# Digital Health Tools for Perioperative Stress Reduction in Integrated Care

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## Abstract

Background: Patients undergoing elective surgery often face symptoms of anxiety and stress. Healthcare systems have limited time and resources to provide individualized stress relief interventions. Research has shown that stress relief interventions and educational resources can improve health outcomes and speed recovery.

Objectives: Digital health tools can provide valuable assistance in stress relief and educational support to patients and family. This paper reports on the design of a novel digital health infrastructure for improving the health condition of patients, during the care path, using virtual reality (VR) and other information and communication technologies (ICT).

Methods: Digital tools developed and integrated into a platform of modules that can be used by patients before but also after an operation, enabling better self-management and self-empowerment.

Results: The designed platform aims at improving the knowledge of patients about their condition, providing stress relief tools, helping them adhere to treatment, as well as providing for effective communication channels between patients and clinicians.

Conclusion: The proposed solution has the potential to improve physical and emotional reactions to stress and increase the levels of calmness and a sense of wellbeing. Information provided through the platform enhances health literacy and digital competence, and increases the participation of the patient in the decision-making process. Integration with third-party applications can facilitate the exchange of important information between patients and physicians as well as between personal applications and clinical health systems.

## Keywords

Stress relief; Self-management; Empowerment; Virtual reality; Interoperability

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## 1. Introduction

Patients undergoing elective surgery often exhibit symptoms of stress, anxiety and fear [1]. Regardless of the type of procedure, surgery has been shown to raise anxiety levels. A recent study has shown that more than half of patients report anxiety and

fear, and that only 52% of patients knew the type of surgery they were going to have [2]. Preoperative adult patients attribute their anxiety to the anticipation of pain, and other possible surgery outcomes such as loss of independence, changes in body image and death [3,4]. Other worries leading to surgical anxiety include financial burdens, surgical results, infections, losing mobility, long recovery and others. Anxiety is a common physiological and psychological reaction to stress factors and situations that pose threat. Symptoms of anxiety include a variety of behavioural, subjective, and physiological responses that may vary among different persons, and can include, but are not limited to, excessive sweating, nausea, nervousness in the stomach, shortness of breath, sleep difficulties, irregular heartbeat and others.

Unfamiliar environments and preoperative requirements can contribute further to confusion and stress. Feelings of uncertainty, fear, hesitation and anxiety are quite common for people expecting to be operated. These feelings may interfere with the emotional well-being of patients and their ability to follow instructions through the perioperative patient journey. Patient experience has been directly linked to emotional functioning and surgical outcomes [5]. Failure to provide appropriate anxiety and stress relief causes unnecessary discomfort, longer hospital stays, increased expenses, and less than optimal clinical outcomes.

Preventing pre-surgical anxiety can help patients achieve positive outcomes on health and wellbeing. Several streategies and techniques have been used to manage preoperative stress and anxiety, ranging from simple techniques (including listening to music and other plain relaxation techniques) to information provision, consultation with nurses, and even more advanced methods, such as patient education interventions and the use of modern information and comunication technology (ICT) tools [6,7]. For example, providing preoperative patients the opportunity to listen to music before surgery can be an effective intervention to decrease anxiety and help patients to cope with a potentially challenging or stressful procedure. Music has been shown to relieve anxiety among preoperative patients on several occasions [8]. However, very few patients receive adequate stress relief support prior to a surgical procedure.

Education and information about the surgery are also involved in the psychological experience of the patient. Provision of preoperative education and information is inversely related with preoperative anxiety. Education and information have been shown to help decrease preoperative anxiety levels in patients resulting in less surgical complications [2,8]. Preoperative education can also be used to activate patients towards becoming collaborative partners in managing their own health care. Patients that take a collaborative role show modified competence in managing their diseases, which positively improves outcomes such as satisfaction, cost, health status, and function [9]. Education efforts that are patient-centred and patient-specific have been shown to be the most effective [10], however, resource constraints make face-to-face education sessions unlikely. Implementing face-to-face personalized education sessions is costly and difficult.

Interventions based on ICT, geared towards increasing familiarity with surgical procedures and hospital environments have been shown to help patients feel informed about possible benefits and harms of their options [11]. ICT has been also accepted as a useful tools for pain management [12,13], anxiety and stress relief [14], and could be used as a cost-effective complement, or even a first-hand primary intervention [15]. Virtual Reality (VR) can offer patients an immersion experience in the perioperative environment. VR interventions can be helpful in empowering patients and enhancing a more positive experience. The impact of VR in stress relief has been studied in numerous research applications [16,17], with public surveys indicating very promising results. A clinical trial published this year [18] showed promise in VR helping to distract children from self-reported pain and anxiety during medical procedures. The review studied the impact of VR on seventeen children receiving treatment for burns, dental and tumour related health needs. The results were featuring VR as a distraction tool offering a safe solution in counteracting anxiety related to medical interventions. A randomized controlled trial of patients undergoing cranial and spinal operations studying the exposure effect between a preoperative VR experience and standard preoperative experience, showed that the immersive VR experience led to higher Amsterdam Preoperative Anxiety and Information Scale (APAIS) score while reducing preoperative Visual Analogue Scale (VAS) stress scores [19]. However, available applications focus only on providing informative content, neglecting the importance of patient empowerment with a more robust educational curriculum. In addition, evidence has shown that patients scheduled for colorectal cancer surgery, who received a VR experience about the surgery and the recovery period, showed lower pre-procedure anxiety [20].

To this direction, this work describes the design of an ICT platform, dynamically adapted according to patient preferences and medical history, to support patient-centred anxiety relief, self-management, and effective use of health care resources. The platform incorporates VR to reduce stress and anxiety in preoperative patients taking into consideration the significant individual differences regarding preferences for the method of stress relief, the amount of information provided and the mode of delivery [21]. Among others the novelty of the proposed solution is the combination of a wide set of technologies for reducing stress, based on clinical and empirical evidences and best practises. To the best of our knowledge, no other solution today offers such a diverse set of techniques for stress relief and management for patients undergoing elective surgery.

## 2. Method

The development of the proposed ICT environment for preoperative stress management has followed an iterative, detailed requirement elicitation process, involving end-users and capitalizing many years of work on personal health systems. Our solution proposes a customized, modular tool to enhance the hospitalization period with innovative technology merging education and entertainment into a single module [22]. More specifically the design of the solution was based on input from (i) work on patient empowerment through personalized recommendations and educational material, (ii) consultation

meetings with psychologist advisory group, and (iii) related projects such as BOUNCE (https://www.bounce-project.eu), Relief (http://relief-chronicpain.eu) [23,24], iManageCancer (http://www.imanagecancer.eu/), MyHealthAvatar [25,26] and p-medicine (http://p-medicine.eu).

Based on the input, the technological solution was designed to include the following modules, shown in Figure 1; (i) PHR for monitoring patient journey, (ii) Educational and Information Module, (iii) Personalized Recommendations, (iv) Stress Relieving through VR, (v) Communication tools, (vi) Appointments, (vii) Decision Support and (viii) Self-assessment. Privacy needs to be considered from the very beginning of system development and for that reason, a privacy-by-design approach [27,28] has been adopted to wrap the whole architecture, data flow and interactions. The data protection safeguards are built into products and services from the earliest stage of development, in accordance with the European General Data Protection Regulation [29]. The architecture of the digital tool is based on modular building blocks and can be easily extended to support additional requirements and new modules. A VR module focused on providing immersion environments to alleviate stress, offers individualized information about upcoming surgery procedures and perioperative processes, and helps familiarize patients with the hospital environment. All modules have been designed to be flexible and adaptable in order to accommodate policies and guidelines at national, regional, local and institutional levels. Special emphasis has been placed on patient safety. All content is based on clinical guidelines and approved by clinicians.

Interoperability is a key advantage of the system being able to export/import data using both existing standards and proprietary mechanisms. The platform can be used as a standalone application, but can also be integrated through data exchange with third party systems when this is required.

## 3. Results and Discussion

Through the platform, patients are able to report their feelings and ask questions about their upcoming surgery to their clinical professionals though the communication module. They can receive in depth information about their surgery and what is required of them prior and during their hospital stay. In addition, the system supports individualized preferences for stress relief including virtual relaxation environments with music and evidenced based relaxation and distraction techniques. Based on the surgery plan, the system supports a smart decision aid to help patients implement it. VR functionalities are optional and can be used to obtain an immersive experience obtaining education and information and participating in stress relief relaxation activities. Platform modules are described below.

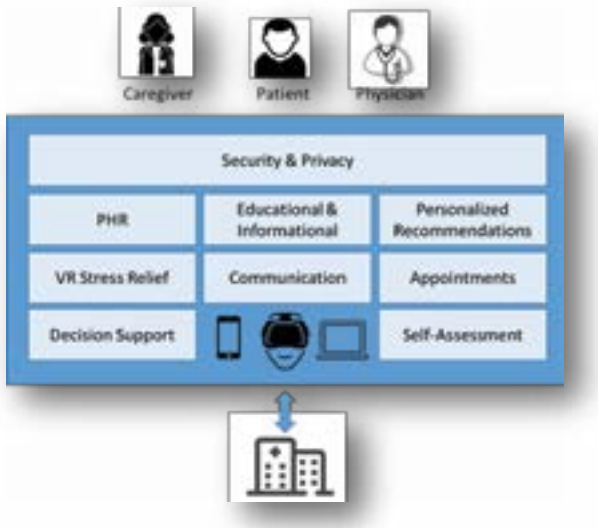


Figure 1: The high-level architecture of the designed solution.

### 3.1 PHR

The PHR module provides the opportunity for patients to register their personal information through personalized profiles, information recording and management. The patients can record their past medical history, their current diagnosis and the surgery they are undergoing as well as their relaxation and communication preferences. In addition, they can share information with their relatives or other persons.

### 3.2 Educational and Information Module (Available also through VR)

This module provides to the users all necessary information about their upcoming operation. Graphics and animation facilitate the comprehension of medical terms and procedures. Pre and post-operation care instructions are included for the patient and their care team (informal carers). The VR software provides visualization of the hospital environment from the operating rooms to the surgical ward and postoperative recovery room based on local plans. Through the use of VR, the patients can navigate through the hospital and familiarize themselves with the environment including hospital facilities and plans. The educational module is tailored to patient needs to enhance information and learning during the hospitalization period with gamification elements and advanced interactive features from within an immersive virtual environment. The proposed VR component transforms patient empowerment to a cost-effective, easily and broadly accessible process. A fully customizable software development kit (SDK) is used to generate educational VR content with minimal adaptations (Figure 2). The latter is accomplished by prototyping the learning pipeline into structured, independent and reusable segments, which are used to generate more complex behaviours.

### 3.3 Personalized Recommendations

Personalized recommendations about managing stress and anxiety help users identify the appropriate technique for calmness and a sense of ease and safety. This module includes specialized psycho-emotional psychometric questionnaires and scales for stress and anxiety detection. The patients are able to record their own experience and pose questions regarding their concerns. Personalized communications are geared towards providing encouragement for post-surgery recovery and return to routine.


Figure 2: Visualizing important information on the upcomming surgery.

A lifestyle monitoring and behavioural change support module contributes to the improvement of adherence to pharmacological and non-pharmacological treatment and lifestyle changes. Also, it provides tools for lifestyle monitoring such as physical activity and sleep patterns. One of the main challenges for the next-generation of gamified simulations and serious games, involves answering the key research question on how to allow the learners and teachers to experience the feeling of "Presence" under a novel educational learning framework in VR learning environments [30]. Our solution targets this need for an immersive educational framework, focusing on personalization capabilities to recreate an ideal virtual environment for stress relief through knowledge.

### *3.4 Stress Relieving through VR*

A head mounted computer display immerses the user within an interactive 3D virtual environment. Based on patient choices, the VR module provides audiovisual immersion environments to promote calmness and stress relief. Head tracking allows the user to actively view the environment in 360 degrees, while listening to a matching soundtrack, through noise cancelling headphones. Hospitalized patients face a challenge that can be assessed as intimidating and complicated. They must seek coping stratagems that help them deal with a situation that is unfamiliar and frightening. It is crucial, therefore, that the patient's emotional, social and educational needs be nurtured concomitant with treatment in order to facilitate the patient's eventual transition back home and everyday life. Studies have shown that VR is directly applicable and effective to pain and anxiety management for wellness [31-33]. ORamaVR has pioneered the development of a novel platform (M.A.G.E.S.™platform [34]) for prototyping any experiential, gamified VR training scenario, from medical-surgical training till recently the anxiety/ motivation management of Alzheimer patients [35]. The key component of M.A.G.E.S. ™ platform lies on the customizable SDK platform able to generate educational training scenarios and immersive experiences with minimal adaptations and code-free due to the Visual Scripting and Rapid Prototyping mechanics. Our modular architecture supports all current and forthcoming VR content generation tecniques. In this work, the VR application layer of the digital tool, prototyped via the M.A.G.E.S.™ platform, provides (i) immersive, gamified educational VR preoperative simulation of the proposed medical procedure in order to familiarize the patients with each step of the patient journey, and (ii) mindfulness/ wellness VR layer for coping with the post-operation effects.

### *3.5 Smart Communication*

The communication pillar provides two modules, the document and multimedia sharing, and the guidance based on evidenced based knowledge. The document and multimedia sharing enhances the communication between the patient and its peers, including the healthcare team, with high-quality content (such as an image of a wound) that can be immediately shared. Based on the condition of the patient, this module provides guidance that follows evidenced based knowledge. A special search engine that provides only validated information to the patient [36-38] has been implemented, based on natural language processing and semantic search [39,40]. Patients can enter key words in natural language and the system provides specific validated resources relevant to the patient need for information. The validation of information comes from the healthcare team that has to provide the content to the system for indexing and retrieval. This module is very important as it provides the tools for patients to interact with their clinical team.

### *3.6 Appointments*

The module for booking a new appointment provides the option to the user to request appointments with the physician. The module also supports simple navigation if accessed by a smartphone that supports GPS sensor.

### *3.7 Decision Support*

This module provides the central knowledge-based system for guidance and support for patient monitoring and management as well as a set of interrelated tools that focus on specific aspects of the decision process. More specifically, based on the collected profiling information for patients, it provides personalized reassuring information about risks, symptoms and psychological support, whereas it will guide doctors about optimal care paths for the individual patient, based on reliable, clinically and scientifically validated care pathways. In addition, it learns from the data gathered from patients, providing them with guidelines on how to return to their daily routine.

### *3.8 Self-assessment Module*

This module enables the self-assessment of patient regarding stress, pain and anxiety during their whole surgery journey. Patients can provide self-assessment information about wound healing and recovery after discharge. All information collected can be instantly visualized for both patients and clinicians whereas the collection of the aforementioned information is implemented through easy to fill questionnaires, mobile phone and smart watch sensors.

In addition, a data sharing module [41] will enable patients to select documents and content from their health record and to

share them with other members or their doctors. Upon selection, the appropriate message will be sent to the recipient and the information will be visible in the recipient's account. The patient can revoke at will this sharing permission. The different modules of the platform will use a data lake that will support interaction among the various components in an integrated way [42]. The web-based platform can be accessed through a mobile phone, a tablet or the VR equipment.

The platform will undergo a usability evaluation [43] to collect user feedback. Input will be implemented until the integrated system reaches an acceptable level of usability.

## 4. Expected Impact

The implementation of the stress relief platform provides evidenced based techniques and methods to support perioperative patients through their patient journey. Emphasis is given on empowerment and self-management turning the focus towards a more holistic approach to the patient experience. Providing education and information in combination with continuous monitoring and personalized assessment and choices enhances the emotional support for the patient towards the upcoming surgery. The implementation of this solution is expected to have an impact on improving patient outcomes, shortening the length of hospital stay, and reducing non-show for the surgical appointment. Patient engagement and patient satisfaction are core drivers for the design of the platform moving towards a more citizen centred approach with the person taking active part in their condition throughout the patient journey.

## 5. Conclusion

This paper presents an overview of the high-level scenario and application components of the applications for stress management in pre-operative contexts. The introduced platform provides innovative functionalities through open source tools, facilitating effective interactions between patients and health professionals. The platform offers psychological and emotional assessment and encouragement tools and promotes health-related behaviours through personalized recommendations. The proposed solution has the potential to improve physical and emotional reactions to stress, increase the levels of calmness and a sense of wellbeing, and empower patients in pre-operative conditions. Information provided through the platform advances and enhances health literacy and digital competence and increases the participation of the patient in the decision-making process. Integration with third-party applications can facilitate the exchange of important information between patients and physicians as well as between personal applications and clinical health systems. The use of the platform does not intend to replace medical practice but contributes towards patient empowerment and self-management acting as a facilitator towards effective management of stress and anxiety.

## 6. Disclaimer

Any opinions, results, conclusions, and recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the projects mentioned within the text or the European Commission.

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