Jun 25th, 9:00 AM

Potential benefits of designing immersive technologies to reduce anxiety in the perioperative patient journey

Nikou Javadi
University of South Australia, Australia

Ian Gwilt
University of South Australia, Australia

Aaron Davis
University of South Australia, Australia

Citation

Javadi, N., Gwilt, I., and Davis, A. (2022) Potential benefits of designing immersive technologies to reduce anxiety in the perioperative patient journey, in Lockton, D., Lenzi, S., Hekkert, P., Oak, A., Sádaba, J., Lloyd, P. (eds.), *DRS2022: Bilbao*, 25 June - 3 July, Bilbao, Spain. https://doi.org/10.21606/drs.2022.491

DRS 2022
Bilbao 25th June — 3rd July

Potential benefits of designing Immersive technologies to reduce anxiety in the perioperative patient journey

Nikou Javadi[a*], Ian Gwilt[a], Aaron Davis[a]

[a]University of South Australia, Adelaide, Australia

*Corresponding e-mail: javny002@mymail.unisa.edu.au

doi.org/10.21606/drs.2022.491

Abstract: This research investigates if virtual and augmented reality (VR/AR) technologies can be used to help people cope with the anxiety associated with a surgical procedure in the patient health care journey. Perioperative anxiety is a natural response to surgery stress which may happen at any point before or after a surgical procedure. Research has shown that high level of perioperative anxiety are a potential health and recovery threat for a patient due to the effects on psychologic and physiologic responses. The concept of Digital Health is increasingly playing a more substantial role in health care provision and there is a body of research showing that technology-based therapeutic tools can play an effective, acceptable, and cost-effective role in many aspects of health care delivery. Through a series of multistakeholder engagement activities, this research aims to devising a set of guiding principles and practices for the design and application of AR/VR interventions in the clinical setting. This paper presents the findings from a Policy Delphi study, conducted with healthcare professionals working in perioperative environments.

Keywords: perioperative anxiety; digital health; patient experience; user centered design

1. Introduction

Digital health is an emerging area of practice that explores how digital technologies can be used to enhance and extend the care that is provided to patients. There are many ways to define digital health, but key features of these definitions often propose that the digital health should empower patients to be more in control of their healthcare journey (Mesko et al., 2017; Kostkova, 2015), and that digital health can increase the scale and reach of healthcare interventions, supporting more people to receive a higher standard of care with less resources (Murray et al., 2016).

One of the key areas of interest that will be explored in this paper is how digital technologies can be used to improve patient outcomes by reducing their levels of stress and anxiety as they move through the healthcare system. In particular, the paper explores how immersive

technologies such as Virtual Reality (VR) and Augmented Reality (AR) can be applied in the surgical journey to reduce stress and anxiety in pre- and post-surgery environments.

In 2014, Marsch and Gustafson speculated on the opportunities that VR and AR may have in this area of practice (Marsch & Gustafson, 2014), and recent experimental research has found these technologies to be very effective in healthcare treatments (D'Alessandro et al., 2020; Olbrecht et al., 2020). For instance, AR-based serious game was used by Botella and colleagues (2017) in a mobile device for the purpose of facilitating exposure treatment. In other study Baus and Bouchard (2014) explored the role of AR and VR technologies in experimental learning in the treatment of different kind of phobias. However, this research does not specifically look at the use of these technologies in addressing perioperative stress. In this paper, we unpack some of the key psychological mechanisms associated with both triggering and overcoming perioperative anxiety before presenting the findings from a Policy Delphi study that has generated a series of qualitative insights from clinicians working in these environments.

2. Perioperative anxiety

Anxiety is defined as a feeling of unease, worry, fear, tension, and apprehension. It is a response to external or internal stimuli that can have behavioral, emotional, cognitive, and physical symptoms (Mulugeta et al., 2018). The perioperative period is one of the stressful periods for most surgical patients and can often triggers emotional, cognitive and physiological responses. Perioperative anxiety refers to patient reactions in respect to disease, hospitalisation, the planned use of anaesthesia, surgery, and the unknown in general (Bedaso & Ayalew, 2019). Moreover, anticipating an operation can bring about high levels of anxiety at any point before and after surgical procedure, regardless of the type and severity of the surgery itself. Pritchard (2009) estimates that between 60 and 80 per cent of adult patients experiences some level of heightened anxiety as part of a surgical journey.

Perioperative anxiety is an important issue because it can lead to a range of adverse patient outcomes, including greater anaesthetic requirements, postoperative pain, longer for wounds to heal, psychological distress and lower surgical satisfaction (Gonzalez-Lemonnier et al., 2010; Gras et al., 2010; Munafo and Stevenson, 2001; Timberlake et al., 1997). Caumo et al. (2004) assert that perioperative anxiety increases the chances of moderate-to intense pain and postoperative anxiety by three times. Advantages that are associated with the management of perioperative anxiety include better recovery, reduced need for drugs for anaesthesia, higher pain tolerance, and reduced hospital stay. All these factors lead to the reduction of the total cost and complications of post-operation period (Babashahi et al. 2010).

The severity of the anxiety can vary significantly between patients, and is often associated with sociodemographic factors, psychosocial factors, the specific type of surgery, the possible complications of the operation, the method of anaesthesia, and the provision and

recall of preoperative information (Pritchard, 2009; Mitchell, 2005; Jun & Lee, 2017; Nigussie, 2014).

Within this, there are three primary psychological constructs that have been associated with perioperative anxiety:

- the fear of the unknown
- the idea of being sick, and
- the possibility of life-ending (Pritchard, 2009; Mitchell, 2005; Jun & Lee, 2017; Nigussie, 2014).

The fear of the unknown is a particularly interesting area when considering the potential applications of VR or AR interventions because patients having the surgery for the first time record higher levels of anxiety as compared to those who have been operated before (Caumo, 2004).

Within the category of 'having surgery' there are many different experiences and types of processes that occur. There are also a series of key triggers for phobias that are associated with healthcare that are summarized in Table 1 below.

Table 1. Psychological conditions that may be triggered along the surgical journey. Adapted from McLenon & Rogers, 2019; Akinsulore et al., 2015; Schmid et al., 2009).

Phobia	**Description**
Nosocomephobia	Hospital-related fear and anxiety
Tomophobia	Fear of undergoing a surgical or other invasive medical procedure
Claustrophobia	Fear of being in an enclosed space
Trypanophobia	Fear of needles
Iatrophobia	Fear of doctors
Mysophobia	Fear of germs
Hemophobia	Fear of blood
Thanatophobia	Fear of death
Hypochondriasi	Fear that psychical symptoms are related to underlying health issues

The lifetime prevalence of tomophobia (the fear of undergoing a surgical or other invasive medical procedure) is estimated at 12.8 per cent (Schmid et al., 2009). With 2.7 million

surgical procedures occurring in Australia each year (AIHW, 2019), approximately 340 000 Australians are likely to experience tomophobia each year.

Several strategies and techniques have been used to manage perioperative stress and anxiety, including pharmacological and non-pharmacological methods (Lopez-Yufera et al. 2020; Bandelow et al., 2017). The non-pharmacological methods are differentiated into five categories: psychological, physical, nutritional, digital, and elemental health interventions (Marcia et al., 2021, Aytekin et al., 2016). VR and AR have been shown to be an effective intervention to alleviate perioperative anxiety and pain in adults (D'Alessandro et al., 2020; Olbrecht et al., 2020). These technologies, fit within the digital category of intervention, but there may be opportunities for these technologies to facilitate psychological intervention.

3. Digital health and VR/AR

In simple terms VR and AR, refers to technologies that aim to extend an individual's sensory environment by emulating or simulating aspects of our physical reality through the use of digital technologies (Alqudimat et al., 2021). VR transposes users to an alternative setting and or a fully digital three-dimensional visualization, which creates a sense of immersion by allowing them to interact with the virtual environment (Logan et al., 2020). AR enhances an existing physical environment with additional virtual objects embedded in that space (i.e., by adding additional digital information layers) (Khor et al., 2016).

The development of VR and AR technologies has led to the possibility of integrating virtual and physical objects in a range of ways (Flavian & Orus, 2019). Wearable and portable devices have also strengthened the link between virtual and physical environments (and where we might experience a mix of both) and helps to create digital / physical hybrid experience (Ometov et al. 2021). Critically, this hybrid experience can be an active means of communication rather than a passive or observational experience (Riva, 2016).

The development of active engagement through VR or AR provides opportunities for these systems to be integrated into the psychological interventions that are used to treat perioperative anxiety such as the dissemination of or exposure to information. In the healthcare context, this is often referred to as 'personal change' and sits within a broad literature of psychological tactics for behaviour change. Interventions that trigger this 'personal change' can play an adaptive role in the management of symptoms that are associated with anxiety and distress (Riva et al., 2016; Higginson, & Mansell, 2008). For example, AR exposure-based therapy (ARET) and VR exposure therapy (VRET) are recognized therapeutic approaches for overcoming irrational behaviours (Baus & Bouchard, 2014; Wrzesien et al., 2015). Beyond their use in clinical settings, AR and VR are also used in the medical and health fields for education and training, medical database visualization, surgical simulation, psychotherapy, neurological rehabilitation, design for healthcare facilities, and telemedicine (Riva, 2015; Yeung et al., 2021; Cerritelli et al., 2021; Cortés-Pérez et al., 2021; Schiza et al., 2019; Baniasadi & Mohammadzadeh, 2020; Ong et al., 2021).

Although literature has been published on the potential of VR and AR in psychological interventions in some areas (such as those described above), there is limited literature on the use of VR and AR technologies in the reduction of perioperative period anxiety in adults. With an increasing focus patient-centred approaches in healthcare, and the demonstrated willingness to integrate digital technologies into healthcare, AR and VR technologies appear to present a unique and well-timed opportunity to create proactive psychologically driven interventions in the perioperative experience, increasing the personalization, safety, and quality of healthcare services (Alqudimat et al., 2021; Vles et al., 2020; Riva, 2014; Spoto et al., 2016).

4. Immersive technologies as a 'change' agent

There are a wide range of behaviour change theories that operate at different levels of psychological complexity. These range from the Theory of Planned Behaviour (Ajzen 1991) based on a pattern of antecedent, behaviour and consequence, to socially and culturally embedded models of Social Practice Theory (Shove et al., 2012), and more nuanced habit-based approaches such as the Transtheoretical Model of Behaviour Change (Prochaska & DiClemente 1986). While these forms of change are often predicated on a past (bad) state and a future (good) state, the use of immersive technologies in supporting positive experiences of healthcare journeys does not fit neatly into any of these frameworks. Instead, the research to date has focused primarily on a concept of 'personal change' (Riva et al., 2016).

Personal Change relates to how people cope with events that are outside of the scope of their typical experience, and can include events such as moving house, changing school or workplace, or breaking up with a partner (Riva et al., 2016). The primary focus of Personal Change is a change in one's conceptual system that is developed from the perceptions one has of their own experiences, behaviour, or other information (Higginson and Mansell, 2008). Personal Change is an important psychological concept in understanding the management of symptoms of distress that can be associated with the traumatic events, and importantly, the ability to undertake Personal Change can be linked to broader psychological well-being (Cohen & Sherman 2014; Kottler, 2014).

Approaches to build capacity to cope with Personal Change are being developed within clinical psychology, however, there is not yet a clear understanding of the psychological mechanisms that enable Personal Change, and there is little consistency in the findings from different therapeutic approaches (Chicchi et al., 2015; Van Krevelen & Poelman 2010; Hugues, Fuchs & Nannipieri, 2011).

Many people successfully negotiate Personal Change without the help of psychotherapeutic treatment, and recent advances in neuroscience and psychology are now enabling a better perspective of Personal Change that may offer insights into how VR and AR technologies could play a supportive role. In neuroscience, the brain is understood as creating an embodied simulation of the body in the world to represent and predict actions, concepts

and emotions (Riva & Mantovani, 2019). AR and VR work in a similar way and promise a plethora of experiences to people who engage in them, both positive and negative. A simple seated experience of AR or VR can trigger excitement or fear, but when combined with other physical acts, such as when deployed in partnership with exercise or meditation, these technologies can create more complex experiences. Examples from the literature include using AR or VR in training and skill development, in deep relaxation practices, or for the general support of well-being (Georgiev et.al. 2012; Lambrakopoulos et.al. 2017; Vazquez et.al. 2018; Schutte et.al. 2017). As an extension to this, Singh and colleagues (2018) argue that AR and VR may help healthy individuals to redesign themselves in view of achieving a much more meaningful, purposeful, and exciting life.

Regardless of the context of their deployment, immersive technologies have the potential for supporting Personal Change alongside the kinds of clinical changes described in the previous section (Riva et al., 2016). Specifically, both VR and AR can transform our external experience by increasing personal efficacy and self-reflectiveness through a sense of presence and emotional engagement (Bandura, 2006). In further examining the elements that might impact upon the effectiveness of VR and AR interventions in helping people to reduce perioperative anxiety, there are three key elements that can be extracted from the literature on Personal Change that may be instructive for practitioners in this space.

- First, the process of change requires *self-reflectiveness*: an intense focus on the particular instance or experience creating the conflict (Wolfe, 2002). By focusing on this experience as much as possible, the individual can relive and identify any significant element (e.g., conceptual, behavioural, emotional, and motivational) facilitating its reorganization (Riva, 2014).
- Second, the process of change requires *personal efficacy* (Bandura, 2001; Bandura, 2006): individuals have to believe that they have the power to effect changes through their actions. Without it there, they are not willing to act or to keep on acting in the face of problems and difficulties.
- Finally, the process of change can be dramatically boosted by *transformative experiences* (Riva et al., 2016; Gianakis & Carey, 2011), forcing individuals to critically examine and eventually revise their core assumptions and beliefs.

Available literature on VR and AR technologies in addressing the anxiety issues support the value of these technologies as experiential learning tool and simulative tool for controlled exposure to critical/fearful situations. However, there is not yet clarity within the literature as to whether these elements should be addressed through the simulation potential of VR and AR to undertake the kinds of exposure therapies described previously, using the experiential learning possibilities to address these issues through a more abstract mechanism, or indeed some combination of both.

5. Methodology and methods

This paper presents the findings from an early stage of an ongoing research project that is seeking to co-design a VR or AR intervention that can be tested in perioperative environments. The research uses a qualitative methodology to explore the priorities for the design of VR or AR interventions in reducing anxiety in perioperative experiences. A qualitative approach is effective in seeking an understanding of the underlying relationship between the variables and an explanation of the observations (Austin & Sutton, 2014). Qualitative research includes methods that are used on the qualification of data in relation to seeking explanations for certain phenomena and observations (Aspers & Corte, 2019). Research methods that fall under the qualitative approach to research enhance development of insight by focusing on meanings, identities, and experiences (Austin & Sutton, 2014).

The work that is presented here is the second stage of the larger project (see Figure 1) and is based on a Policy Delphi study (Keeney et al., 2011). This stage of the research collected insights from an expert group of anaesthetists which is being used as the basis for engaging with end-users of the system (people with recent lived experience of a surgical procedure). The study design uses the Policy Delphi process to inform the framing of the co-design workshops with patients. This is seen as an important way of ensuring the co-design workshops are narrow enough in focus to respond to potential areas for innovation that had been identified by professional participants and build upon the first stage of the Policy Delphi.

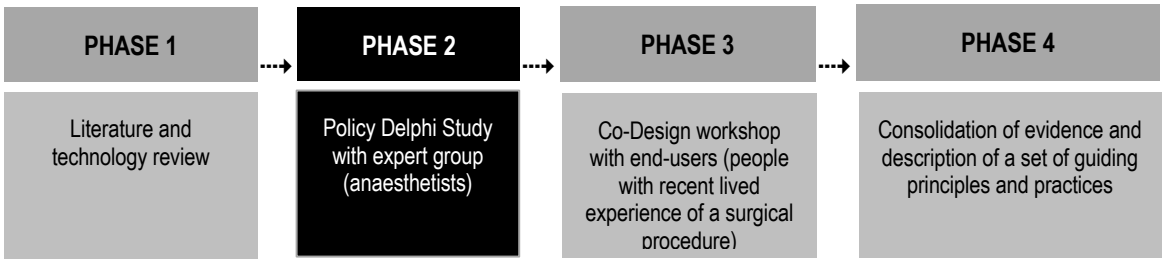

Figure 1. Overall research project framework highlighting phase 2 (reported on in this paper)

A key part of the larger study is an investigation into how patients perceive their individual needs when involved in surgical procedures and it is hoped that the findings will offer new insights into the nature of the information that patients may want during the perioperative period and how this information can might be delivered. The research also aims to identify which software packages/modalities might be of use for patient populations at different stages of perioperative journey, and in which healthcare environment, patients might receive greatest benefit from AR/VR interventions. A synthesis of these finding will be used to deliver a set of guiding principles and practices for how these types of interventions might

be deployed to reduce perioperative anxiety, minimize pharmacological interventions, and ultimately improve patient experience and outcomes.

5.1 The design of the policy delphi study

The Policy Delphi method is similar to a Delphi study in that it seeks to arrive at a shared set of outputs or guidelines through a distributed process. As with a Delphi study, the process is conducted in a series of rounds. However, unlike a traditional Delphi study, the first stage of the process is based on a series of expert interviews rather than a survey (Manley, 2013). Following the expert interviews, an inductive coding process was used. Policy Delphi has the ability to produce a "rich, meaty, stimulating body of opinion" (Manley, 2013). It is a tool to help the decision maker (e.g. policy maker or researchers) collect insights on a particular phenomenon. Traditionally Delphi methods aim to gaining consensus but some types of Delphi's, such as Policy Delphi, aim to support decisions by structuring and discussing the diverse views of the preferred future (Turoff, 2006).

The Policy Delphi method was considered appropriate for engaging with healthcare professionals because it offered a more flexible model of participation than a typical co-design workshop while still maintaining some level of collaboration between participants. It also allowed for a more rich and varied exploration than a survey. In this case anaesthetists and surgeons were chosen as the healthcare experts to survey because they have longitudinal contact with patients in and around the surgical process, as well as significant responsibility for patient outcomes. Additionally, anaesthetists were selected because their role is often misunderstood by patients. Many patients have low levels of literacy about anaesthesia, and often assume an anaesthetist's only job is to administer the anaesthetic at the start of the operation. Such misunderstanding may lead to higher anxiety levels, lower satisfaction levels, and patients' postoperative recovery may be negatively affected due to psychoendocrinologic reactions (Peng et al., 2020).

There is no best practice sample size advocated for Delphi studies (Manley, 2013). The number of participants is dependent upon the topic under investigation, the relevant perspectives required, representation, resources available and range of expertise required. 15 participants were recruited and interviewed, 10 of whom were registered anaesthetists with greater than 20 years' experience, while the remaining 5 were surgeons, also each with more than 20 years' experience.

Purposive sampling was used in this part of the study to target a group of expert participants (anaesthetists) that were likely to be able to represent the views of a wider professional group. A purposive sample, also referred to as a judgmental or expert sample, is a type of nonprobability sample that aims to produce a sample that can be logically assumed to be representative of the population. Purposive sampling is often used in qualitative and mixed methods research and involves an iterative process of selecting research subjects rather than starting with a predetermined sampling frame (Palinkas et al., 2016). This allowed a

snowballing recruitment process that used the professional networks of initial participants to identify further anaesthetists with an interest in addressing the research question.

The following two topics were posed in a semi-structured interview that lasted between 45 minutes and 1 hour depending on the complexity and detail of each participants' response:

- Participants were asked to describe the perioperative environment and processes through their professional experiences which in their opinion caused anxiety.
- Participants were asked to describe their understanding of augmented and virtual reality technologies and how they thought that they may be used in the future to help reduce perioperative anxiety in patients.

5.2 Coding process

Thematic analysis is a flexible qualitative analysis method that supports researchers to explore perspectives among participants (Nowell et al., 2017). In this research an inductive method was used to ensure the coding was emergent from the participants' contributions rather than assigned based on a pre-determined set of values (Braun & Clarke, 2019). Each interview was read, and initially coded at sentence level. These codes were grouped together to create themes and were adjusted after each interview. After coding the first three interviews, the coding shifted to longer segments of text. An effort was made to move from descriptive codes to interpretive codes, to identify the broader connections among participants' experiences. After each interview was coded, the coding matrix was reviewed to identify the salient elements in the participants' experiences. At the end of the coding process, the findings were shared with the expert group and an agreed set of outcomes from the process was established to take forward into the next stage of the project. A thematic analysis process was undertaken following the coding process outlined in Gioia and colleagues (2012). This resulted in coding both 1st order concepts and 2nd order themes and aggregate dimensions.

6. Results and Discussion

Data collected from the Policy Delphi process was used to identify the knowledge gap and key patterns in regard to perioperative anxiety from the expert perspective. This data was also be used to establish a baseline understanding of the level of comprehension and interest in using augmented and virtual reality to address perioperative anxiety in patients. The thematic analysis identified four main periods where anxiety may be triggered:

1. Hospital period (covering both pre-arrival and the arrival experience)
2. Pre-operative phase
3. Intra-operative phase, and
4. Post-operative phase.

These four periods illustrate the broad multidimensional nature of perioperative anxiety. An overview of the themes within each of these periods that emerged through the Policy Delphi study is presented in Figure 2 below.

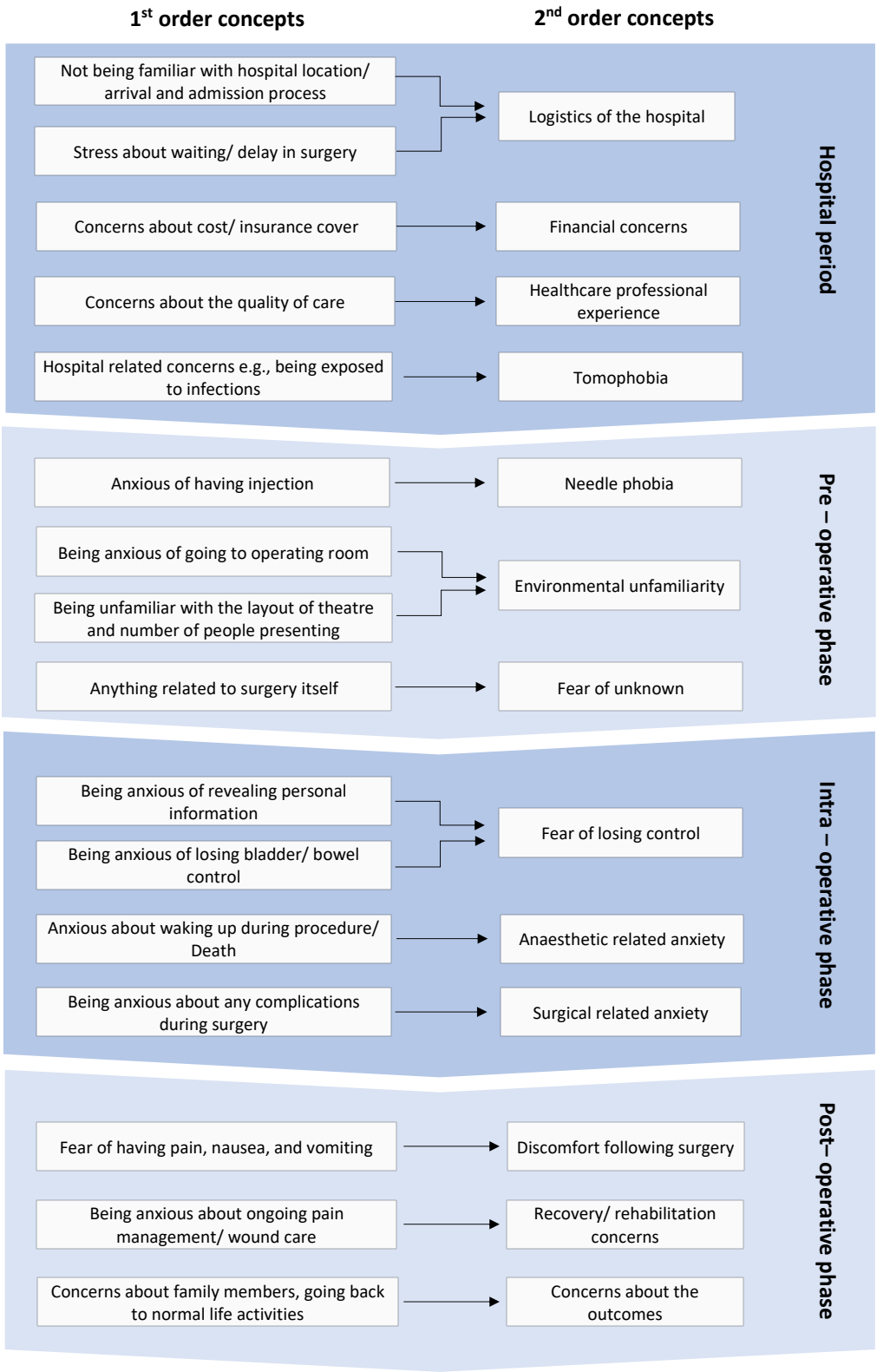

Figure 2: Thematic analysis coding from Policy Delphi study expert opinion on perioperative stress

Many of the concerns raised by the expert group were in line with previous research, including identifying the risk regarding harm or discomfort, scheduling issues, concerns related to others, limited understanding or information regarding surgery, and concerns related to the hospital environment and staff (King et al., 2019; Bradt et al., 2013; Gue, 2015). However, a number of additional perioperative concerns were also identified that were not described by existing literature. These concerns related to current health status, e.g. COVID related issues affecting the time of waiting lists and complications of admission process, contracting an illness or infection while in hospital such as being exposed to Methicillin-Resistant Staphylococcus Aureus (MRSA), aesthetic aspects of surgery including surgical scars, and a lack of personal privacy.

A key theme that emerged was the need for personalisation, and the consideration of individual circumstance. The highly personal nature of some concerns identified by the expert group may help explain why generic educational interventions have had mixed success in the past (King et al., 2019). It was identified that many patients hold beliefs regarding their own susceptibility to complications and diseases based on their personal medical history, making information that is prepared for the 'average patient' difficult to apply to them. Critically, the research identifies a number of potentials pathways to reduce perioperative anxiety that are based on mass-customisation and personalisation rather than the development of generic resources and approaches.

6.1 Improving access to shared decision-making processes

Access to health information is essential in the shared decision-making (SDM) process between the patients and healthcare practitioners. SDM involves collaboration between the patient and the practitioner to discuss treatment options, ensures that the patient is adequately informed, and decides on the care options taking into consideration the patient's principles and preferences (Lizarondo et al., 2016).

To be able to make the best decision regarding treatment options, patients require an adequate level of health literacy and comprehensive information sources. This should include information about their condition and all possible treatment alternatives, risks and benefits (ACSQHC, 2013). Individuals' ability to access, understand and use information about their condition will influence the decisions they make, and actions they take, and help them to cope better with their surgical related anxiety (Davis et al., 2007; ACSQHC, 2013). To support their health literacy, patients require readily accessible, clear, focused, usable and evidence-based information about their health condition, the available healthcare choices, and costs, risks and likely outcomes from each (ACSQHC, 2014).

However, little is known about how, why and where patients access health information (Stacey et el. 2017; Lizarondo et al., 2016). Research shows, patients recalled approximately 10-30% of information provided by healthcare practitioners prior to their perioperative journey (Richard & Lussier, 2017). In order to improve patient health literacy, more needs to be known regarding whether patients are utilising any of the information available to them

in making health decisions regarding elective surgery, or what information sources are most readily accessed and valued. It has been suggested that despite the explosion of available information, patients may still receive care that is based more on their provider's habits and choices, than their own preferences (Davis et al., 2007).

6.2 Distraction, Education, and Companionship

Immersive technology has been successfully employed to promote relaxation and reduce surgical anxiety, and it has notably matured through time, showing a relevant potential in improving and regulating emotional well-being. Two main approaches aiming at achieving relaxation, stress reduction and emotion regulation can be found in the literature. The first one employs mainly "generic environments" by which users are exposed to relaxing narratives stimuli and try to gain control over body physiological activation. The second requires users to be active, implying an interaction with VR or AR contents to train emotion regulation. What is emergent from the Policy Delphi process is that there may be a third category of intervention that is made possible through VR or AR content: companionship. Many of the anaesthetists described one of the key challenges in the patient's journey as the lack of continuity in the experience and suggested that a companion or guide through the process that may or may not be there to help educate the patient could be of value.

While some initial prototyping of the broad structures for the intervention based on the Policy Delphi is underway, the content of the interventions is to be co-designed through a series of workshops with people with lived experience of the surgical journey described below. This will make this one of the first studies to extend the discourse on selective immersive technology approach based on patient-personalised contents, built on distinctive features picked-up by lived experience of people who have recently undergone elective surgery or short stay procedures.

7. Limitations and further research

A significant limitation of the data presented in this paper is that it represents only the first part of an ongoing process. The perspectives represent only the professional experience of the surgical journey and as such are only presenting part of the picture. In the next phase of this research, a series of co-design workshops will explore the lived experience of people who have recently undergone elective surgery or short stay procedures. This will allow the results of the Policy Dephi process to be combined with and augmented by patient experiences through the co-design process. A key part of the latter stages of this research is to allow professionals and patients to undertake a collaborative sense-making process through the co-design workshops. The inclusion criteria for the next stage of this project are:

- experience of having an elective day-surgery in a hospital;
- self-identify as having limited general exposed to healthcare environments;
- age >18.

The codesign sessions will be used to explore perspectives and opinion for the participants with lived experience, to share and understand at what points along the patient journey did they feel particularly anxious and in what situations. To achieve this a patient journey mapping process will be used to identify potential pinch points in the experience.

In the second part of the workshop participants will discuss their understanding of VR and AR technologies and consider how, when, and where these might be used as a way of addressing perioperative anxiety. Specific activities will be developed that allow the participants to understand the different stages of the journey identified above (Figure 2), as well as the three modes of content interaction identified (distraction, education, and companionship). Participants will also explore what sort of content or information might be desired at different points in this journey.

Findings from the co-design workshops will be triangulated with the findings from the Delphi study and the broader literature and technology review, to formulate a set of guiding principles and practice for the implementation of VR and AR interventions to mitigate perioperative anxiety.

8. Conclusion

There is a body of research showing that technology-based therapeutic tools can play an effective, acceptable, and cost-effective role in many aspects of health care delivery, and immersive technologies have been shown to be specifically viable in clinical settings as a non-pharmacologic intervention. The current evidence on the use of immersive technologies in acute and chronic pain highlights a tremendous opportunity for this technology (Logan et al., 2021). This study provides an initial framework for the exploration of the timing, type of content, and form of delivery that could be applied to address perioperative patient anxiety and promises to be an innovative advancement in the field of immersive technology in healthcare.

Furthermore, this is one of the first studies to extend the discourse on selective immersive technology approach based on patient-personalised contents. Although this specific approach has not been integrated widely into mainstream clinical practice, there is an overarching recognition that focusing on personalised needs and effective interventions for specific patients can bring economic advantages, particularly if leveraging the efficiencies of digital technologies. By building an immersive system through the lived experience of people who have recently undergone elective surgery or short stay procedures, it is likely that the information presented here will continue to be further augmented in future stages of the project.

9. References

Akinsulore, Owojuyigbe, A. M., Faponle, A. F., & Fatoye, F. O. (2015). Assessment of preoperative and postoperative anxiety among elective major surgery patients in a tertiary hospital in Nigeria. *Middle East Journal of Anaesthesiology*, *23*(2), 235–240.

Alqudimat M, Mesaroli G, Lalloo C, Stinson J, Matava C. State of the Art: Immersive Technologies for Perioperative Anxiety, Acute, and Chronic Pain Management in Pediatric Patients. Curr Anesthesiol Rep. 2021 Jul 14:1-10. doi: 10.1007/s40140-021-00472-3. Epub ahead of print. PMID: 34276254; PMCID: PMC8277426.

Aspers, & Corte, U. (2019). What is Qualitative in Qualitative Research. *Qualitative Sociology*, *42*(2), 139–160. https://doi.org/10.1007/s11133-019-9413-7

Austin, Z., & Sutton, J. (2014). Qualitative research: getting started. *The Canadian journal of hospital pharmacy*, *67*(6), 436–440. https://doi.org/10.4212/cjhp.v67i6.1406

Australian Commission on Safety and Quality in Health Care. Health literacy: Taking action to improve safety and quality. Sydney: ACSQHC, 2014.

Australian Institute of Health and Welfare (2019), Elective surgery - Australian Institute of Health and Welfare, https://www.aihw.gov.au/reports-data/myhospitals/sectors/elective-surgery

Aytekin A, Doru Ö, Kucukoglu S. The effects of distraction on preoperative anxiety level in children. J Perianesth Nurs 2016;31(1):56–62

Ajzen. (1991). The theory of planned behaviour: Reactions and reflections. Psychology & Health, 26(9), 1113–1127. https://doi.org/10.1080/08870446.2011.613995

Bailey L. Strategies for decreasing patient anxiety in the perioperative setting. AORN J. 2010;92(4):445–60.

Bandelow, B., Michaelis, S., & Wedekind, D. (2017). Treatment of anxiety disorders. *Dialogues in clinical neuroscience*, *19*(2), 93–107. https://doi.org/10.31887/DCNS.2017.19.2/bbandelow

Bandura A. Social cognitive theory: an agentic perspective. Annu Rev Psychol (2001) 52:1–26. doi:10.1146/annurev.psych.52.1.1

Bandura A. Toward a psychology of human agency. Perspect Psychol Sci (2006) 1(2):164–80. doi:10.1111/j.1745-6916.2006.00011.x

Baniasadi, Ayyoubzadeh, S. M., & Mohammadzadeh, N. (2020). Challenges and practical considerations in applying virtual reality in medical education and treatment. *Oman Medical Journal*, *35*(3), 1–10. https://doi.org/10.5001/omj.2020.43

Baus, & Bouchard, S. (2014). Moving from virtual reality exposure-based therapy to augmented reality exposure-based therapy: A review. *Frontiers in Human Neuroscience*, *8*, 112–112. https://doi.org/10.3389/fnhum.2014.00112

Bradt, Dileo, C., Shim, M., & Bradt, J. (2013). Music interventions for preoperative anxiety. *Cochrane Library*, *2013*(6), CD006908–CD006908. https://doi.org/10.1002/14651858.CD006908.pub2

Bedaso, & Ayalew, M. (2019). Preoperative anxiety among adult patients undergoing elective surgery: a prospective survey at a general hospital in Ethiopia. *Patient Safety in Surgery*, *13*(1), 18–18. https://doi.org/10.1186/s13037-019-0198-0

Brug, Conner, M., Harre, N., Kremers, S. P. ., McKellar, S., & Whitelaw, S. (2005). The Transtheoretical Model and stages of change: a critique: Observations by five Commentators on the paper by Adams, J. and White, M. (2004) Why don't stage-based activity promotion interventions work? Health Education Research, 20(2), 244–258. https://doi.org/10.1093/her/cyh005

Caumo W, Schmidt AP, Schneider CN, Bergmann J, Iwamoto CW, Adamatti LC, Bandeira D, Ferreira MB. Risk factors for postoperative anxiety in adults. Anaesthesia. 2004 Aug;56(8):720-8. doi: 10.1046/j.1365-2044.2001.01842.x. PMID: 11493233.

D'Alessandro, L. N., Brown, S. C., Campbell, F., Ruskin, D., Mesaroli, G., Makkar, M., & Stinson, J. N. (2020). Rapid mobilization of a virtual pediatric chronic pain clinic in Canada during the COVID-19 pandemic. *Canadian journal of pain = Revue canadienne de la douleur*, *4*(1), 162–167. https://doi.org/10.1080/24740527.2020.1771688

Cerritelli, Chiera, M., Abbro, M., Megale, V., Esteves, J., Gallace, A., & Manzotti, A. (2021). The Challenges and Perspectives of the Integration Between Virtual and Augmented Reality and Manual Therapies. *Frontiers in Neurology*, *12*, 700211–700211. https://doi.org/10.3389/fneur.2021.700211

Chicchi Giglioli, Pallavicini, F., Pedroli, E., Serino, S., & Riva, G. (2015). Augmented Reality: A Brand New Challenge for the Assessment and Treatment of Psychological Disorders. *Computational and Mathematical Methods in Medicine*, *2015*, 862942–12. https://doi.org/10.1155/2015/862942

Cohen, & Sherman, D. K. (2014). The psychology of change: Self-affirmation and social psychological intervention. *Annual Review of Psychology*, *65*(1), 333–371. https://doi.org/10.1146/annurev-psych-010213-115137

Cortés-Pérez, Sánchez-Alcalá, M., Nieto-Escámez, F. A., Castellote-Caballero, Y., Obrero-Gaitán, E., & Osuna-Pérez, M. C. (2021). Virtual Reality-Based Therapy Improves Fatigue, Impact, and Quality of Life in Patients with Multiple Sclerosis. A Systematic Review with a Meta-Analysis. *Sensors (Basel, Switzerland)*, *21*(21), 7389. https://doi.org/10.3390/s21217389

Davis, Jacklin, R., Sevdalis, N., & Vincent, C. A. (2007). Patient involvement in patient safety: what factors influence patient participation and engagement? *Health Expectations : an International Journal of Public Participation in Health Care and Health Policy*, *10*(3), 259–267. https://doi.org/10.1111/j.1369-7625.2007.00450.x

Flavian, Ibanez-Sanchez, S., & Orus, C. (2019). The impact of virtual, augmented and mixed reality technologies on the customer experience. *Journal of Business Research*, *100*, 547–560. https://doi.org/10.1016/j.jbusres.2018.10.050

Georgiev, Georgieva, I., Gong, Z., Nanjappan, V., & Georgiev, G. V. (2021). Virtual Reality for Neurorehabilitation and Cognitive Enhancement. Brain Sciences, 11(2), 221. https://doi.org/10.3390/brainsci11020221

Gianakis M, Carey TA. An interview study investigating experiences of psychological change without psychotherapy. Psychol Psychother (2011) 84(4):442–57. doi:10.1111/j.2044-8341.2010.02002.x

Gras S, Servin F, Bedairia E, Montravers P, Desmonts JM, Longrois D, Guglielminotti J. The effect of preoperative heart rate and anxiety on the propofol dose required for loss of consciousness. Anesth Analg. 2010 Jan 1;110(1):89-93. doi: 10.1213/ANE.0b013e3181c5bd11. Epub 2009 Nov 12. PMID: 19910628.

Guo. (2015). Preoperative education interventions to reduce anxiety and improve recovery among cardiac surgery patients: a review of randomised controlled trials. *Journal of Clinical Nursing*, *24*(1-2), 34–46. https://doi.org/10.1111/jocn.12618

González-Lemonnier, S, Bovaira-Forner, M, Peñarrocha-Diago, M & Peñarrocha-Oltra, D 2010, 'Relationship between preoperative anxiety and postoperative satisfaction in dental implant surgery with intravenous conscious sedation', *Medicina Oral, Patología Oral y Cirugía Bucal*, vol. 15, no. 2, pp. e379–e382.

Haldar, S, Filipkowski, A, Mishra, SR, Brown, CS, Elera, RG, Pollack, AH & Pratt, W 2016, '"Scared to go to the Hospital": Inpatient Experiences with Undesirable Events', *AMIA ... Annual Symposium Proceedings*, vol. 2016, pp. 609–617.

Higginson, & Mansell, W. (2008). What is the mechanism of psychological change? A qualitative analysis of six individuals who experienced personal change and recovery. *Psychology and Psychotherapy*, *81*(3), 309–328. https://doi.org/10.1348/147608308X320125

Hugues, Fuchs, P., & Nannipieri, O. (2011). New Augmented Reality Taxonomy: Technologies and Features of Augmented Environment. In *Handbook of Augmented Reality* (p. 850). Springer.

Khor, Baker, B., Amin, K., Chan, A., Patel, K., & Wong, J. (2016). Augmented and virtual reality in surgery-the digital surgical environment: Applications, limitations and legal pitfalls. *Annals of Translational Medicine*, *4*(23), 454–454. https://doi.org/10.21037/atm.2016.12.23

King, Bartley, J., Johanson, D. L., & Broadbent, E. (2019). Components of preoperative anxiety: A qualitative study. *Journal of Health Psychology*, *24*(13), 1897–1908. https://doi.org/10.1177/1359105317709512

Kostkova. (2015). Grand challenges in digital health. Frontiers in Public Health, 3, 134–134. https://doi.org/10.3389/fpubh.2015.00134

Kottler. (2014). *Change : what really leads to lasting personal transformation / Jeffrey A. Kottler.* Oxford University Press.

Lambrakopoulos, G.; Begetis, N.; Katifori, A.; Karvounis, M.; Ioannidis, Y. (2017). Experimental evaluation of the impact of virtual reality on the sentiment of fear. In Proceedings of the 23rd International Conference on Virtual System & Multimedia (VSMM); Goodman, L., Addison, A., Eds.; Institute of Electrical and Electronics Engineers: Dublin, Ireland, pp. 20–26, doi:10.1109/vsmm.2017.8346251.

Lee JS, Park YM, Ha KY, Cho SW, Bak GH, Kim KW. Preoperative anxiety about spinal surgery under general anesthesia. Eur Spine J. 2016 Mar;25(3):698-707. doi: 10.1007/s00586-015-3788-2. Epub 2015 Feb 11. PMID: 25670066.

Lizarondo, Pham, C., Aromataris, E., Munn, Z., Gibb, C., & Karnon, J. (2016). Strategies for implementing shared decision making in elective surgery by healthcare practitioners: a systematic review protocol. *JBI Database of Systematic Reviews and Implementation Reports*, *14*(12), 100–108. https://doi.org/10.11124/JBISRIR-2016-002959

Logan, Simons, L. E., Caruso, T., Gold, J. I., Greenleaf, W., Griffin, A., King, C., Menendez, M., Olbrecht, V., Rodriguez, S., Silvia, M., Stinson, J., Wang, E., Williams, S., & Wilson, L. (2020). Leveraging VR/AR to combat chronic pain in youth: Position paper from the Interdisciplinary Network on Virtual and Augmented (AR/VR) Technologies for Pain (INOVATE-Pain) Management (Preprint). *Journal of Medical Internet Research*. https://doi.org/10.2196/25916

Lopez-Yufera, E., López-Jornet, P., Toralla, O., & Pons-Fuster López, E. (2020). Non-Pharmacological Interventions for Reducing Anxiety in Patients with Potentially Malignant Oral Disorders. *Journal of clinical medicine*, *9*(3), 622. https://doi.org/10.3390/jcm9030622

Madden, & Kleinlugtenbelt, Y. V. (2017). Cochrane in CORR®: Decision Aids for People Facing Health Treatment or Screening Decisions. *Clinical Orthopaedics and Related Research*, *475*(5), 1298–1304. https://doi.org/10.1007/s11999-017-5254-4McLenon J, Rogers MAM. The fear of needles: A systematic review and meta-analysis. J Adv Nurs. 2019 Jan;75(1):30-42. doi: 10.1111/jan.13818. Epub 2018 Sep 11. PMID: 30109720.

Manley. (2013). The Policy Delphi: A Method for Identifying Intended and Unintended Consequences of Educational Policy. *Policy Futures in Education*, *11*(6), 755–768. https://doi.org/10.2304/pfie.2013.11.6.755

Marcia Pestana-Santos, Maria Joao Pereira, Adriana Pestana-Santos, Eduardo Santos, Andreia Goncalves, Daniela Cardoso, Lurdes Lomba, & Margarida Reis Santos. (2021). Effectiveness of non-pharmacological interventions to manage anxiety in adolescents in the perioperative period:

A systematic review and meta-analysis. *Journal of Perioperative Nursing*, *34*(3), e–15–e–25. https://doi.org/10.26550/2209-1092.1130

Marsch LA, Gustafson DH. The Role of Technology in Health Care Innovation: A Commentary. J Dual Diagn. 2013;9(1):101-103. doi: 10.1080/15504263.2012.750105. PMID: 23599690; PMCID: PMC3626450.

Meskó, Drobni, Z., Bényei, Éva, Gergely, B., & Győrffy, Z. (2017). Digital health is a cultural transformation of traditional healthcare. mHealth, 3, 38–38. https://doi.org/10.21037/mhealth.2017.08.07

Mitchell, M 2010, 'General anaesthesia and day-case patient anxiety', *Journal of Advanced Nursing*, Accepted for publication 18 December 2009, 66(5), 1059–1071.

Matthias, & Samarasekera, D. N. (2012). Preoperative anxiety in surgical patients - experience of a single unit. *Acta Anaesthesiologica Taiwanica*, *50*(1), 3–6. https://doi.org/10.1016/j.aat.2012.02.004

Mulugeta, Ayana, M., Sintayehu, M., Dessie, G., & Zewdu, T. (2018). Preoperative anxiety and associated factors among adult surgical patients in Debre Markos and Felege Hiwot referral hospitals, Northwest Ethiopia. *BMC Anesthesiology*, *18*(1), 155–155. https://doi.org/10.1186/s12871-018-0619-0

Murray, Hekler, E. B., Andersson, G., Collins, L. M., Doherty, A., Hollis, C., Rivera, D. E., West, R., & Wyatt, J. C. (2016). Evaluating Digital Health Interventions: Key Questions and Approaches. American Journal of Preventive Medicine, 51(5), 843–851. https://doi.org/10.1016/j.amepre.2016.06.008

Nigussie, S, Belachew, T & Wolancho, W 2014, 'Predictors of preoperative anxiety among surgical patients in Jimma University Specialized Teaching Hospital, South Western Ethiopia', *BMC Surgery*, vol. 14, no. 1, pp. 67–67.

Nowell, Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis. International Journal of Qualitative Methods, 16(1), 1–13. https://doi.org/10.1177/1609406917733847

Olbrecht VA, O'Conor KT, Williams SE, Boehmer CO, Marchant GW, Glynn SM, Geisler KJ, Pickerill HM, Ding L, Yang G, King CD. Transient Reductions in Postoperative Pain and Anxiety using Virtual Reality in Children. Pain Med. 2021 Jun 27:pnab209. doi: 10.1093/pm/pnab209. Epub ahead of print. PMID: 34175959.

Ometov, Shubina, V., Klus, L., Skibińska, J., Saafi, S., Pascacio, P., Flueratoru, L., Gaibor, D. Q., Chukhno, N., Chukhno, O., Ali, A., Channa, A., Svertoka, E., Qaim, W. B., Casanova-Marqués, R., Holcer, S., Torres-Sospedra, J., Casteleyn, S., Ruggeri, G., … Lohan, E. S. (2021). A Survey on Wearable Technology: History, State-of-the-Art and Current Challenges. *Computer Networks (Amsterdam, Netherlands : 1999)*, *193*, 108074. https://doi.org/10.1016/j.comnet.2021.108074

Ong, Wilczewski, H., Paige, S. R., Soni, H., Welch, B. M., & Bunnell, B. E. (2021). Extended reality for enhanced telehealth during and beyond covid-19: Viewpoint. *JMIR Serious Games*, *9*(3), e26520–e26520. https://doi.org/10.2196/26520

Park S, Kang CH, Hwang Y, Seong YW, Lee HJ, Park IK, Kim YT. Risk factors for postoperative anxiety and depression after surgical treatment for lung cancer†. Eur J Cardiothorac Surg. 2016 Jan;49(1):e16-21. doi: 10.1093/ejcts/ezv336. Epub 2015 Sep 26. PMID: 26410631.

Pritchard MJ. Identifying and assessing anxiety in pre-operative patients. Nurs Stand. 2009 Aug 26-Sep 1;23(51):35-40. doi: 10.7748/ns2009.08.23.51.35.c7222. PMID: 19753776.

Prochaska, & Diclemente, C. C. (1986.). Toward a Comprehensive Model of Change. In Treating Addictive Behaviors (pp. 3–27). Springer US. https://doi.org/10.1007/978-1-4613-2191-0_1

Schmid, M, Wolf, RC, Freudenmann, RW & Schönfeldt-Lecuona, C 2009, 'Tomophobia, the phobic fear caused by an invasive medical procedure - An emerging anxiety disorder: A case report', *Journal of Medical Case Reports*, vol. 3, no. 1, pp. 131–131.

Richard, Glaser, E., & Lussier, M. (2017). Communication and patient participation influencing patient recall of treatment discussions. Health Expectations : an International Journal of Public Participation in Health Care and Health Policy, 20(4), 760–770. https://doi.org/10.1111/hex.12515

Riva. (2015). Phenomenology of Positive Change: Personal Growth. In *Enabling Positive Change: Flow and Complexity in Daily Experience* (pp. 18–38). DE GRUYTER OPEN. https://doi.org/10.2478/9783110410242.2

Riva, Baños, R. M., Botella, C., Mantovani, F., & Gaggioli, A. (2016). Transforming experience: The potential of augmented reality and virtual reality for enhancing personal and clinical change. *Frontiers in Psychiatry*, *7*, 164–164. https://doi.org/10.3389/fpsyt.2016.00164

Riva, Wiederhold, B. K., & Mantovani, F. (2019). Neuroscience of Virtual Reality: From Virtual Exposure to Embodied Medicine. Cyberpsychology, Behavior and Social Networking, 22(1), 82–96. https://doi.org/10.1089/cyber.2017.29099.gri

Schiza, Matsangidou, M., Neokleous, K., & Pattichis, C. S. (2019). Virtual Reality Applications for Neurological Disease: A Review. *Frontiers in Robotics and AI*, *6*, 100–100. https://doi.org/10.3389/frobt.2019.00100

Schutte, N.S.; Bhullar, N.; Stilinovi c, E.J.; Richardson, K (2017). The impact of virtual environments on restorativeness and affect. Ecopsychology, 9, 1–7, doi:10.1089/eco.2016.0042.

Shove, Pantzar, M., & Watson, M. (2012). The Dynamics of Social Practice. SAGE Publications.

Sigdel S. Perioperative anxiety. Clinical Trials Patent. 2015;1(1):2.

Singh, D.K.A.; Rahman, N.N.A.; Seffiyah, R.; Chang, S.Y.; Zainura, A.K.; Aida, S.R.; Rajwinder, K.H.S (2017). Impact of virtual reality games on psychological well-being and upper limb performance in adults with physical disabilities: A pilot study. Med J. Malays, 72, 119–121.

Spoto, Bourhaleb, F., & Petrone, G. (2016). Augmented reality supporting innovation and accuracy in advanced radiation therapy facilities. *Radiotherapy and Oncology*, *118*, S97–S97. https://doi.org/10.1016/S0167-8140(16)30200-6

van Krevelen DWF, Poelman R (2010). A survey of augmented reality technologies, applications and limitations. *Int J Virtual Real,* 9(2):1–20.

Vazquez, C.; Xia, L.; Aikawa, T.; Maes, P (2018). Words in motion: Kinesthetic language learning in virtual reality. In Proceedings of the 18th International Conference on Advanced Learning Technologies (ICALT); Institute of Electrical and Electronics Engineers: Mumbai, India; pp. 272–276, doi:10.1109/icalt.2018.00069.

Villiger, Bohli, D., Kiper, D., Pyk, P., Spillmann, J., Meilick, B., Curt, A., Hepp-Reymond, M.-C., Hotz-Boendermaker, S., & Eng, K. (2013). Virtual Reality–Augmented Neurorehabilitation Improves Motor Function and Reduces Neuropathic Pain in Patients With Incomplete Spinal Cord Injury. *Neurorehabilitation and Neural Repair*, *27*(8), 675–683. https://doi.org/10.1177/1545968313490999

Vles, Terng, N. C. ., Zijlstra, K., Mureau, M. A. ., & Corten, E. M. . (2020). Virtual and augmented reality for preoperative planning in plastic surgical procedures: A systematic review. *Journal of Plastic, Reconstructive & Aesthetic Surgery*, *73*(11), 1951–1959. https://doi.org/10.1016/j.bjps.2020.05.081

Yeung, A., Tosevska, A., Klager, E., Eibensteiner, F., Laxar, D., Stoyanov, J., Glisic, M., Zeiner, S., Kulnik, S. T., Crutzen, R., Kimberger, O., Kletecka-Pulker, M., Atanasov, A. G., & Willschke, H. (2021).

Virtual and Augmented Reality Applications in Medicine: Analysis of the Scientific Literature. *Journal of medical Internet research*, *23*(2), e25499. https://doi.org/10.2196/25499

Wrzesien, Burkhardt, J.-M., Botella, C., & Alcañiz, M. (2015). Towards a Virtual Reality- and Augmented Reality-Mediated Therapeutic Process model: a theoretical revision of clinical issues and HCI issues. *Theoretical Issues in Ergonomics Science*, *16*(2), 124–153. https://doi.org/10.1080/1463922X.2014.903307

About the Authors

Nikou Javadi is a PhD candidate in visual communication at the University of South Australia, receiving the UniSA Vice Chancellor and President's Scholarship 2020. Javadi trained as an architect, and works as an anaesthetic clinical nurse at Burnside Hospital, Adelaide, Australia.

Professor Ian Gwilt is Professor of Design at the University of South Australia. Formerly a member of the Lab4Living at Sheffield Hallam University, Professor Gwilt has worked with a range of participant groups to develop iterative solutions to a range of social and technological challenges using the co-design methodology.

Dr Aaron Davis is a Lecturer in Architecture at the University of South Australia. His research focuses on co-design, end-user engagement, and interdisciplinary collaboration. Dr Davis has a strong interest in enabling diverse participation, and capturing the value of processes.