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Stakeholder and patient experience with virtual reality in burn treatment – a study of the Cold River application in a clinical setting

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Summary

The use of virtual reality (VR) in medicine is rapidly expanding, particularly in areas like pain management, surgical training, and mental health therapy. This study examines the implementation and effects of the Cold River VR application, a fully immersive tool designed to help manage pain and anxiety during dressing changes for burn trauma patients in a Czech hospital. The Cold River application immerses patients in a peaceful, interactive virtual environment, utilizing eye-tracking technology to engage them without the need for physical controllers, which could interfere with wound care. The study included 67 participants and found that Cold River effectively distracted patients, making the often painful and anxiety-provoking dressing changes more bearable. While stakeholder interviews indicated that the VR application was generally well-received and seen as a valuable tool in reducing patient discomfort, challenges such as lengthy calibration and occasional issues with nausea and headset discomfort were noted. Importantly, the Cold River application increased patient engagement and reduced the psychological burden associated with burn care, though it also highlighted the need for customization based on individual patient preferences and conditions. Overall, the experience with Cold River suggests that immersive VR holds significant potential for improving patient care during burn treatment, particularly when tailored to specific patient needs and contexts.

Key words

virtual reality – burn treatment – pain – anxiety – stakeholder and patient experiences

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Introduction

The application of virtual reality (VR) across various fields of medicine has experienced exponential growth in recent years [1]. VR is particularly utilized in medicine for surgical training, pain management, and therapeutic interventions for mental illnesses [2]. The origins of VR use in medicine trace back to the early 1990s, driven by the need for medical professionals to visualize complex medical data, especially during surgery and in surgical planning [3]. One of the earliest therapeutic VR applications was SnowWorld, which successfully reduced pain and anxiety during dressing changes for two American teenagers suffering from burn trauma [4].

Burn trauma occurs when the human body is exposed to a threshold level of thermal energy (or, for instance, chemicals) for a sufficient duration, leading to tissue damage [5]. The severity of burns is categorized into up to four degrees. However, trauma does not solely pertain to physical pain; it is equally important to address psychological injuries, which may manifest as heightened anxiety or depression [6], potentially escalating to post-traumatic stress disorder [7]. The intensity of burn pain can significantly impair patients' physical, psychological, and social functioning, drastically diminishing their quality of life [8].

In addition to pharmacological pain therapy for burn trauma patients, there are numerous non-pharmacological interventions (e.g., music therapy, relaxation techniques, hypnosis, and aromatherapy) designed to distract from the sensation of pain. VR appears to be the most promising among these interventions, as it not only distracts from pain but also reduces anxiety symptoms and enhances patient cooperation [9]. Studies also consistently highlight the beneficial role of immersion, i.e., the feeling of being deeply engaged in the VR experience [10].

The potential of VR in managing symptoms in patients with burn trauma, particularly in areas such as pain, anxiety, depression, and fatigue, has garnered considerable attention. Ioannou et al.

Tab. 1. Participant demographic.

	Count	%
Gender		
female	22	33
male	45	67
Age (years)		
18–20	4	6
21–30	7	10
31–40	10	15
41–50	22	33
51–60	11	16
61–70	10	15
71–80	3	4
Education		
primary school	14	21
secondary school	36	54
university	15	22
unspecified	2	3
Total burn surface area		
0–4%	27	40
5–9%	19	28
10–14%	14	21
≤ 15%	6	9
unspecified	1	1
Etiology		
flame burn	32	48
scalding	23	34
electro trauma	6	9
chemical injury	4	6
other	2	3

synthesized findings from 14 studies and emphasized the predominantly positive impact of VR on symptom relief [11]. A notable exception was a study that measured anxiety levels before and after burn wound treatment using VR [12]. This review also highlighted the effectiveness of VR in alleviating pain, particularly among pediatric and adult burn patients. However, one study diverged from the majority by concluding that VR did not have a statistically significant effect on pain reduction [13].

VR alleviates pain primarily by diverting attention. This diversion engages our psychological processes, which compete for the attention typically focused on pain perception, particularly during painful procedures such as regular dressing changes in burn trauma patients. Matsangidou et al. categorized VR strategies for procedural pain management into two groups – basic (i.e., any activity within VR) and advanced distraction techniques using VR [14]. Among the latter, a snowy environment is particularly noted, with studies suggesting that such a setting may induce a sensation of "coolness," which could be associated with pain reduction, especially in burn victims. The Cold River application we utilized was developed based on the player/game/therapy model, which emphasizes the synergy between the player, the game, and therapeutic outcomes [15].

The purpose of this article is to present the use of fully immersive VR in the care of patients during dressing changes within a Czech hospital setting through the VR application Cold River, and to share the experiences of the key stakeholders in our study – namely, the treating physician, nurse, and the patients themselves.

Material and methods

Inclusion and exclusion criteria of the participants

A total of 71 patients from the University Hospital Královské Vinohrady in Prague expressed interest and provided informed consent to participate in this study. However, only 67 participants saw it through to completion (Tab. 1). Before obtaining written consent, every participant received comprehensive information regarding the research's purpose and procedures. No financial inducements were provided to the participants. The research spanned from September 2021 to August 2023. To be eligible, participants needed to meet the following criteria – they must have sustained a thermal injury covering 0.4% or more of their total body surface area (TBSA) and be actively undergoing treatment for it. Conversely, participants were excluded if they had significant burns on the head and face, an acute psychotic disorder, neurodegenerative diseases, or any other neurological conditions that could impair cognitive function.

Stakeholder group identification and definition

The healthcare personnel, including doctors and nurses, who were assigned to the project by the department head as agreed, underwent training focused on the standardized use of VR, including its calibration and the completion of a checklist. This was followed by a pilot test with five participants to verify the entire procedure, including the developing VR application, Cold River. After evaluating and implementing all the feedback (e. g., for better stability, visual skids were added to the boat to enhance the sense of safety and stability in the virtual environment, and more colors were added to positively influence mood), the Cold River VR application was finalized.

Instruments

The main tools for this article include VR and unstructured interviews. The interviews were conducted by the first author of this text (Martin Zielina) with the aim of determining, after all patients in the study had completed the process, what challenges the individual stakeholders, including the attending physician and nurse, encountered during the repeated use of the virtual application for dressing changes in burn trauma patients and how they assess the further use of VR.

Virtual reality

VR comprises both hardware and software components. In our study, the hardware used included the HTC® Vive

Pro Eye HMD (HTC Corporation, Taiwan), which integrates Tobii® eye-tracking technology (Fig. 1). This device features dual OLED displays with a resolution of 2,880 × 1,600 pixels (615 PPI) and is equipped with 3D spatial sound, providing an immersive audio experience. For the software, we utilized the Cold River application to create a highly immersive virtual environment [16].

Fig. 1. HTC® Vive Pro Eye VR headset with controllers and base stations [31].

Cold River

We named the VR application Cold River because it immerses the patient in a serene experience of floating down a river in a small boat, peacefully drifting through a landscape at the cusp of winter and spring. Through the headphones, the patient hears not only the gentle sounds of flowing water but also the chirping of birds. Along the riverbanks, there are rocky outcrops adorned with mysterious symbols, hot air balloons hovering overhead, and occasionally, colorful crystals appear. The patient interacts with the virtual environment solely through eye movements, thanks to an integrated eye-tracking camera, and is rewarded with points for their curiosity. This represents a revolutionary approach compared to existing applications, where navigation in VR has traditionally been controlled by handheld devices, requiring significant movement that could interfere with wound care. Additionally, before each use, the VR headset is sterilized to prevent the potential transmission of infection. Sterilizing the controllers would further increase the time required to use the VR technology. The revolutionary aspect of this technology also lies in the installed eye-tracking camera within the headset, which responds only to eye movements, allowing the patient to interact freely and without restrictions with the digital environment. This effectively engages their attention, leaving less capacity to perceive pain and anxiety during dressing changes. Patients can also choose to stop at virtual ports to play mini-games, such as feeding animals or throwing snowballs at snowmen. Users can view the landscape in 360°, and to enhance the feeling of safety, they can even see a life jacket on their virtual body. The virtual environment is cool, dominated by cool-toned colors [17], or it features a snowy setting inspired by previous hypnotherapy practices used with patients for inducing local anesthesia [18]. In developing the Cold River therapeutic VR game for burn trauma patients, we utilized the Player-Game-Therapy model [15].

Procedure

Each participant underwent two dressing sessions, with a segment of each incorporating immersive VR (Fig. 2). The experimental group was subjected to a high-immersion VR environment (Cold River), whereas the control group was exposed to a low-immersion environment featuring static images. Additionally, both groups underwent a dressing session without any VR intervention. We employed a repeated-measures crossover design.

Upon providing informed consent, participants were sequentially assigned to either the experimental or control group. Both groups underwent identical procedures, differing only in the content displayed through the head-mounted displays (HMD) with eye-tracking. Each participant attended two consecutive wound care sessions, which consisted of dressing removal, wound cleaning, and the application of new dressings. VR was incorporated into one segment of each session – either during the initial phase (dressing removal) or the concluding phase (wound cleaning and new dressing application). In their subsequent sessions, participants experienced VR during the segment opposite to their initial session. The experimental group viewed a highly immersive environment we called Cold River, while the control group was presented with static images within the virtual environment (Fig. 3).

Results

Participant demographics and burn characteristics

The demographic characteristics of the study participants are presented in Tab. 1. The study included 67 participants, with a gender distribution of 33% female and 67% male, an age range of 18 to 74 years, with an average age of 46.46 (SD = 14.61). In terms of education, 54% had completed secondary school, 22% had a university degree, and 21% had completed primary school. Regarding TBSA, 40% of participants had burns covering 0–4% of their body surface,

Fig. 2. Changing dressings with VR.

while 28% had 5–9% TBSA, and 21% had 10–14% TBSA. The primary etiology of burns was flame burns (48%), followed by scalding (34%) and electro trauma (9%). The mean duration of the VR experience was 17.26 min (SD = 7.22).

Experience of stakeholders with the VR application

Following the conclusion of the study, interviews were conducted with the key stakeholders who were present during most of the dressing changes and thus have the most extensive experience with implementing VR into the care of burn trauma patients during these procedures. In the final section, we provide an overview of the predominant reactions from patients who took the opportunity to share their personal experiences with VR.

Treating physician

The physician noted that some patients were uncomfortable with the winter landscape because, given their lack of epidermis, they felt cold. In this context,

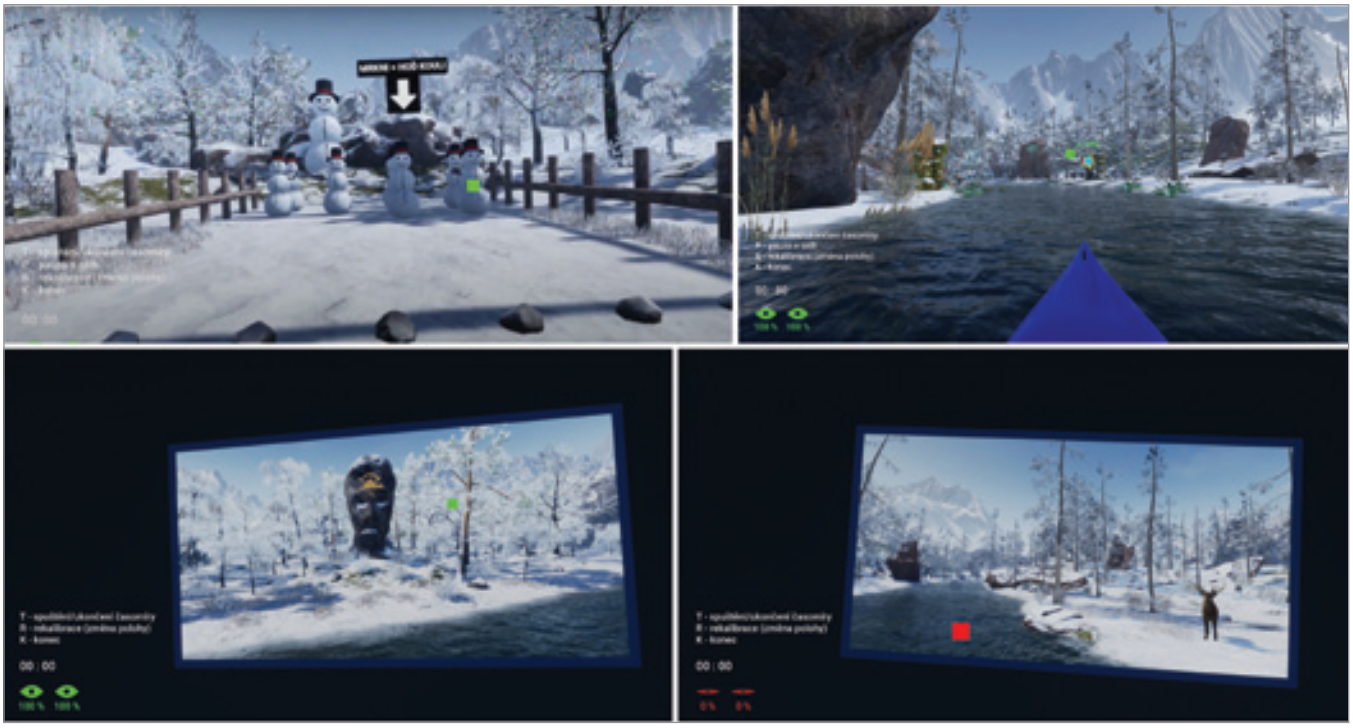

Fig. 3. At the top are images from the interactive, highly immersive VR application Cold River (experimental group), and at the bottom are low-immersive static images (control group).

she suggested that it might be more appropriate to increase the perceived temperature and emphasize the spring season instead. She also mentioned that some patients were upset when they were assigned to the control group, which did not allow them to experience the fully interactive virtual environment. The doctor noted that the most bothersome aspect for healthcare providers was sometimes the lengthy calibration process of the VR goggles. This calibration process also excluded patients with burns on their hands, as they were unable to assist with the calibration due to the fine motor skills required to turn the knob. The application seemed to be more appealing to men; however, there are generally fewer female burn patients.

Some patients experienced nausea, which could have been triggered by the water or the boat they were floating on in the virtual environment. The boat's implied rocking motion could also have contributed to feelings of nausea, according to the doctor. Additionally, the suitability of patients varied depending on the number of participants, some of whom were foreigners and not ideal respondents for this study. The study also excluded patients who had upper limb impairments or suffered from epilepsy. Out of all the patients approached, only about two declined participation. However, most were eager to try it, as they were often bored in the ward. In the past, patients could engage in various work activities, which they would also request themselves.

Initially, VR complicated the dressing changes, but this gradually improved as the staff became more accustomed to it through daily practice. The doctor also appreciated that they didn't have to engage in as much conversation with the patients, as sometimes healthcare workers lack the mood, time, or energy for extensive interactions. In this regard, VR served as a useful tool. Patients also tolerated the dressing changes better with VR and, in some cases, even looked forward to the next VR-assisted session. On the other hand, the doctor does not believe that VR had any impact on the healing process itself, but it did keep the patients more entertained. She concluded that while VR influenced the course of the dressing change, it did not affect the actual healing of the wounds. She also appreciated the study's design, which allowed patients to see their bandaged wounds. The doctor even speculated that if patients had not been able to see their wounds in this way, they might not have been as eager to participate in the study. The most painful part is the removal of bandages and the cleaning of the wounds. Overall, the doctor evaluated the integration of VR positively: "It's useful, it suits our needs. Especially for children. Patients particularly liked the snowmen."

Treating nurse

The treating nurse noted that during the study, she transitioned to working in the outpatient clinic, but whenever there was a need for dressing changes related to the study, she would always return to the dressing room. She further stated that it was not always possible to strictly follow every protocol due to the need to adapt to the current conditions during the dressing changes. For the nurse, this was an interesting and new experience in dealing with burn patients. However, she immediately mentioned that, especially at the beginning, it was challenging to become familiar with the documentation, fill it out correctly, and ensure that the correct procedures were followed without making mistakes. According to the nurse, it is one thing to be shown how to do it, and another to adhere to it precisely under time pressure. She admitted that it was stressful at first, but over time, she got used to it.

Another stressful aspect was learning to operate the VR application. While it was not overly complicated, remembering to first turn on the VR, then calibrate it, and manage the timers during dressing changes added to the complexity. Calibration could sometimes be a nightmare, and there were times when they had to give up (the nurse set a maximum of 30 min for calibration because patients would start sweating and become anxious, feeling it was their fault; for the nurse, this was stressful because she was exhausted from both the calibration and calming the patient, and even when successful, both she and the patient were worn out).

Even though the work was divided among the staff (one nurse was responsible for the practical part, another for documentation, and the physician for patient selection), coordinating their efforts was sometimes very challenging, especially when there was an influx of patients.

The nurse described the patients as generally cooperative. Despite receiving analgesics, the dressing changes were still painful and demanding for the patients. According to the nurse, VR helped to distract the patients mentally, allowing them to perceive less pain. Based on her experience, the nurse would recommend using VR for large and extensive dressing changes. She also found that VR had the advantage of reducing the need for conversation, allowing her to focus more on the dressing change itself. For her, this was a mental and verbal relief. The nurse noted that she also had more time to focus on herself. She recalled five patients who strictly refused VR during the project, stating that they didn't see the point or that it made them feel sick. There were occasional uncomfortable situations when patients in the same room were split between the experimental and control groups. Sometimes this was amusing. In cases where patients protested, the nurse managed by honestly explaining that they received what was assigned to them according to the study protocol. Patients differed in that some wanted to experience VR again, even after completing all dressing changes in the study, while

others were glad when their VR experience ended after the second session.

The nurse believes that VR is not suitable for the elderly or for people in states of anxiety, who have an increased need to control the situation, including monitoring the dressing process. When asked whether VR should be used only for part of the dressing change or throughout the entire procedure, the nurse thought it should vary from patient to patient. Some patients wanted to see the dressing process, while others preferred not to. According to the nurse, dressing changes also vary in terms of pain, and it is impossible to predict in advance how a patient will react to their burned areas during the change. This could often be discerned non-verbally, even when patients were wearing the VR headset. There might be just a brief moment, but then they would quickly re-engage with the game. Sometimes, they might even vocalize their discomfort with a brief "ouch." The only time VR couldn't be used was when patients had to lie on their stomachs. In such cases, they always tried to position the patient in a semi-sitting posture.

The greatest challenges occurred at the beginning when they were learning to navigate the study design in all its aspects, properly manage their time, and learn how to interact with the patients. This experience highlighted the importance of organizing everything efficiently. The nurse also emphasized the strong support she received in the workplace and that she always had access to everything she needed. Nevertheless, there were far more dressing changes done without VR than with it. This was due to several exclusion criteria, such as various psychiatric diagnoses, visual impairments, bandaged fingers that prevented fine motor skills during calibration, epilepsy, or language barriers.

The nurse doesn't recall any explicitly negative reactions. In her view, one could say there was a mix of positive and somewhat negative responses. A certain group of patients was disappointed that they only had static images. On the other hand, younger patients who had the experimental application found it enjoyable. There were also neutral patients, as well as those who did not wish to comment on the experience.

Patients

After each dressing change, patients completed a series of questionnaires and had the opportunity to provide feedback on the study. Since every patient enrolled in the study underwent the dressing change procedure twice, they had repeated opportunities to share their thoughts. Not every patient chose to use this option, but the majority did, and overall, their reactions were positive. However, there were also several neutral comments, and some feedback was rather negative.

In terms of positive responses, patients particularly appreciated how VR distracted them from the procedure (e. g., "The experience was beautiful for me because I saw a stunning winter landscape and didn't think about the dressing change at all," or "When I had the headset on, I didn't even notice that they were doing anything to me"). This distraction made the dressing change more bearable for many and alleviated their distress (e. g., "Thanks to VR, I completely forgot about the real world and didn't have to focus on my injury. I didn't have to look at the wound, and I felt much less anxious," or "VR was fun; it was a nice change and an excellent way to relax – good for a laugh").

There were also several neutral reactions, where patients indicated that VR did not particularly engage them ("Unfortunately, VR didn't interest me much. I was already in a milder stage of healing"). Besides the healing progress, a significant factor influencing patients' reactions was whether they were placed in the experimental group, where they could experience a highly immersive virtual environment, or in the control group, where they only saw static images. Some patients in the control group felt that the static images did not meet their expectations of VR (e. g., "The images kept repeating. I might as well have looked at the pictures in the doctor's office, and it would have been the same," or "Virtuality needs a story, energy, and impact. It can't just be flipping through images – without sound"). Some expectations were beyond what the current VR application could fulfill (e. g., "I would have liked more images or programs with different seasons, complemented by relaxing music").

Finally, the negative feedback mostly concerned the physical aspects of VR (e. g., "The headset is heavy and difficult to put on," or "My glasses fogged up during the VR session"). Another group consisted of patients with heightened anxiety, who admitted that they needed to have control over the dressing change, which VR distracted them from (e. g., "When I had the headset on, I felt more afraid and uncertain about what was happening to me. When they took it off, I felt calmer because I could see the cleaning process," or "At first, it was fine, but during the treatment, VR annoyed me – I couldn't communicate well and couldn't prepare for the pain or gauge how much longer it would take. I'm someone who has difficulty relaxing and likes to have things under control. I think it's great for children and other personality types"). There were also occasional complaints about nausea ("During the VR session, I felt quite nauseous, started sweating, and felt slightly dizzy. After removing the VR headset, I felt fine, and everything went smoothly. I didn't feel much pain during VR. If I hadn't felt sick, it would have been a good way to relax the patient") or the loss of contact with the caregivers (e. g., "Perhaps [in my opinion] there was a lack of contact with the caregiver – the headphones drown out communication").

Discussion

Stakeholders and participants in this study agree on the positive effects that

VR can offer burn trauma patients during dressing changes. However, it is important to distinguish between the different technologies collectively labeled as VR. With the rapid advancement of VR technology, it is crucial to distinguish between its various definitions and technological improvements. In contemporary VR, high-resolution HMD have become the norm [19]. The fundamental principles of VR are presence, immersion, and interactivity [20]. Presence refers to the sensation of being in a particular place, even when physically located elsewhere [21]. Immersion encompasses both the technical configuration of the VR system and the user's engagement within that virtual realm [22]. This heightened sense of immersion can be facilitated by a user's unfamiliarity with VR and gaming [23]. Interactivity assesses the capabilities of users to manipulate the virtual environment [24]. Although VR can be immersive or non-immersive [25], immersive interventions, especially fully immersive ones, have been found to be more effective in reducing burn pain intensity [26]. In the context of burn patient dressings, the most substantial pain control benefits derive from fully immersive and interactive VR [27].

There is also consensus among stakeholders and participants regarding the weaknesses associated with the use of VR in this study. The main issues can be summarized as cybersickness, calibration problems, the weight of the VR headset, the unsuitability of the VR headset for patients with heightened anxiety, and older age related to vision difficulties. The side effects of using VR are generally very minor, with a reported low incidence of 0 to 8% [28], and the most common ones include nausea, vomiting, eye strain, and dizziness, which are collectively referred to as cybersickness [29]. This phenomenon is most explained by the sensory conflict theory. This refers to the discrepancy that occurs between the ocular and vestibular systems when the senses do not receive the usual sensory feedback that would be expected in such a scenario. This lack of synchronization is believed to cause cybersickness [30].

The calibration challenges primarily stemmed from the necessity to standardize the correct placement of the VR headset for the study. To address this, healthcare personnel assisted not only with the application of the headset but also with the calibration of the eye-tracking camera. This process was often complicated by the participants' inexperience. Additionally, the calibration instructions were displayed solely within the VR headset, leaving healthcare staff to rely on verbal descriptions, which did not always facilitate an accurate calibration. In some cases, the calibration process was unsuccessful. Another complication involved the weight of the headset, which was particularly noticeable to some participants during extended use, especially when considering the various positions required for wound care. Several participants reported increased anxiety when they lacked visual control over the dressing change, which limited the benefits of VR for these individuals. Lastly, it is important to note that visual impairment, often associated with older age, posed a significant challenge. To maintain standardization, these participants typically required a much longer calibration process.

Conclusion

The study's findings highlight that Cold River effectively distracted patients, making the painful and anxiety-inducing dressing changes more tolerable for many. Stakeholder interviews revealed that while the VR application was generally well-received and considered a valuable tool in reducing patient discomfort, there were challenges such as the lengthy calibration process and occasional issues with nausea and headset discomfort. Importantly, the Cold River application allowed for greater patient engagement and lessened the psychological burden associated with burn care, though it also underscored the need for customization based on individual patient preferences and conditions. As part of future development, there are plans to adapt Cold River for use in low-cost VR headsets to reduce the weight of the device and make it accessible for outpatients.

Roles of the authors

Martin Zielina – conceptualization (lead), writing – original draft (lead), methodology (lead), writing – review and editing (equal), interview (lead);

Robert Zajíček – writing – review and editing (equal), methodology (supporting), supervision (equal);

Břetislav Lipový – writing – review and editing (equal), methodology (supporting), supervision (equal).

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References

1. Yeung AW., Tosevska A., Klager E., et al. Virtual and augmented reality applications in medicine: analysis of the scientific literature. *J Med Internet Res.* 2021, 23(2): e25499.

2. Li L., Yu F., Shi D., et al. Application of virtual reality technology in clinical medicine. *Am Transl Res.* 2017, 9(9): 3867.

3. Chinnock C. Virtual reality in surgery and medicine. *Hosp Technol Ser.* 1994, 13(18): 1–48.

4. Hoffman HG., Doctor JN., Patterson DR., et al. Virtual reality as an adjunctive pain control during burn wound care in adolescent patients. *Pain.* 2000, 85(1–2): 305–309.

5. Lipový B., Suchánek I., Gregorová N. Doživotní následky po popálení jako trest za neposlušnost. *Pediatr Praxi.* 2011, 12(3): 199–200.
6. Herndon DN., Ross E., Blears EE. Challenges and opportunities in contemporary burn pain management. *Pain Medicine.* 2018, 19(4): 641.
7. Spronk I., Polinder S., Van Loey NE., et al. Health related quality of life 5–7 years after minor and severe burn injuries: a multicentre cross-sectional study. *Burns.* 2019, 45(6): 1291–1299.
8. Gauffin E., Öster C., Sjöberg F., et al. Health-related quality of life (EQ-5D) early after injury predicts long-term pain after burn. *Burns.* 2016, 42(8): 1781–1788.
9. Scapin S., Echevarría-Guanilo ME., Junior PR., et al. Virtual reality in the treatment of burn patients: a systematic review. *Burns.* 2018, 44(6): 1403–1416.
10. Triberti S., Repetto C., Riva G. Psychological factors influencing the effectiveness of virtual reality-based analgesia: a systematic review. *Cyberpsychol Behav Soc Netw.* 2014, 17(6): 335–345.
11. Ioannou A., Papastavrou E., Avraamides MN., et al. Virtual reality and symptoms management of anxiety, depression, fatigue, and pain: a systematic review. *SAGE Open Nurs.* 2020, 6: 2377960820936163.
12. van Twillert B., Bremer M., Faber AW. Computer-generated virtual reality to control pain and anxiety in pediatric and adult burn patients during wound dressing changes. *J Burn Care Res.* 2007, 28(5): 694–702.
13. Kipping B., Rodger S., Miller K., et al. Virtual reality for acute pain reduction in adolescents undergoing burn wound care: a prospective randomized controlled trial. *Burns.* 2012, 38(5): 650–657.
14. Matsangidou M., Ang CS., Sakel M. Clinical utility of virtual reality in pain management: a comprehensive research review. *Br J Neurosci Nurs.* 2017, 13(3): 133–143.
15. Mader S., Natkin S., Levieux G. How to analyse therapeutic games: the player/game/therapy model. *International Confererence on Entertainment Computing* 2012.
16. Zielina M., Šmahaj J., Raudenská J., et al. Využívání a vytváření terapeutických her ve virtuální realitě a model hráč/hra/terapie. *Ceskslov Psychol.* 2022, 66(3): 332–348.
17. Wang H., Liu G., Hu S., et al. Experimental investigation about thermal effect of colour on thermal sensation and comfort. *Energy Build.* 2018, 173: 710–718.
18. Wain HJ., Amen DG. Emergency room use of hypnosis. *Gen Hosp Psychiatry.* 1986, 8(1): 19–22.
19. Trost Z., France C., Anam M., et al. Virtual reality approaches to pain: toward a state of the science. *Pain.* 2021, 162(2): 325–331.
20. Mütterlein J. The three pillars of virtual reality? Investigating the roles of immersion, presence, and interactivity. *Hawaii International Conference on System Sciences* 2018.
21. Witmer BG., Singer MJ. Measuring presence in virtual environments: a presence questionnaire. *Presence.* 1998, 7(3): 225–240.
22. McMahan A. Immersion, engagement, and presence: a method for analyzing 3-D video games. *The Video Game Theory Reader: Routledge* 2003: 67–86.
23. Geslin E., Bouchard S., Richir S. Gamers' versus non-gamers' emotional response in virtual reality. *J Cyberther Rehabil.* 2011, 4(4): 489–493.
24. Jarvis L. Narrative as virtual reality II: revisiting immersion and interactivity in literature and electronic media: by Marie-Laure Ryan, Baltimore, John Hopkins University Press, 2015, 304 pp. Taylor & Francis, 2019. *Int J Perform Arts Dig Media.* 2019, 15(2): 1–2.
25. Le May S., Tsimicalis A., Noel M., et al. Immersive virtual reality vs. non-immersive distraction for pain management of children during bone pins and sutures removal: a randomized clinical trial protocol. *J Adv Nurs.* 2021, 77(1): 439–447.
26. Felnhofer A., Weiss L. Overcoming pain with virtual reality: exploring the potential of VR as a tool for pediatric pain management. *Dig Psychol.* 2023, 4(1): 27–34.
27. Hoffman HG., Rodriguez RA., Gonzalez M., et al. Immersive virtual reality as an adjunctive non-opioid analgesic for pre-dominantly Latin American children with large severe burn wounds during burn wound cleaning in the intensive care unit: a pilot study. *Front Hum Neurosci.* 2019, 13: 262.
28. Smith V., Warty RR., Sursas JA., et al. The effectiveness of virtual reality in managing acute pain and anxiety for medical inpatients: systematic review. *J Med Internet Res.* 2020, 22(11): e17980.
29. Almeida A., Rebelo F., Noriega P., et al. Virtual reality self induced cybersickness: an exploratory study. *Springer International Publishing* 2018.
30. Shafer DM., Carbonara CP., Korpi MF. Modern virtual reality technology: cybersickness, sense of presence, and gender. *Media Psychol Rev.* 2017, 11(2): 1.
31. VIVE [online]. Available from: https://www.vive.com/us/newsroom/2020-03-02/.

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