may be overcome by the use of VR programs, such as the one described in this case study.

The development of this dual VR experience entails meticulous attention to content creation and validation. The findings and insights presented herein contribute to the growing knowledge domain of educational VR development. They underscore the feasibility and potential of harnessing immersive technologies to cultivate engaging and impactful virtual experiences

Acknowledgements.

We thank all the healthcare providers, educators, and medical students who participated in the development of the VR experiences. In particular, we thank the Directorate of Education and Training of Leiden University.

Disclosure of Interests.

This research was subsidized by the Leiden Learning and Innovation Center. The authors have no further conflicts of interest to declare.

NOTES ON CONTRIBUTORS.

K. Hoek is a clinician specializing in education and communication within anesthesiology and intensive care and conducted this research. She was responsible for conceptualization, methodology, investigation, data curation, writing – original draft, writing – review & editing, visualization, and project administration.

M. van Velzen is an educationalist, clinical research coordinator, and assistant professor at the Department of Anaesthesiology of the Leiden University Medical Center. She contributed to validation, and supervision.

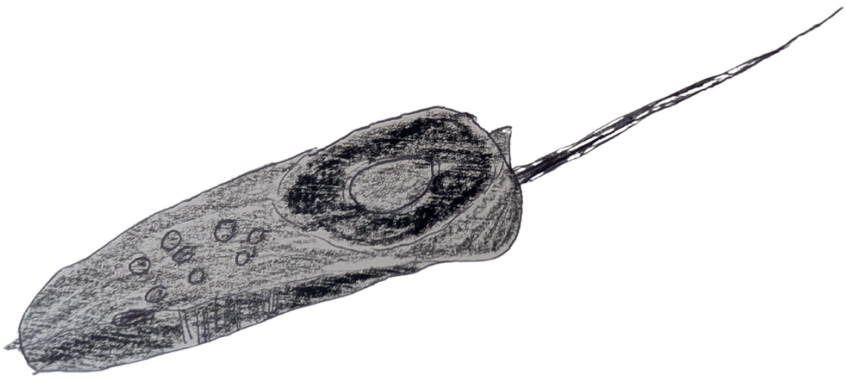
J. van der Hage is a professor of surgery, specializing in intracurricular education in surgery. He cosupervised the research and was responsible for validation, review & editing, and project administration.

E. Sarton is a Professor of Anaesthesiology specializing in education in medical training. She was responsible for supervision, and validation.

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Section V



Discussion and conclusion

V

Discussion and conclusion

SUMMARY PER SECTION

Section II – Communication in High-Stress Situations

This section examined whether and how immersive VR simulation can support the training of communication and teamwork skills in high-stress clinical situations, with a particular focus on CRM in anaesthesiology.

Across Chapters 1 and 2A–C, this section demonstrated that our VR-based simulation is feasible, acceptable, and educationally meaningful for training non-technical skills under pressure. Through a user-centered design process combined with failure modes and effects analysis, an adaptable, multiplayer VR scenario was developed that allowed real-time modulation of clinical parameters. This adaptability proved essential for aligning scenario complexity with cognitive load and learner needs, a limitation of many existing preset VR simulations.

Evaluation studies showed high engagement, perceived realism, and educational relevance, supporting outcomes at Kirkpatrick levels 1 and 2. Participants reported increased awareness of communication patterns, situational awareness, and team coordination during scenarios. However, this section also made clear that evidence for behavioural transfer to clinical practice (levels 3–4) remains limited at this stage. The work therefore positions VR not as a replacement for existing simulation modalities, but as a complementary approach with particular strengths in scalability, accessibility, and controlled exposure to high-stress situations.

Section III – Communication for Patient Comfort

This section focused on therapeutic communication as a mechanism for improving patient comfort and reducing preoperative anxiety, and explored whether patient-embodied VR experiences could enhance clinicians' sensitivity to the effects of language, tone, and non-verbal behaviour.

Across Chapters 3–6, the studies showed that good intentions alone are insufficient: communication subtly shapes patient experience through suggestion, expectation, and emotional framing. Patient-embodied VR enabled clinicians to experience clinical encounters from the patient's perspective, making the emotional impact of routine language and behaviour tangible rather than theoretical.

Qualitative findings consistently demonstrated increased awareness, reflection, and perceived behavioural change among healthcare professionals. Quantitative results showed modest but directionally positive effects on patient anxiety when VR-based experiences were embedded within a broader bundle of non-pharmacological interventions.

Importantly, divergence between qualitative and quantitative findings highlighted the complexity of capturing the impact of communication on patient outcomes.

This section therefore contributes not by claiming definitive clinical effects, but by showing that therapeutic communication is experientially learnable, while also being strongly shaped by context, timing, organisational constraints, and the nature of patient experience.

Section IV – Communication and Team Culture in the Operating Room

This section addressed communication as a social and cultural phenomenon within the operating room, with particular attention to non-verbal rapport, hierarchy, and the hidden curriculum encountered by trainees.

Chapter 7 demonstrated that key elements of rapport—such as gaze, posture, timing, and spatial positioning—are enacted implicitly in routine clinical practice and are rarely made explicit in training. These behaviours contribute to team cohesion, culture, and psychological safety, yet remain difficult to apprehend for novices.

Chapter 8 translated these insights into an educational intervention by developing VR-embodied experiences that externalised elements of the hidden curriculum for medical interns. By allowing learners to observe and reflect on OR dynamics from an embodied perspective, the intervention aimed to support sense-making during the transition into clinical practice.

Together, these studies showed that experiential and observational learning approaches can make team norms visible and discussable. The section acknowledged that such interventions still need further validation in order to study behavioural change, and improved onboarding of novices within hierarchical complex systems.

Bridging the Three Domains

This thesis demonstrates that immersive, embodied simulation can meaningfully strengthen communication training in healthcare by making implicit behaviours visible, enabling perspective-taking, and supporting behavioural change across multiple clinical settings. Across the three domains explored in Sections II, III, and IV we can observe that communication is not a set of isolated techniques but a relational, context-sensitive competence.

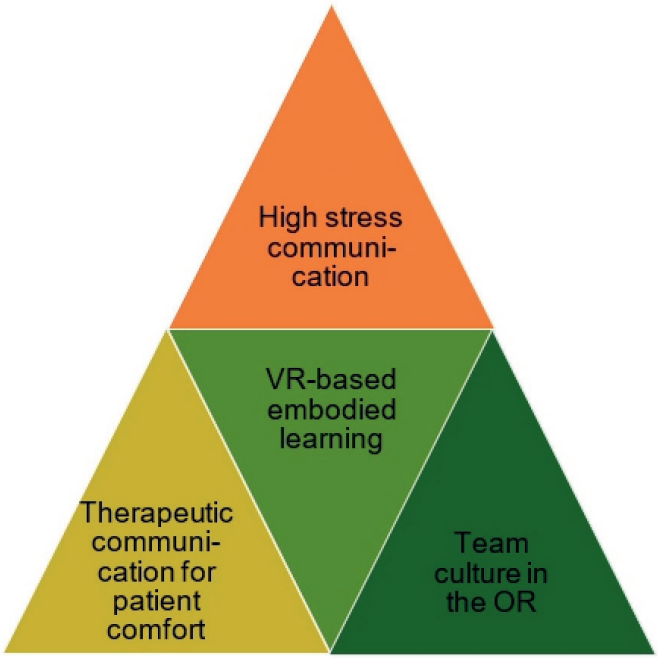


Figure 1. Visual aid with Triangle model outlining this thesis
Upper triangle: High stress communication in section II
Left triangle: TC for patient comfort in section III
Right triangle: Team culture in the OR in section IV
Middle triangle: overlapping theme VR-embodied learning

Figure 1 illustrates this integration through the Triangle Model developed in this thesis. Each vertex represents one communicative domain—high-stress communication (Section II), therapeutic communication for patient comfort (Section III), and team culture in the OR (Section IV)—while the overlapping centre reflects the shared mechanism: embodied VR learning. Together, these findings show that although the clinical settings differ, the educational principle is the same. Learners benefit when they can *feel* the consequences of their communicative choices. VR enabled clinicians to observe their own habits, experience their impact, and adjust behaviour in a controlled, reflective environment.

Thematic Integration of Findings

From design to relevance

Several chapters in this thesis (Chapters 2, 4, and 8) focused on the development of VR-based simulations and experiences. Across these cases, a consistent pattern emerged: end users clinicians, and educators, were actively involved, in the development process, the resulting tools in accordance with actual practice, adapted to learner needs, and more likely to be accepted.

Immersion leading to perspective

Across Chapters 2, 4–8, immersive experiences enabled perspective shifts: from clinician to patient, from actor to observer, from novice to insider. Patient-embodied VR exposed subtle elements such as tone, timing, status, and nonverbal cues that usually remain implicit. The *Proteus effect*, experiential learning theory, and emotional resonance all combined. Indeed, this was not a conceptual learning outcome; it was **felt**. The training sessions that followed, combining VR with clinical teaching, allowed this insight to be taken into practice.

From validation to implementation

The validation chapters provide important evidence that these VR experiences are not only feasible, but also educationally relevant using the Kirkpatrick model as a framework (**Figure 2**).

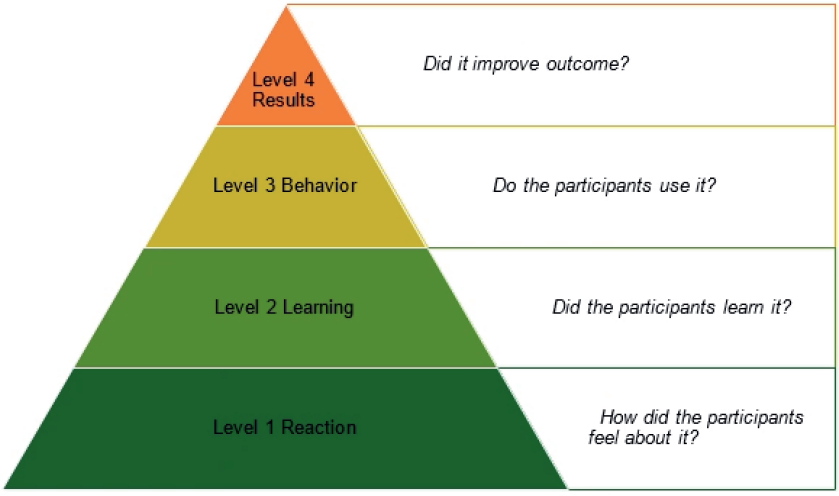


Figure 2. Kirkpatrick four-level training evaluation model

Educational and Clinical Implications

Figure 3 visualises the developmental stage of each tool within the Kirkpatrick framework, highlighting up to what level validation has advanced and where long-term effects remain to be studied. Together, these findings support a layered implementation model in which immersive experience is followed up by further validation and evaluation in clinical settings.

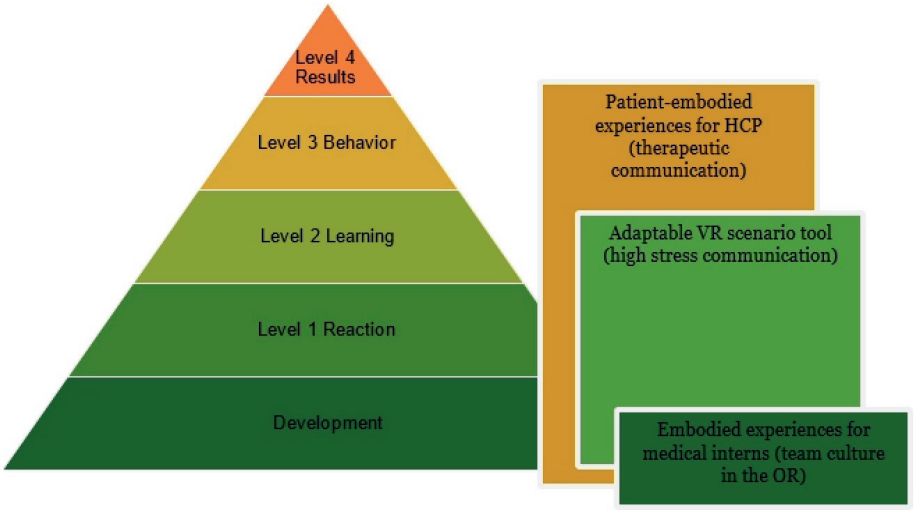


Figure 3. Progress of VR training tools across Kirkpatrick's levels within this

- **Level 1 (Reaction):** High engagement and perceived relevance in Chapter 2 (CRM training) and Chapter 4 (embodied TC experience).
- **Level 2 (Learning):** Increased awareness of communicative style in Chapter 4, perceived knowledge gains in Chapters 5 and 6.
- **Level 3 (Behaviour):** Observable changes in daily practice in acute admission settings (Chapter 5) and behavioural adjustments within a broader TC intervention bundle (Chapter 6).
- **Level 4 (Results):** Modest changes in patient anxiety (Chapter 6), indicating promising but not yet conclusive clinical impact.

Limitations

Limits of Embodied VR

While embodied VR proved effective in making implicit communicative processes visible and experientially accessible, this thesis also highlights important limits to what immersive simulation can represent and achieve. VR environments necessarily offer selective representations of clinical reality. They can evoke perspective-taking, emotional engagement, and heightened awareness, yet they only partially capture the complexity of real-world clinical practice and can never provide a complete picture. As a result, immersive experiences may foreground certain dimensions of communication while attenuating others. This selectivity should be acknowledged explicitly, as it constitutes an inherent limitation of any simulation-based approach.

Transfer, Hierarchy, and Context

Across the studies included in this thesis, increased awareness and perceived learning did not consistently translate into sustained behavioural change or demonstrable clinical outcomes. This limitation cannot be attributed solely to study design or evaluation level, but reflects broader structural characteristics of healthcare practice. Communication is enacted within existing hierarchical systems, time-pressured environments, and organisational cultures that may constrain the application of newly acquired insights.

In such contexts, heightened sensitivity to communication dynamics does not necessarily lead to behavioural change, particularly for learners or junior staff with limited positional power. Without organisational support long term, communicative awareness may remain latent or be selectively applied. These findings suggest that transfer should not be conceptualised as an individual learning outcome alone, but as a context-dependent process shaped by team culture, and implementation conditions. Consequently, the impact of immersive communication training is likely to depend as much on its integration within organisational structures as on the quality of the educational intervention itself.

FUTURE DIRECTIONS

Section II: Communication in High-Stress Situations

Building on the feasibility and early educational relevance demonstrated in this thesis, the next step for VR-based high-stress communication training is to clarify where VR adds value relative to the current gold standard of manikin-based simulation, and where it does not. Comparative work in other acute scenarios has already used randomized or quasi-experimental designs to contrast VR with high-fidelity manikin simulation, often finding feasibility and sometimes comparable performance, but also highlighting that equivalence cannot be assumed and may depend on the targeted outcome (1). In this

context, future studies should move from a general "does it work?" question to a more actionable one: which elements of CRM communication and teamwork are best developed in VR, and which require manikin-based or in-situ team training?

A particularly useful strategy is to map these outcomes onto Entrustable Professional Activities (EPAs) and evaluate whether specific EPAs (or EPA-components such as recognising deterioration, initiating escalation, closed-loop communication, leadership, and task prioritisation) show differential learning curves or transfer patterns across modalities (2). Early work using VR for EPA-aligned formative assessment and serious-game platforms with scoring algorithms suggests this is feasible, but also underscores the need for careful validity evidence if such scores are used beyond formative feedback.

For implementation, elements of faculty training need further development into VR-specific competencies: onboarding learners into immersive environments, managing cognitive load and simulator discomfort, using scenario adaptability deliberately, and conducting debriefings that connect in-VR actions to clinical reasoning and team behaviour. Recent work focusing specifically on immersive VR debriefing practice reinforces that these VR-specific teaching skills are a distinct requirement.

Finally, sustainable curricular integration will require an infrastructure layer that links VR sessions to competency-based education and supports longitudinal evaluation. This includes (1) alignment with EPA frameworks and local assessment systems, (2) mechanisms to store and retrieve performance for follow-up coaching, and (3) the responsible use of learning analytics. Emerging literature on "metaverse"/immersive simulation notes the growing availability of automated metrics and dashboards that can support formative feedback, but also emphasises that integration into high-stakes decisions remains limited and that human interpretation during debriefing is still essential. The most defensible near-term direction is therefore a hybrid assessment approach: a "virtual score" or performance trace that supports structured debriefing and progress tracking, combined with facilitator judgement and team-based reflection (1, 3, 4). Newer systems aimed at automated assessment of communication behaviours (e.g., closed-loop communication) show promise, but they strengthen—rather than replace—the case for rigorous validation, transparency about what is being measured, and clear boundaries around use (formative vs summative).

Section III: Communication for Patient Comfort

The findings in Section III suggest that patient-embodied VR is effective in increasing clinicians' awareness of the experiential impact of communication. Future research should therefore focus less on whether such awareness can be generated, and more on how it can be sustained and translated into routine clinical practice.

Future work should more explicitly address the contextual embedding of therapeutic communication. The modest and variable effects on patient anxiety observed in this thesis indicate that communication is strongly shaped by organisational routines, and the broader care environment. Studying patient-embodied VR as part of longitudinal or bundled interventions may therefore offer a more realistic basis for evaluating its impact.

From an educational perspective, patient-embodied VR may be best positioned as a tool for early sensitisation and reflective learning, rather than as a means of standardising behaviour. Future curricula should explore how such experiences can be integrated within competency-based training trajectories while acknowledging the relational and context-dependent nature of patient comfort and anxiety (5).

Section IV: Communication and Team Culture in the Operating Room

The findings in Section IV indicate that non-verbal rapport, hierarchy, and the hidden curriculum shape how team culture is learned and enacted in the operating room. Future research should therefore move from making these dynamics visible towards determining **whether and how immersive interventions can influence day-to-day team behaviours**, particularly those related to teamwork, speaking up, and psychological safety. Recent work suggests immersive training may affect observable teamwork or safety behaviours in OR settings, but generalisability and mechanisms remain to be clarified.

A key direction is to evaluate VR-embodied experiences as part of structured **onboarding and transition support**, where the educational goal is orientation and sense-making rather than immediate behavioural standardisation. This includes studying whether early exposure to implicit norms reduces uncertainty and improves participation during the first period of OR entry, and whether effects persist beyond the immediate training context.

Finally, implementation-focused research is needed to understand how such interventions can be integrated into existing educational and organisational structures. Also here, this includes faculty development for facilitation and debriefing, and evaluation approaches that can capture cultural change over time rather than only immediate learner reactions.

Closing Statement

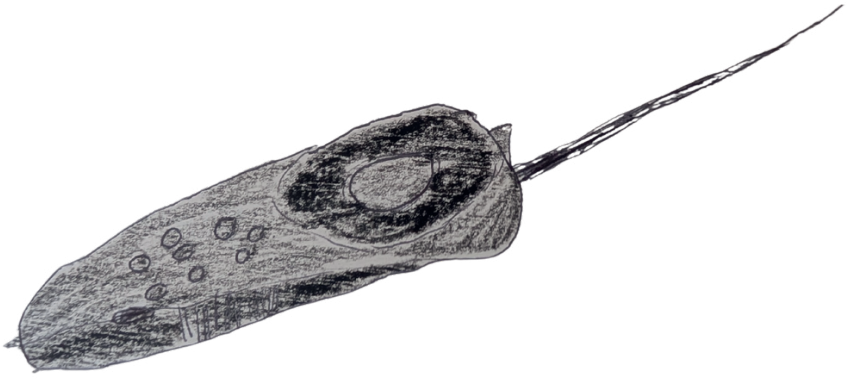
This thesis demonstrates that immersive, embodied simulation can be meaningful for communication training by making what is usually implicit visible, experiential, and open to reflection. It also shows that two constraints must be taken seriously: higher fidelity does not automatically lead to better learning, and transfer into clinical practice remains difficult within the sociotechnical reality of healthcare.

Within this thesis, substantial progress has been made in establishing feasibility and in understanding how these experiences are perceived and used as learning catalysts. At the same time, answering these questions has led to new ones. Some of these arise within the broader "why simulation works" paradigm, concerning which elements of embodied training matter most and under which conditions learning persists, and how can implementation be shaped to support real-world uptake? These questions now define the work that lies ahead if immersive communication training is to realise its promise beyond the training setting.

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Section VI



Portfolio

VI

Portfolio

OVERVIEW OF THE PHD TRAJECTORY

This PhD trajectory originated from a practical question arising from clinical practice: how therapeutic communication skills could be trained in a way that would be meaningful and acceptable within everyday healthcare settings. Rather than positioning communication training as a matter of opinion, the research focused on developing experiential approaches that could make the relevance of communication tangible and open to discussion.

The first project within this trajectory was the development of a patient-embodied virtual reality (VR) experience. During the same period, coinciding with the COVID-19 pandemic, limitations of traditional in-person simulation became apparent. This context led to the development and evaluation of VR-based simulation training for communication in high-stress situations (Section II).

Subsequent work addressed therapeutic communication and patient experience (Section III), including phenomenological and mixed-methods studies and the development of a therapeutic communication training programme in nursing education. In parallel, research was conducted on non-pharmacological interventions for preoperative anxiety.

The final phase of the PhD focused on communication as a relational and cultural phenomenon within the operating room (Section IV), including observational research on non-verbal rapport and the development of a VR experience exposing elements of the hidden curriculum for medical interns.

DISSEMINATION OF RESEARCH OUTPUT

Scientific articles

Year	Title	Journal / Conference	Type	Status
2025	From theory to practice: simulation in anaesthesiology through active learning experiences	IHCI	Conference paper	Published
2023	Therapeutic communication: a nursing educational program, study protocol	JMIR	Journal article	Published
2025	Beyond manikins: virtual simulation training in a post-COVID era	Medical Education	Journal article	Published
2025	Development of a real-time adaptable VR scenario training for anaesthesiology education	CSEDU	Conference paper	Published
2025	Evaluation of a VR simulation program: a mixed-method study	PEC Innovation	Journal article	Published
2024	Development of a patient-embodied experience, how and why?	CSEDU	Conference paper	Published
2024	A VR experience exposing the hidden curriculum of the operating room	IHCI	Conference paper	Published
2023	Response to comments on patient-embodied VR	Patient Education and Counseling	Letter / Response	Published
2023	Patient-embodied virtual reality as a learning tool for therapeutic communication skills among anaesthesiologists	Patient Education and Counseling	Journal article	Published
	A good intention does not suffice			Submitted
	Effects of a bundle of non-pharmacological interventions on preoperative anxiety			Submitted
	Non-verbal elements of rapport			Submitted

Scientific presentations

Year	Title	Conference	Type
2026	Immersive virtual reality for anaesthesia simulation training: a pilot study on presence, embodiment and user acceptance	EuroAnesthesia Rotterdam	Poster presentation
2026	Therapeutic communication, a nursing educational program, implementation and analysis on Kirkpatrick level 1 and 2	EuroAnesthesia Rotterdam	Poster presentation
2026	Effects of a bundle of non-pharmacological interventions on preoperative anxiety: a mixed methods study	EuroAnesthesia Rotterdam	Poster presentation
2026	Data, AI en VR, kennis voor nu en de volgende stap	NVA PhD dag, Utrecht	Presenter
2025	Preopative anxiety, so what?	NVA Wetenschapsdag Utrecht	Keynote speaker
2024	Nonverbal elements for rapport in the endoscopy department, a video ethnographic study	ICCH, Zaragoza	Pitch presentation (with Pitch award)

Year	Title	Conference	Type
2024	VR simulatie: hoe en waarom simulatie werkt	NVA dagen 2024, Maastricht	Presenter
2024	VR development for the OR, a UCD design	ESIC 2024, Milaan	Poster presentation
2023	VR, development of a patient-embodied experience	IAMSE 2023, Cancun	Poster presentation
2022	Comfort study, a PAR design	NVA Wetenschapsdag	Presentation
2022	VR, the development of a patient-embodied experience	NVA Wetenschapsdag	Presentation
2022	How VR can encompass empathy in the OR	ICCH, Glasgow	Artistic presentation

Courses and Training Activities

Year	Course	Institution	Hours / ECTS
2020	Responsible Research	Leiden University	42h
2020	Basic Methods and Reasoning in Biostatistics	Leiden University	42h
2020	Leiden Onboarding Programme	Leiden University	10h

Grants and Funding

Year	Grant	Funder	Role	Amount (€)
2022	VR equipment	ZonMw	Applicant	5000
2023	Virtual Reality Trainer voor Anesthesisten	TFF	Applicant	200.000
2025	Virtual Reality Trainer voor Anesthesisten 2.0	TFF	Applicant	200.000
2025	Gereedmaking operatiekamer	DUTCH Stichting	Co-applicant	500.000

Teaching and Supervision

During the PhD trajectory, I supervised Dutch medical students during *wetenschapsstages*, as well as bachelor and master students in social sciences (psychology, anthropology) and XR/VR development. Supervision activities included collaboration with the Saxion Extended Reality Lab, supporting student projects related to VR prototyping and user-centered design.

I also taught and facilitated simulation sessions and therapeutic communication training for healthcare professionals, reaching over 200 participants. In addition, themed weeks in the operating room focusing on comfort care were organised, contributing to interdisciplinary learning and practice development.

Chapter overview and authorship credits

Below is a listwise overview of all chapters included in the dissertation *Development and implementation of VR-simulated experience to train communication skills*, including verified DOI numbers where available, followed by a consolidated CRediT contribution table.

SECTION II – COMMUNICATION IN HIGH-STRESS SITUATIONS

Chapter 1

From theory to practice: simulation in anaesthesiology through active learning experiences

Type: Conference paper *Intelligent Human-Computer Interaction* 2024

Authors: Krista Hoek, Monique van Velzen, Elise Sarton
Status: Published
DOI: **10.1007/978-3-031-88705-5_3**

Chapter 2A

Beyond manikins: virtual simulation training in a post-COVID era

Type: article *Medical Education* 2025

Authors: Krista Hoek, Monique van Velzen, Elise Sarton
Status: Published
DOI: **10.1111/medu.15685**

Chapter 2B

Development of a real-time adaptable virtual reality scenario training for anaesthesiology education: a user-centered design

Type: conference paper International Conference on Computer Supported Education 2024

Authors: Krista Hoek, Christina Jaschinski, Elise Sarton
Status: Published
DOI: **10.5220/0012755600003693**

Chapter 2C

Evaluation of a VR simulation program: a mixed method study
Type: article *Patient Education and Counseling Innovation*

Authors: Krista Hoek, Monique van Velzen, Elise Sarton, Christina Jaschinski

Status: Published

DOI: **10.1016/j.pecinn.2025.100441**

SECTION III – COMMUNICATION FOR PATIENT COMFORT AND ANXIETY REDUCTION

Chapter 3

A good intention does not suffice
Author: Krista Hoek

Status: Submitted
DOI: *Not available (submitted)*

Chapter 4A

Patient-embodied virtual reality as a learning tool for therapeutic communication skills among anaesthesiologists: a phenomenological study
Type: article in *Patient Education and Counseling* (2023)

Authors: Krista Hoek, Monique van Velzen, Elise Sarton
Status: Published
DOI: **10.1016/j.pec.2023.107789**

Chapter 4B

Response to correspondence on patient-embodied virtual reality as a learning tool for therapeutic communication skills among anaesthesiologists
Type: response in *Patient Education and Counseling* (2023)

Authors: Krista Hoek, Monique van Velzen, Elise Sarton
Status: Published
DOI: **10.1016/j.pec.2023.107980**

Chapter 4C

Development of a patient-embodied experience: how and why?
Type: conference paper *Serious Games for Education 2o24*

Authors: Krista Hoek, Monique van Velzen, Elise Sarton
Status: Published
DOI: **10.5220/0012755800003693**

Chapter 5A

Therapeutic communication: a nursing educational program – study protocol of a mixed method design
Type: study protocol in *Journal of Medical Internet Research* (2025)

Authors: Krista Hoek, Louise Suur, Monique van Velzen, Elise Sarton
Status: Published
DOI: **10.2196/65795**

Chapter 5B

Therapeutic communication: a nursing educational program – implementation and analysis
Authors: Krista Hoek, Louise Suur, Monique van Velzen, Elise Sarton

Status: Submitted
DOI: *Not available (submitted)*

Chapter 6

Effects of a bundle of non-pharmacological interventions on preoperative anxiety: a mixed methods study
Authors: Krista Hoek, Rutger van der Schrier, Monique van Velzen, Elise Sarton

Status: Submitted
DOI: *Not available (submitted)*

SECTION IV – COMMUNICATION AND TEAM CULTURE IN THE OPERATING ROOM

Chapter 7

Non-verbal elements of rapport during endoscopic procedures

Authors: Krista Hoek, Monique van Velzen, Hannah van Zweeden, Jurjen Boonstra, Elise Sarton

Status preprint, submitted
DOI: **10.21203/rs.3.rs-4562058/v1**

Chapter 8

A VR experience exposing the hidden curriculum of the operating room: a case study

Type: conference paper International Conference on Computer Supported Education 2024

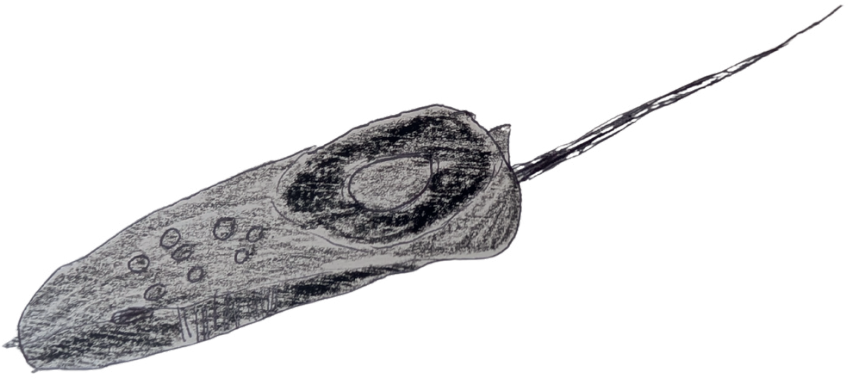
Authors: Krista Hoek, Christina Jaschinski, Monique van Velzen, Elise Sarton
Status: published
DOI: **10.1007/978-3-031-88705-5_1**

CRediT contribution table

Chapter	Conceptualization	Methodology	Software	Investigation	Data Curation	Formal Analysis	Writing – Original Draft	Writing – Review & Editing	Visualization	Project Administration	Funding Acquisition
Ch 1	✓	✓	✓	✓	–	–	✓	✓	✓	✓	✓
Ch 2A	✓	✓	✓	✓	–	–	✓	✓	✓	✓	✓
Ch 2B	✓	✓	✓	✓	–	–	✓	✓	✓	✓	✓
Ch 2C	✓	✓	–	✓	✓	✓	✓	✓	✓	✓	✓
Ch 3	✓	✓	–	–	–	–	✓	✓	–	✓	–
Ch 4A	✓	✓	–	✓	✓	✓	✓	✓	–	✓	–
Ch 4B	✓	–	–	–	–	–	✓	✓	–	✓	–
Ch 4C	✓	✓	✓	✓	–	–	✓	✓	✓	✓	–
Ch 5A	✓	✓	–	–	–	–	✓	✓	–	✓	–
Ch 5B	✓	✓	–	✓	✓	✓	✓	✓	–	✓	–
Ch 6	✓	✓	–	✓	✓	✓	✓	✓	–	✓	–
Ch 7	✓	✓	–	✓	✓	✓	✓	✓	–	✓	✓
Ch 8	✓	✓	✓	✓	–	–	✓	✓	✓	✓	–

Legend: ✓ = substantial contribution

Section VIII



Addenda

VII

Addenda

CURRICULUM VITAE

Krista Hoek was born on 11 July 1989 in Naarden, the Netherlands. She graduated from Vechtstede College in Weesp in 2006, after which she started her academic career in Paris at the medical school of the Sorbonne, Université Pierre et Marie Curie, in 2007. After completing her medical studies, Krista started her residency in Anaesthesiology in France, on Réunion Island, where she worked for one year. She continued her residency at Leiden University Medical Center. During this period, she became familiar with clinical research and started the PhD trajectory that resulted in this thesis.

In 2023, she started a fellowship in Intensive Care Medicine, which she completed in 2024. She subsequently worked as an anaesthesiologist at Leiden University Medical Center until 2025, the year she started working as an anaesthesiologist at Erasmus Medical Center, where she continues to work. She combines her clinical work as an anaesthesiologist with a research position at Leiden University Medical Center.

Krista joined the scientific committee of EuroXR in 2024 and the scientific committee of Dutch United Training Concepts for Healthcare in 2025.

Krista lives in Rotterdam and is married to Daniel. Together, they have three children: Saya, Nomi and Miya.

NEDERLANDSE SAMENVATTING

Communicatie is een essentieel onderdeel van veilige, effectieve en mensgerichte zorg. In de klinische praktijk bepaalt communicatie niet alleen hoe informatie wordt overgedragen, maar ook hoe patiënten veiligheid, vertrouwen, angst, pijn en comfort ervaren. Daarnaast beïnvloedt communicatie hoe zorgteams samenwerken, beslissingen nemen en omgaan met druk, onzekerheid en hiërarchie. De manier van communicatie kan hierbij directe gevolgen hebben voor patiëntveiligheid, patiëntbeleving en teamfunctioneren.

Toch worden veel communicatieve vaardigheden in de zorg nog beperkt expliciet onderwezen. Een aanzienlijk deel van professioneel communicatiegedrag wordt impliciet aangeleerd: door observatie, routines, voorbeeldgedrag en de cultuur van de werkvloer. Daardoor blijven belangrijke aspecten van communicatie, zoals toon, timing, lichaamshouding, non-verbale afstemming, teamnormen en machtsverhoudingen vaak onzichtbaar. Dit proefschrift vertrekt vanuit de gedachte dat communicatie niet alleen een individuele vaardigheid is, maar een relationele en contextafhankelijke competentie die ontstaat tussen mensen, binnen systemen en onder invloed van klinische cultuur.

Dit proefschrift onderzoekt hoe virtual reality (VR), simulatie en embodied experiences kunnen worden ontwikkeld en ingezet om communicatievaardigheden in de zorg te trainen. De nadruk ligt daarbij niet op VR als technologie op zichzelf, maar op de vraag hoe immersive en ervaringsgerichte leeromgevingen kunnen bijdragen aan bewustwording, reflectie en mogelijk gedragsverandering. De centrale gedachte is dat communicatie niet alleen cognitief begrepen moet worden, maar ook ervaren, herkend en besproken moet kunnen worden.

Het proefschrift is opgebouwd rond drie domeinen: communicatie in hoog-stress klinische situaties, therapeutische communicatie voor patiëntencomfort, en communicatie en teamcultuur in de operatiekamer. Binnen drie secties worden acht hoofdstukken gepresenteerd, waarin telkens een ander aspect van communicatie onderwijs, VR-ontwikkeling, validatie of implementatie centraal staat.

Het eerste domein betreft communicatie in hoog-stressituaties binnen de anesthesiologie. In acute perioperatieve situaties zijn technische vaardigheden onmisbaar, maar veilig handelen hangt ook af van situational awareness, besluitvorming, leiderschap, taakverdeling en teamcommunicatie, oftewel human factor skills. Hoofdstuk 1 schetst de onderwijskundige en klinische achtergrond van simulatieonderwijs binnen de anesthesiologie. Het hoofdstuk laat zien dat simulatie niet primair een technologie is, maar een onderwijsmethode waarmee zorgverleners in een veilige omgeving technische en niet-technische vaardigheden kunnen oefenen. Daarbij wordt pop simulatie vergeleken

met VR-simulatie, met aandacht voor realisme, cognitieve belasting, debriefing, schaalbaarheid en praktische uitvoerbaarheid.

Hoofdstukken 2A, 2B en 2C bouwen hierop voort door de ontwikkeling en eerste validatie van een VR-simulatie voor anesthesie training te beschrijven. Binnen deze hoofdstukken werd onderzocht of een adaptieve multiplayer VR-simulatie een aanvullende rol kan spelen in het trainen van crisis resource management (CRM) en communicatie onder druk. De VR-simulatie werd ontwikkeld via een user-centered design-proces, gecombineerd met analyse van mogelijke fouten en risico's. Een belangrijk ontwerpprincipe was dat de trainer het scenario moest kunnen aanpassen aan het niveau en gedrag van de deelnemers, bijvoorbeeld door klinische parameters tijdens het scenario te veranderen. Deze adaptiviteit is relevant omdat een te eenvoudig scenario onvoldoende meerwaarde heeft, terwijl een te complex scenario kan leiden tot cognitieve overbelasting. De introductie beschrijft deze ontwikkeling als een multiplayer, scenario-adaptief VR-systeem voor anesthesiologie, ontwikkeld via een user-centered proces en onderzocht met kwalitatieve en kwantitatieve methoden. De evaluaties in Section II lieten zien dat deze vorm van VR-simulatie haalbaar, acceptabel en educatief relevant is. Deelnemers ervaren de scenario's als betekenisvol en herkenden elementen uit de klinische praktijk. Zij rapporteren meer bewustzijn van communicatiepatronen, taakverdeling, team coördinatie en besluitvorming onder druk. Tegelijkertijd laten deze hoofdstukken vooral vroege onderwijsuitkomsten zien, zoals tevredenheid, ervaren relevantie en zelfgerapporteerd leren. In termen van het Kirkpatrick-model bevinden de sterkste resultaten zich vooral op niveau 1 en 2: reactie en leren. Er is nog onvoldoende bewijs dat deze VR-training op zichzelf leidt tot duurzame gedragsverandering in de klinische praktijk of tot betere patiëntuitkomsten. VR moet daarom niet worden gezien als vervanging van bestaande simulatie vormen, maar als een aanvullende onderwijsvorm met specifieke voordelen op het gebied van schaalbaarheid, herhaalbaarheid en gecontroleerde blootstelling aan complexe scenario's.

Het tweede domein richt zich op therapeutische communicatie voor patiëntencomfort en het verminderen van angst. Medische handelingen, ziekenhuisopname en operaties kunnen voor patiënten gepaard gaan met spanning, onzekerheid en verlies van controle. In zulke situaties kunnen woorden, toon, houding en non-verbaal gedrag van zorgverleners de patiëntbeleving versterken of verzachten. Hoofdstuk 3 introduceert de kernboodschap van deze sectie: goede intenties zijn niet voldoende. Communicatie heeft effect, ook wanneer dat effect niet bewust wordt nagestreefd. Verbale en non-verbale communicatie kan verwachtingen, angst, pijnbeleving en vertrouwen beïnvloeden.

Hoofdstukken 4A, 4B en 4C onderzoeken vervolgens de ontwikkeling, validatie en toepassing van patient-embodied VR om bewustwording van therapeutische communicatie te vergroten. In deze ervaringen kijkt de zorgverlener niet naar een patiënt, maar

ervaart hij of zij een klinische situatie vanuit het perspectief van de patiënt. Hierdoor wordt voelbaar hoe taal, toon, tempo, aanraking, aandacht en afwezigheid van aandacht kunnen binnenkomen bij iemand die afhankelijk is van zorg. Deze perspectiefwisseling maakt de emotionele impact van alledaagse communicatie concreter dan theoretische uitleg alleen. De studies binnen deze hoofdstukken lieten zien dat patient-embodied VR kan bijdragen aan bewustwording, empathie en reflectie bij zorgverleners. Deelnemers herkenden eigen communicatie gewoonten en gaven aan bewuster te willen omgaan met taalgebruik, non-verbaal gedrag en de manier waarop zij patiënten voorbereiden op medische handelingen.

Hoofdstukken 5A en 5B verplaatsen deze inzichten naar de klinische onderwijspraktijk. In deze hoofdstukken wordt een blended therapeutische communicatietraining voor verpleegkundigen op een acute opnameafdeling beschreven en geëvalueerd. De training combineerde e-learning, een patient-embodied VR-ervaring en een didactische trainingsdag met ervaringsgerichte oefeningen. De kwalitatieve bevindingen wezen op ervaren gedragsverandering en meer aandacht voor patiënt comfort in de dagelijkse praktijk. Daarmee laten deze hoofdstukken zien dat therapeutische communicatie niet alleen als concept onderwezen kan worden, maar ook ingebed kan worden in een praktische training voor zorgverleners.

Hoofdstuk 6 onderzoekt vervolgens de toepassing van deze trainingsvorm binnen een bredere interventiebundel in de preoperatieve holding. Deze bundel bestond uit therapeutische communicatietraining voor zorgverleners en niet-farmacologische interventies voor patiënten, waaronder VR en muziek. Het doel was om preoperatieve angst en patiënt comfort te beïnvloeden. De kwantitatieve resultaten lieten bescheiden en niet eenduidige effecten zien, terwijl de kwalitatieve resultaten wel een positieve invloed op werkomgeving en patiëntbeleving suggereerden. Deze discrepantie is belangrijk, omdat zij laat zien dat de impact van communicatie moeilijk te vangen is in één uitkomstmaat. Communicatie werkt in interactie met context, timing, werkdruk, patiëntkenmerken, organisatorische randvoorwaarden en de bredere cultuur van zorg. Dit proefschrift claimt daarom niet dat VR-gebaseerde training op zichzelf angst van patiënten aantoonbaar vermindert, maar laat zien dat therapeutische communicatie ervaringsgericht trainbaar is en dat patient-embodied VR een krachtige ingang kan bieden voor bewustwording en reflectie.

Het derde domein betreft communicatie en teamcultuur in de operatiekamer. De operatiekamer is een complexe en hiërarchische omgeving waarin verschillende disciplines nauw samenwerken onder tijdsdruk. Communicatie bestaat daar niet alleen uit gesproken taal, maar ook uit blikken, stilte, lichaamshouding, ruimtelijke positionering, aanraking, routines en impliciete verwachtingen. Juist deze subtiele vormen van com-

municatie dragen bij aan samenwerking, vertrouwen, veiligheid en het gevoel ergens bij te horen.

Hoofdstuk 7 onderzoekt daarom de non-verbale elementen van rapport in de operatiekamer en klinische praktijk. Met een video-etnografische benadering werd zichtbaar hoe zorgverleners door oogcontact, houding, afstand, timing en fysieke nabijheid afstemming creëren met patiënten en collega's. Zulke gedragingen lijken klein, maar kunnen grote betekenis hebben voor comfort, vertrouwen, teamcohesie en psychologische veiligheid.

Hoofdstuk 8 beschrijft de ontwikkeling van VR-embodied ervaringen voor medische studenten en jonge artsen die de operatiekamer betreden. Het doel was niet om één juiste manier van communiceren voor te schrijven, maar om studenten en jonge artsen te helpen herkennen welke normen, hiërarchieën en verwachtingen aanwezig zijn in de klinische omgeving. Door de operatiekamer vanuit dit perspectief te ervaren, kunnen impliciete teamdynamieken zichtbaar en bespreekbaar worden gemaakt. Daarmee biedt VR een mogelijkheid om het onuitgesproke in de klinische cultuur onderdeel te maken van onderwijs en begeleiding.

Over de drie domeinen heen laat dit proefschrift zien dat communicatie geen losse technische vaardigheid is, maar een klinische, relationele en culturele competentie. Communicatie ontstaat tussen mensen, binnen systemen, onder invloed van rollen, emoties, tijdsdruk, hiërarchie en professionele normen. VR kan hierin een waardevolle rol spelen omdat het situaties niet alleen kan tonen, maar ook kan laten ervaren. Het maakt perspectiefwisseling mogelijk: van zorgverlener naar patiënt, van teamlid naar observator, en van buitenstaander naar deelnemer. Hierdoor kunnen aspecten van communicatie die normaal impliciet blijven, zichtbaar, voelbaar en bespreekbaar worden.

De integratie tussen de hoofdstukken wordt zichtbaar in het driehoeksmodel van dit proefschrift. Daarin vormen high-stress communication, therapeutische communicatie voor patiëntencomfort en teamcultuur in de operatiekamer de drie domeinen, terwijl VR-based embodied learning het overkoepelende mechanisme vormt. Vanuit die gedachte laten Hoofdstukken 2, 4 en 8 vooral zien hoe VR-gebaseerde leeromgevingen ontwikkeld kunnen worden; Hoofdstukken 4 tot en met 8 laten zien hoe immersive ervaringen perspectiefwisseling kunnen ondersteunen; en Hoofdstukken 5 en 6 laten zien wat er gebeurt wanneer deze ervaringen worden ingebed in klinische trainings- en implementatiecontexten.

De belangrijkste bijdrage van dit proefschrift is daarom niet de conclusie dat VR beter is dan bestaande onderwijsvormen. De bijdrage ligt in het laten zien hoe VR en embodied learning kunnen worden ingezet als katalysator voor bewustwording, reflectie en gesprek over communicatie.

Tegelijkertijd vraagt de inzet van VR om kritische nuance. Meer realisme leidt niet automatisch tot beter leren. Een VR-ervaring blijft altijd een ontworpen selectie van de werkelijkheid en kan nooit de volledige complexiteit van de klinische praktijk vangen. Bovendien is transfer naar dagelijks gedrag moeilijk. Toekomstige studies moeten daarom niet alleen vragen óf VR werkt, maar vooral voor welk leerdoel, bij welke doelgroep, onder welke omstandigheden en met welke vorm van begeleiding, debriefing en implementatie.

Samenvattend toont dit proefschrift aan dat VR-simulaties en embodied experiences waardevolle middelen kunnen zijn om communicatieonderwijs in de zorg te verdiepen. De hoofdstukken laten gezamenlijk zien dat VR krachtig kan zijn als onderdeel van een bredere onderwijs- en implementatiestrategie. VR maakt zichtbaar wat vaak impliciet blijft, versterkt perspectiefwisseling en biedt ruimte om communicatie niet alleen als vaardigheid, maar als onderdeel van professionele cultuur en patiëntgerichte zorg te benaderen. Daarmee draagt dit proefschrift bij aan de verdere ontwikkeling van medisch onderwijs waarin zorgverleners niet alleen leren wat zij moeten zeggen of doen, maar ook leren begrijpen wat hun communicatie teweegbrengt.

ACKNOWLEDGEMENTS

Firstly, I would like to thank all my colleagues, doctors and nurses, hospital managers, co-authors and colleagues for giving me the opportunity to start up my research and training. Thank you for visiting the comfort weeks, for developing VR-experiences together, for letting me conduct interviews and for listening to me during my scientific presentations.

To all the patients who participated in our studies, thank you for your contribution.

A big thank you to all my interns from psychology, medical anthropology, medical school, and applied sciences. It was a pleasure having you around, and our journey together has taught me so much.

Elise.Thank you for showing up so many times for my presentations (abroad), I don't think many researchers have had a promoter who held their baby in a conference abroad while they were presenting a study.

A huge thank you to Monique, an incredible source of guidance throughout the journey and chapters. I know this thesis would not have happened without you.

A special thank you to Albert, who saw potential in me from the start, insinuating after my first 'Journal Club' as first-year resident, I should start research; thank you for showing a belief in me as a researcher in those early days.

Another special thanks to Saidja, who has had the challenging job of finding a new equilibrium for several research lines. It is one thing to have people help you start, it's another thing to have someone who enables research to continue after the completion of a PhD.

To my family and friends, thank you for your constant support and for the persistent, and often humorous, inquiries about when I would finally complete my studies. To my parents, who have always tried to understand the nature of my work— fully understood or somewhat simulated —your pride means the world to me. I hope that this thesis (or at least the summary) will help clarify what I've been dedicated to over these past years.

To my dear Matthanja and Leaf: thank you for supporting me through the final hurdles.

A special thanks to my beautiful daughters, who have waited for me during holidays, weekends and free time when I needed to finish a manuscript or assist a digital meeting. Thank you for testing the VR-goggles to be kid-proof and thank you for showing me that work is never more important than family life. Your presence has taught me the art of prioritization and multitasking, and I am grateful for the joy and balance you bring to my life.

And finally, to Daniel—thank you, in every step of this journey.



Financial support for the publication of this thesis was provided by

Immersive Tech Week

Tech For Future

