Patients' Acceptance regarding the Implementation of Virtual Reality in Cancer Treatment: A Systematic Review

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Abstract

Background. This review aimed at providing an overview of cancer patients' perceptions of the implementation of virtual reality (VR) technologies during their treatment. VR was used in interventions to improve patients' treatment conditions. Thereby patients' verbal reactions were examined firstly regarding their perception of non-immersive and immersive VR. Secondly, their comments were compared in regard to either psychoeducation- or distraction VR interventions.

Methods. The database Scopus was searched and studies that (1) provided qualitative information of patients' perceptions about VR in cancer treatment (2) either using non-immersive videos or any kind of immersive VR; (3) administered VR alone or in combination with other treatments, and included (4) all types of cancer and all ages of cancer patients were selected for this review.

Results. 15 studies were selected with samples from 7 to 180 participants. (1) Patients' verbal reactions were predominantly positive, with no differences in perception or acceptance toward either non-immersive or immersive VR. (2) 7 studies conducted psychoeducation VR interventions and 8 studies examined distraction VR interventions. VR interventions yielded positive effects that were confirmed by patients' comments.

Conclusion. This review's results are in favor of the VR technology and can be used as a basis for future research. Nevertheless, a few negative comments concerning VR lead to the assumption that the interventions need to be individually tailored. This should be respected to extend patients' treatment adherence. Limitations result from the quality of selected studies and findings could not be generalized to the entire cancer community. For future research, results from a broader population should be examined in mixed methods to state certain recommendations regarding the implementation of VR in oncological treatment.

Keywords: virtual reality, acceptance, perception, cancer, oncological treatment, cancer patients, distraction, psychoeducation, a review

Introduction

The development of new technologies is growing fast and various domains make use of the novel machineries. In particular, virtual technologies have been effectively adopted in automobile design processes, military simulation purposes as well as in medical contexts (Mazuryk & Gervautz, 1996). Virtual reality (VR) can be defined as a non-invasive simulation technology that uses three dimensions (width, length, depth) to establish a real-time digital environment (Bani Mohammad & Ahmad, 2019). There exist two types: the first, immersive type uses full immersion by implementing a head-mounted display (HMD), which presents the user with a digital world. By tracking a user's head movement, it creates a sense of actual presence in the new environment. In other words, people feel placed into another world. The second approach is a non-immersive system that uses computer screens and keyboards to allow interaction between the user and the external, virtual environment on a 2D basis. It is assumed that non-immersive VR does not create as adequate feelings of presence as immersive VR; leading to lower levels of interaction between a person and the technology (Shahrbanian et al., 2012). But, according to Tiiro (2018) the use of immersive VR and an HMD poses a higher risk of experiencing cybersickness with the symptoms such as a headache, nausea, and vomiting. Nevertheless, both types have reached a high value in the entertainment industry before they were also recently adopted in medical contexts (Li, Montaño, Chen, & Gold, 2011).

In clinical settings, VR has been proven to effectively attenuate pain, for instance in painful burn wound care, acute, and chronic pain treatment (Rutter, Dahlquist, & Weiss, 2009). Also, levels of anxiety have been decreased by using VR, which enhances patients' willingness to cooperate during medical procedures (Li et al., 2011). Furthermore, patient acceptance ratings of VR technologies in lower-back pain rehabilitation are promising (Su, Yeh, Lee, & Huang, 2015). Hence, interests are rising for further implementation of VR because it is an effective, frequently accepted, non-pharmacological intervention with high flexibility for individual tailoring. Particularly in oncological contexts, VR can achieve non-pharmacological analgesic effects in acute pain experiences during treatment, like chemotherapies or cancer related surgeries. Moreover, in a study by Chirico et al. (2019) VR effectively decreased breast cancer patients' anxiety as well as negative mood states. Concluding, studies have demonstrated that VR positively affects patients' physical as well as psychological health.

Even though quantitative measurements show beneficial effects of VR, for example, a reduction in patients' fear and pain, the question remains: how do patients experience and perceive the new technology and its effects during their hospitalization? Baños et al. (2013)

support the positive view of VR as an adjunct in cancer treatment from patients' perspective. According to their research, patients evaluated VR (on the "satisfaction with intervention scale") as "moderately positive" (Baños et al., 2013, p. 266). But patients' opinions, in form of qualitative measurements, about the new technology have been less sufficiently explored. The qualitative perspective is favorable because it gives in-depth knowledge about multiple individual perceptions, feelings and experiences (Shidur Rahman, 2016). Qualitative data offers the possibility to interpret humans' actions as seen in the case of VR implementation as adjunct to cancer treatment.

The aim of this review is to give an overview of patients' perceptions of the implementation of non-immersive and immersive VR technologies in cancer treatment. Further, it also aims to give an explanation for the beneficial effects of VR that were measured quantitatively. Therefore, it will be focused on patients' acceptance on a qualitative level that is presented in verbal reactions toward VR during cancer treatment. This review's results can be used by intervention designers as well as physicians who would like to use technique-based interventions in their clinic. The acceptance of VR may contribute to an improvement of treatment conditions which yield beneficial effects for the adherence as well as the chances of successful recovery which is the overarching goal in fighting cancer.

The adherence to treatment plays a considerable role in the success of fighting cancer because interruptions or terminations can lead to treatment failure and decreased rates of survival (Schneider & Hood, 2007). But current treatment conditions often prevent adequate adherence. Constant worrying about additional pain and tense feelings about the future can introduce pathological levels of anxiety and usual functioning is significantly impaired (Pitman, Suleman, Hyde, & Hodgkiss, 2018). Aversion regarding chemotherapy additionally complicates motivation and adherence to the treatment. Hence, adjunctive interventions like VR might be a solution if they are accepted by patients. The facilitation of adherence supports optimal health outcomes, and further lead to improved cancer patients' recovery.

To promote patients' adherence and mood states during cancer treatment, VR has been implemented in form of interventions. The most prominent method is the use of VR as distraction. Distraction can be defined as non-pharmacological technique to divert an individual's attention away from a certain stimulus (Windich-Biermeier, Sjoberg, Dale, Eshelman, & Guzzetta, 2007). The effectiveness of VR as distraction to reduce pain anxiety during chemotherapies and cancer surgeries has been validated (Zeng, Zhang, Cheng, Cheng, & Wefel, 2019). But the true working mechanism of distraction in patients' pain perceptions has not been evidenced yet but many theories have been proposed to further explain it. The

theoretical stress and coping model by Lazarus and Folkman (1984) supposes if people perceive a stressful situation as unwinnable, they turn automatically to emotion-focused coping. One emotion-focused strategy is distraction: by changing thoughts, attention is shifted away from the disturbing stimuli and the individual can to some extent stop dealing with it. Therefore, distraction interventions are supposed to be effective in relieving some physical symptoms and help endure stress- or painful situations, like procedures in cancer treatment. Another theory suggests that humans possess a limited capacity for attention (Windich-Biermeier et al., 2007). Meaning, if attention is shifted away from pain, less cognitive capacity is available to concentrate on it. However, many studies have used distraction interventions to attenuate pain (Kwekkeboom, Hau, Wanta, & Bumpus, 2008; Shrimpton, Willis, Tongs, & Rolfo, 2013; Windich-Biermeier et al., 2007). But in order for distraction to work people need to engage with the technology in a way that they reach high levels of interactivity (Hoffman et al., 2008). If an appropriate level of engagement with VR is reached, patients are successfully distracted; leading to pain relief and further to decreased levels of anxiety toward the treatment. The reduction of negative mood states heightens chances of treatment adherence that is necessary for a patient's recovery (Greer et al., 2008).

Another method to implement VR in cancer treatment and support the attenuation of anxiety is via psychoeducation interventions. Those interventions mainly provide information about the disease, the treatment, and ways to improve patients' recovery (Northouse et al., 2014). By gaining more knowledge about their procedure, patients' confusion and uncertainty are minimized (Matsuda, Yamaoka, Tango, Matsuda, & Nishimoto, 2014). This often leads to lower levels of anxiety prior to the treatment because patients feel prepared for the process. Knowledge that is received during treatment can elicit valuable responses, like adopting appropriate behaviors, motivation to continue and adhere medical care. Recently, VR has also been implemented in this type of intervention to support its effectiveness. One specific form of psychoeducation via VR is called Virtual Environment Radiotherapy Trainer (VERT) and has been originally used for the education of medical students and therapists (Boejen & Grau, 2011). Studies show that patients also profit from the program because the technology facilitates gaining knowledge regarding their procedure; leading to lower scores in anxiety as well as higher levels of satisfaction with the treatment procedure (Jimenez et al., 2018). Therefore, psychoeducation delivered via VR technology yields beneficial effects for cancer patients, which heightens the chances for successful treatment (Northouse et al., 2014).

In summary, patients' acceptance of VR interventions plays an important role regarding their adherence to treatment which needs to be considered by intervention designers as well as

physicians who would like use technology-based interventions in their clinic. Previous reviews have mainly focused on the effectiveness of VR interventions from a quantitative viewpoint, therefore, do not examine patients' qualitative perspective. Although, it has been assumed that only immersive VR creates feelings of presence, non-immersive VR technologies have also been proven to work effectively; therefore, patient reactions might give more insight into the individual perception of each technology. Moreover, both VR interventions, distraction and psychoeducation, the software that is presented to patients via the technology will differ which may lead to differing reactions. Hence, it is important to gather insight into differences and similarities of distraction and psychoeducation via non-immersive and immersive VR. Following research questions have been posed to elaborate on the qualitative view of involving VR in cancer treatment. The first research question is:

"What is the perception and acceptance of cancer patients regarding the implementation of non-immersive and immersive VR technologies in their treatment?". The second research question is:

"What are the differences and similarities in patients' perception and acceptance regarding distraction and psychoeducation interventions delivered through VR technology?".

Methods

Study design

This study was performed by using a structured data collection within the database Scopus. The method of a systematic review was adopted by following the PRISMA statement to evaluate the implementation of VR in cancer treatment (Moher, Liberati, Tetzlaff, & Altman, 2009) (Figure 1).

Search strategy

The search string involved a combination of (*"virtual reality"* OR *virtual* OR *videogame*) AND (*cancer* OR *oncolog**) AND (*treat** OR *care* OR *di straction* OR *psychoeducation*) AND (*patient* W/4 (*perception* OR *interview** OR *acceptanc e* OR *experience*))) and were used in one database (Scopus) covering the timeline from 2000 to 2019 and only including English written- and peer-reviewed articles. Due to the fast development of technology, patients' reactions to VR technologies before 2000 are not adequately comparable to more modern VR. That is the reason why it has been decided for this

timeline. Additional sources have been retrieved from reference lists of included (journal) articles. Articles were included in the review if they (1) provided qualitative information of patients' perception about VR in cancer treatment (2) either using non-immersive video games or any kind of immersive VR; (3) administered alone or in combination with other treatments. Additionally, (4) all types of cancer and all ages of cancer patients were included. Exclusion criteria involved (1) articles only using quantitative data, (2) providing psychoeducation to medical students or doctors and (3) that were systematic reviews or meta-analyses.

Data analysis

From chosen abstracts, the author selected full text articles for the review which suit the inclusion and exclusion criteria. For further analyses, patients' interview answers were categorized by using codes. By comparing original codes, that were created by the authors of selected studies, a brought variety of themes was discovered. Due to the detection of only few overlaps between the original codes, new codes were created in a secondary coding scheme to link the original ones together. A bottom-up approach was applied, because the codes were created based on the interview extracts from included studies. All interview extracts were read precisely and main topics were written down. Afterwards, main topics were compared and new codes were created to combine them. On this basis, the following coding scheme was established (see Table 1). The coding scheme is presented in a table format with examples of interview extracts and the overall codes' frequencies. Meaning, how many studies mentioned the code in their interview abstracts.

Retrieved articles were sorted in a table stating descriptive components like title, included cancer type, sample size, type of VR, and codes that were addressed during interviews; with authors listed alphabetically (see Table 2). This step was implemented to create an overview of included articles as well as to answer the first research question.

To ease the comparison of data in psychoeducation interventions and distraction ones and to answer the second research question, a second table was created with type of VR hardware, type of software, in other words, which content the patients saw and experienced in the VR sessions, and interview codes (Table 3). In this table articles were sorted by first stating studies using psychoeducation interventions, then studies using games in connection to psychoeducation and finally distraction interventions.

Results

In total 124 potentially relevant articles resulted from the search, the selection of articles is displayed in a PRISMA flow diagram (see Figure 1). After duplicates were removed, titles were screened, and 76 studies were eliminated from the review. Remaining were checked further by abstract, 13 were removed and the rest of 21 were full text reviewed. 15 studies remain that meet all the inclusion criteria and are used in the following review. Many studies had to be excluded because they explored VR technologies in training of medical students and doctors. Another reason for exclusion was the use of solely reporting quantitative data. Table 1 shows examples of code translation from original codes to the new created ones. This step had to be implemented to compare the studies with each other and to answer the study's research questions.

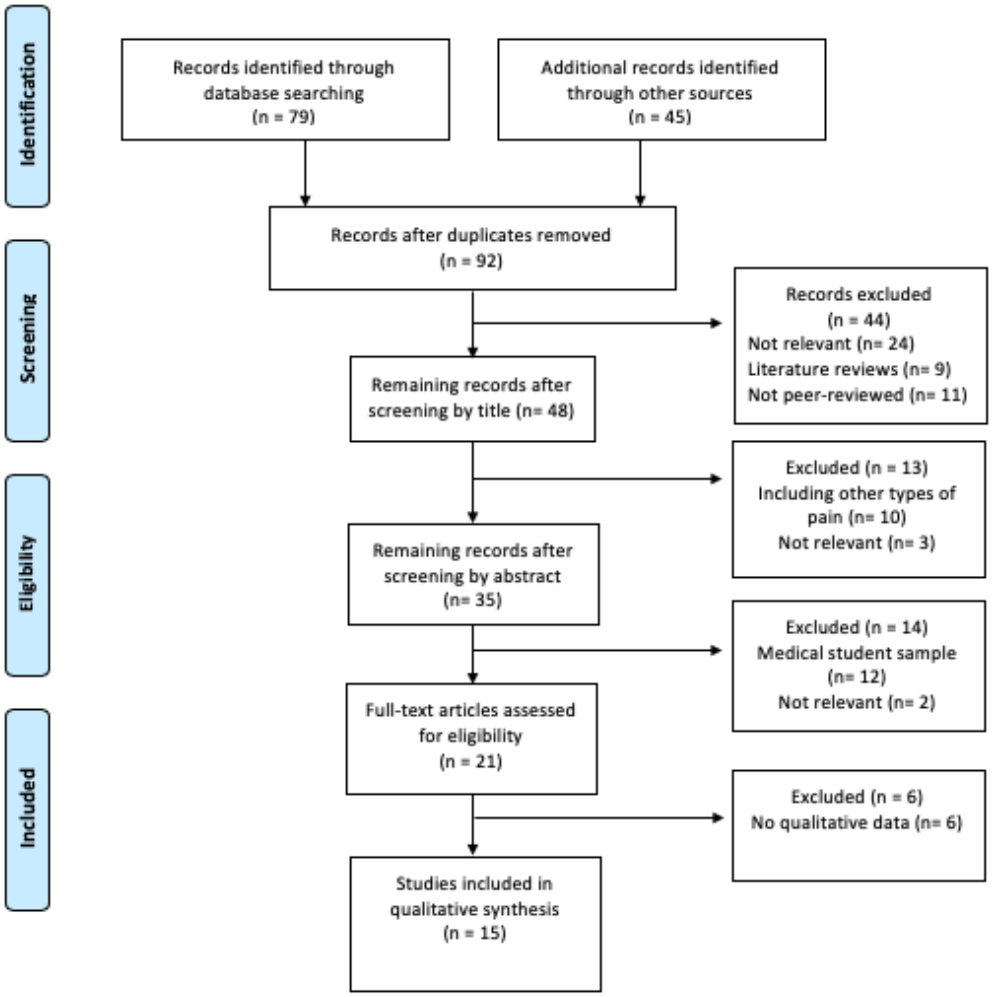

Figure 1. PRISMA flow diagram of study searching process.

Table 1. *Translation of original codes into new codes with examples of interview quotes and the frequency of new codes in selected studies.*

Original codes and themes of interviews	New codes (frequency)	Definition	Examples of interview quotes
Believability and value Game outcomes consequences of improved cancer knowledge Self and others Enjoyment and distraction value Emotional care	Perceived working mechanisms (9)	Patients' experiences during the implementation of VR and perceived consequential effects	- "I think it was reassuring to know I was getting reliable information to the questions that I was seeking answers to." (Loiselle et al., 2013) - "Wanted full information which I received" (Stewart-Lord et al., 2016) - "Totally distracted, took my mind off the procedure" (Windich-Biermeier et al., 2007) - "It kind of took me out of this place for a bit" & "you're not here, you're in another world" (McCabe, Roche, Hegarty, & McCann, 2011) - "One is concentrated on the game and doesn't notice the needle" (Nilsson, Finnström, Kokinsky, & Enskär., 2009) - "It's like you're there.", (Wint, Eshelman, Steele, & Guzzetta, 2002)
Expressed willingness to play Acceptability of game content	Acceptance (9)	Patients' evaluation of VR, like and	- "I would use it and then use other things to [help me] make a decision." (Reichlin et al., 2011)

Access to right amount and type of cancer information Expectations		recommending it or dislike it	- "all subjects preferred the chemotherapy treatment with the virtual reality treatment" (Schneider, Prince-Paul, JoAllen, Silverman, & Talaba, 2004). - "I was skeptical at first… I would recommend it", (Baños et al., 2013) - "cool, fun" (Birnie et al., 2018) - "This is great for people of all ages, even those who are older.", (Jahn, Lakowa, Landenberger, Vordermark, & Stoll, 2012) - "the topic (cancer) would be too personal and "tough (in game)" (Kato & Beale, 2006) - "the kind of games should be discussed with the patients before playing in terms of what is individually reasonable." (Jahn et al., 2012)
Implementation in clinical care Technical issues Accessible 24/7 Correspondence of VR game to child and medical procedure Usability (game design and content)	Ease of use (7)	Patients' perception of facile usability of the VR technology	- "remote control is difficult to steer and manage, and the 3D effect doesn't add anything to the distraction", (Nilsson et al., 2009) - "If I were 10 years younger, I would have had more fun with it.", (Jahn et al., 2012)

			- "it was pretty easy to use because it was just your eyes that were controlling it, the controls were very simple", (Birnie et al., 2018)
Comments of anxiety Relaxation Fear factor Experience and accompanying thoughts Decrease of negative emotions	Reduction of anxiety and induction of relaxation (6)	Perceived emotional changes from patients: in particular, decreased negative emotions and increased levels of positive emotions	- "This is an excellent opportunity to become involved with the treatment and a greater understanding helps to remove the "fear factor" and helps in the healing process." (Sulé-Suso et al., 2015) - "It was worse today because I was getting a new drug" (Windich-Biermeier et al., 2007) - "I was worried prior to session nut now all ok" (Stewart-Lord, Brown, Noor, Cook, & Jallow, 2016) - "this would cheer anyone up", (Baños et al., 2013) - "Yes, I was more relaxed and more confident, my mood improved and every action seemed to happen automatically. I felt less tense.", (Jahn et al., 2012)
Information value and understanding Ease of understanding Level of interest	Understanding and new knowledge (5)	New and improved knowledge on cancer, including an understanding of	- "I didn't need to go anywhere else to look for information once I got on the website.", (Loiselle et al., 2013)

Cross-verifying cancer information Institutionally supported and reliable	treatment and further procedures.	- "I now have a good working knowledge of what my treatment involves and a better understanding of any side effects that may occur.", (Sulé-Suso et al., 2015) - "content in the education program was difficult to understand", and "content covered in the education session helped me feel better prepared for RT treatment", (Jimenez et al., 2018)

Research Question 1

In order to get an overview on included studies, their characteristics are presented in Table 2. Sample sizes differed on a range from 7 to 180 participants. In four studies participants were aged under 18, the rest of the reviewed studies examined patients older than 18 years. Eleven studies included only a specific cancer type or cancer procedure, four conducted interventions involving various cancer types. Moreover, seven studies used immersive VR technologies, the rest of eight studies applied non-immersive VR. Table 2 also answers research question 1: "What is the perception and acceptance of cancer patients regarding the implementation of non-immersive and immersive VR technologies in their treatment?". Patients' verbal reactions were predominantly positive. They perceived VR's beneficial effects and accepted its implementation into their treatment. No recognizable differences in patient reactions toward either immersive or non-immersive could be identified. In the following, it will be elaborated on each code and patients' quotes will be used to compare non-immersive and immersive VR-studies.

Acceptance

Precisely six studies reported patients' comments about the "acceptance" of non-immersive VR, in contrast, participants of three studies using immersive VR addressed "acceptance". Positive comments for non-immersive VR were for example "it is well made, well developed and well planned, I was skeptical at first… I would recommend it", (Baños et al., 2013) or "subjects indicated that they would be willing to use the intervention again.", (Schneider et al., 2004) and "This is great for people of all ages, even those who are older.", (Jahn et al., 2012). More critical views were also mentioned: "some of the patients surely had fun with it, but it was a strange experience for me.", (Jahn et al., 2012). In case of immersive VR interventions studies, the only critical comments from patients were about the content and software of VR. For example, "the topic (cancer) would be too personal and "tough (in game)", (Kato & Beale, 2006). Other reactions regarding acceptance were that "they would like to play a game like this when staying in the hospital", (Kato & Beale, 2006) and "it is fun to play a game when you get stuck with a needle", (Nilsson, Finnström, Kokinsky, & Enskär, 2009). Some also thought about the perception of other patients "I think carrying out this exercise before radiotherapy starts would be beneficial and reassuring to most patients.", (Sulé-Suso et al., 2015).

Perceived working mechanisms

In three studies using non-immersive VR technology, "perceived working mechanisms" were addressed in qualitative interviews. Patients perceived positive effects like "I think it was

reassuring to know I was getting reliable information to the questions that I was seeking answers to.", (Loiselle et al., 2013) and "It takes away this feeling of being trapped in a box or in a prison", and "you are not here, you are in another world." (McCabe et al., 2011). In contrast, six studies which implemented immersive VR received contradictory comments about 3D effects of the technology. In one study it was stated that "the 3D effect doesn't add anything to the distraction", (Nilsson et al., 2009). In another study, a patient commented that "it strengthens the case for delivering information on RT planning and delivery using a 3D imaging system.", (Sulé-Suso et al., 2015).

Ease of use

The code "ease of use" was addressed in five non-immersive studies and in three immersive VR intervention studies. In non-immersive studies, "women thought that the headset was easy to use, they reported experiencing no unusual sensations", (Schneider et al., 2004). Another study used a virtual navigation system that patients could use manually, patients perceived this as a positive feature because "at the beginning I was afraid to look at the information and I preferred to wait until I was ready…", (Loiselle et al., 2013). In another study, participants seemed to first had to get used to the technology: "the system was relatively easy to use. The only difficulty was with the interaction devices in the two first sessions […] I explored the virtual environments for the first time.", (Baños et al., 2013). In studies using immersive VR children and adolescents commented on the usability, for example, "it's very handy just to push the one button and then just look around", (Birnie et al., 2018) and "the remote control is difficult to steer and manage, this is partly a challenge and partly a problem", (Nilsson et al., 2009).

Reduction of anxiety and induction of relaxation

The code "reduction of anxiety and induction of relaxation" was addressed as frequent in non-immersive as well as in immersive intervention studies, respectively three studies for each VR form. In non-immersive studies, many patients commented on their increased level of relaxation like "They [the images] were relaxing when I watched them", (McCabe et al., 2011) and "Yes, I was more relaxed and more confident, my mood improved and every action seemed to happen automatically. I felt less tense.", (Jahn et al., 2012). In an immersive VR intervention, it was mentioned that "This is an excellent opportunity to become involved with the treatment and a greater understanding helps to remove the "fear factor" and helps in the healing process", (Sulé-Suso et al., 2015). In another study after an immersive VR intervention, a patient commented: "I am no longer worried and feel very calm", (Jimenez et al., 2017).

Understanding (new knowledge)

Overall, the code "understanding (new knowledge)" was addressed by five studies, three of them using non-immersive VR and two immersive VR. In non-immersive studies comments like "I have been reading up info on radiation on the internet, but this session helped me to understand radiation better – to the point", and "the game taught something about cancer", (Kato & Beale, 2006) were described by patients. In another non-immersive study, one individual gathered new knowledge not about cancer but about himself due to the intervention: "I can deal with things much better, I'm just a bit more philosophical about what is a major problem", (McCabe et al., 2011). Also, immersive VR interventions received positive comments addressing the increase of new knowledge. For example, "a picture is more powerful to assist understanding than many words", (Sulé-Suso et al., 2015).

Table 2. *Descriptives of included studies, including author, title, cancer type, study sample, VR type and interview themes. The table is sorted starting with immersive studies, continuing with non-immersive ones.*

	Author	Study	Cancer type	Study sample: Number of participants (age in years)	Type of VR	Interview themes
1	Kato and Beale (2006)	Factors Affecting Acceptability to Young Cancer Patients of a Psychoeducational Video Game About Cancer	All cancer types	43 (13-25)	Immersive using state-of- the-art commercial game technology	Acceptance Understanding (new knowledge)
2	Birnie et al. (2018)	Usability Testing of an Interactive Virtual Reality Distraction Intervention to Reduce Procedural Pain in Children and Adolescents With Cancer	Pediatric cancer: implantable venous access device needle insertion	17 (8-18)	Immersive Stereoscopic smartphone display, head-mounted display, noise-cancelling headphones, bluetooth controller	Ease of use Acceptance Perceived working mechanisms

3	Brown-Johnson et al. (2015)	Development and usability evaluation of the mHealth Tool for Lung Cancer (mHealth TLC): A virtual world health game for lung cancer patients.	Lung cancer	8 (20-50)	Immersive Mobile Health Tool for Lung Cancer (mHealth TLC) interactive, immersive 3-dimensional iPad health game	Ease of use Emotions Perceived working mechanisms
4	Nilsson, Finnström, Kokinsky, & Enskär (2009)	The use of Virtual Reality for needle-related procedural pain and distress in children and adolescents in a paediatric oncology unit.	venous punctures or subcutaneous venous port devices	42 (5-18) (intervention group n= 21; control group n= 21)	Immersive standard personal computer with high-end consumer graphics card and a 3D-display, remote control	Acceptance Perceived working mechanisms
5	Sulé-Suso et al. (2015)	Pilot study on virtual imaging for patient information on radiotherapy planning and delivery.	All cancer types	150 (37-80)	Immersive 3D imaging system, 3D glasses	Understanding (and new knowledge) Perceived working mechanisms Reduction of anxiety induction of relaxation (fear)

6	Windich-Biermeier et al. (2007)	Effects of Distraction on Pain, Fear, and Distress During Venous Port Access and Venipuncture in Children and Adolescents With Cancer	cancer with port access or venipuncture	50 (5-18) (intervention group n = 22)	Immersive VR glasses, earphones	Perceived working mechanisms
7	Wint et al. (2002)	Effects of distraction using virtual reality glasses during lumbar punctures in adolescents with cancer.	Cancer undergoing frequent lumbur punctures	30 (13-14) (intervention group n= 17)	Immersive Selection between different distractors, including (1) VR glasses, earphones, 3D, (2) Nintendo Gameboy	Perceived working mechanisms Reduction of anxiety induction of relaxation
8	Jahn et al. (2012)	InterACTIV: an exploratory study of the use of a game console to promote physical activation of hospitalized adult patients with cancer.	All cancer types included	7 (47-70)	Non-immersive Nintendo Wii game console	Ease of use Acceptance Reduction of anxiety induction of relaxation
9	Baños et al. (2013)	A positive psychological intervention using virtual reality for patients with	Metastatic cancer	19 (29-85)	Non-immersive	Ease of use Acceptance

		advanced cancer in a hospital setting: A pilot study to assess feasibility			LCD television, connected to computer, keyboard, mouse, headphones	
10	Jimenez et al. (2018)	Breast Cancer Patients' Perceptions of a Virtual Learning Environment for Pretreatment Education	Breast cancer	19 (45-54)	Non-immersive PowerPoint presentation, virtual presenter tools (VERT)	Understanding (new knowledge) Reduction of anxiety induction of relaxation
11	Loiselle et al. (2013)	Virtual navigation in colorectal cancer and melanoma: an exploration of patients' views	Colorectal cancer or melanoma	20 (mean age: 60.2)	Non-immersive Web-based virtual navigator	Ease of use Understanding (new knowledge) Perceived working mechanisms
12	McCabe et al. (2011)	Open Window': a randomized trial of the effect of new media art using a virtual window on quality of life in	stem cell transplantation for a hematological malignancy	180 (18-69) (interventio n group n= 75)	Non-immersive Remote camera (placed in location), PC, video projector, audio speakers, remote control	Acceptance Understanding (new knowledge) Perceived working mechanisms

		patients' experiencing stem cell transplantation.				
13	Reichlin et al. (2011)	Assessing the acceptability and usability of an interactive serious game in aiding treatment decisions for patients with localized prostate cancer.	Prostate cancer	13 men (45-85)	Non-immersive PC, screen as virtual table	Ease of use Acceptance Perceived working mechanisms
14	Schneider et al. (2004)	Effects of distraction using virtual reality glasses during lumbar punctures in adolescents with cancer	Breast cancer (chemotherapy)	20 women (18-55)	Non-immersive Headset, mouse, CD-ROM	Ease of use Acceptance
15	Stewart-Lord et al. (2016)	The utilisation of virtual images in patient information giving sessions for prostate cancer patients prior to radiotherapy.	Prostate cancer	38 (49-79)	Non-immersive PowerPoint presentation, virtual presenter tools	Reduction of anxiety induction of relaxation Acceptance

Research Question 2

Lastly, more details on the VR interventions with hardware and software descriptions as well as codes from the interviews in those studies are shown in Table 3. In this table the studies are sorted differently: starting with psychoeducation interventions, also games focusing on cancer and continuing with distraction interventions. In the following, differences and similarities of used codes in psychoeducation and distraction interventions are shown and patients are quoted for elaboration. Seven studies conducted psychoeducation VR interventions and eight studies examined distraction VR interventions. Both kinds of VR interventions yielded positive effects that were confirmed by patients' comments. Nevertheless, a few negative comments were mentioned, describing difficulties in usage or no experienced effects.

Psychoeducation VR Interventions

The most prominent code addressed in psychoeducation studies is "Understanding (new knowledge)". Most studies received positive comments like "I now have a good working knowledge of what my treatment involves and a better understanding of any side effects that may occur." (Sulé-Suso et al., 2015). Also, games with cancer content were perceived positively as "preparation for me [a player] to be an informed consumer of healthcare.", (Brown-Johnson, Berrean, & Cataldo, 2015). Further, gathering and understanding information about their disease also affected patients' mood: "When you use that, it's less scary. You understand whats going on in your body.", (Loiselle et al., 2013). In contrast to distraction interventions, patients often explained their perception of future in general or future treatment "the unknown can quite often create a certain amount of fear and anxiety and by being able to go onto the website, it alleviated a lot of those concerns.", (Loiselle et al., 2013). This effect was also mentioned in another study by Jimenez et al. (2018): "Markings and use of it later to deliver precise prescribed treatment improved my confidence and expectation". Multiple patients commented that doctors often do not have enough time "the doctor's time is limited … he can't provide you with all the information that you might want …", (Loiselle et al., 2013). Thus, a favorable aspect of psychoeducation session was that "I wanted full information which I received", (Stewart-Lord et al., 2016). But one negative comment was also included because one patient thought that the "content in the education program was difficult to understand", (Jimenez et al., 2018).

Distraction VR Interventions

In distraction interventions, the code "acceptance" was most often addressed. Many participants reacted positively and were motivated to recommend it to other people: "This is great for people of all ages, even those who are older.", (Jahn et al., 2012). The value of

distraction was expressed by comments like: "one is concentrated on the game and doesn't notice the needle" (Nilsson et al., 2009), "I was just distracted and I was just sitting there playing it. It was fun and I liked it!", (Birnie et al., 2018), and "Took her mind off the procedure", (Windich-Biermeier et al., 2007). In contrast to psychoeducation interventions, patients' comments only focused on the current effects of the intervention "It is fun to play a game when you get stuck with a needle", (Nilsson et al., 2009). But negative comments were also made about the content of distraction VR, for example, "the kind of games should be discussed with the patients before playing in terms of what is individually reasonable." (Jahn et al., 2012).

Table 3. *VR technology characteristics and codes gathered from interviews. Starting with psychoeducational VR interventions (1-7), continuing with VR distraction interventions (8-15).*

	Author	VR software	Included Codes
1	Jimenez et al. (2018)	Psychoeducation VERT: CT scan, including treatment plan and dose prescription of left-sided breast cancer treatment	Understanding (new knowledge) Reduction of anxiety induction of relaxation
2	Stewart-Lord et al. (2016)	Psychoeducation VERT: CT scan planning, preparation information for treatment	Reduction of anxiety induction of relaxation Acceptance
3	Sulé-Suso et al. (2015)	Psychoeducation VERT: personal CT scan images emphasize on treated area, explanation of radio therapy plan, possible side effects	Understanding (and new knowledge) Perceived working mechanisms Reduction of anxiety induction of relaxation
4	Loiselle et al. (2013)	Psychoeducation Cancer information about individual diagnosis, treatment, health care facility, care services, videos, journals, application forms (e.g. for financial support)	Ease of use Understanding (and new knowledge) Perceived working mechanisms
5	Reichlin et al. (2011)	Psychoeducation Information on potential cancer side effects, corresponding treatment → help patients understand how side effects can impact quality of life	Ease of use Acceptance Perceived working mechanisms

6	Brown-Johnson, et al. (2015)	Psychoeducation (via game) Player (patient) in cancer center achieving optimal health literacy & self-management	Ease of use Reduction of anxiety induction of relaxation Perceived working mechanisms
7	Kato and Beale (2006)	Cancer related game 3-dimensional, paced-action game with realistic environments, Game where player fights cancer	Acceptance Understanding
8	Birnie et al. (2018)	Distraction Interactiv game: travel as a scuba diver through a peaceful underwater environment surrounded by creatures (e.g., sea turtles, fish, whales) and coral reef, searching for treasure	Ease of use Acceptance Perceived working mechanisms
9	Nilsson et al. (2009)	Distraction virtual world game/application, ‘‘The hunt of the diamonds’’: catching diamonds floating in an amusement park; Calming virtual world	Ease of use Acceptance Perceived working mechanisms
10	Jahn et al. (2012)	Distraction & Physical activity Wii Sports, Family Trainer, Sports Island, Family Ski and Snowboard	Ease of use Acceptance
11	Baños et al. (2013)	Distraction Emotional parks, walk through nature (joy, relaxation)	Ease of use Acceptance
12	McCabe et al. (2011)	Distraction Nine art channels: nature, locations of personal significance, visual abstraction, classic artworks → connection to the outside world	Acceptance Understanding (new knowledge) Perceived working mechanisms

13	Schneider et al. (2004)	Distraction Deep-sea diving, walking through an art museum, solving a mystery	Ease of use Acceptance
14	Windich-Biermeier et al. (2007)	Distraction (1) Skiing Swiss Alps, strolling down Paris sidewalks, quiet mountain streams (2) games Jurassic Park or SuperMario Advance	Perceived working mechanisms
15	Wint et al. (2002)	Distraction Skiing Wiss Alps, explosive drag racing, stroll down Paris sidewalks, quiet mountain streams	Perceived working mechanisms Reduction of anxiety induction of relaxation

Discussion

This study aimed to answer two research questions regarding patients' verbal reactions toward the implementation of VR technologies in their oncological treatment. The first question "What is the perception and acceptance of cancer patients regarding the implementation of non-immersive and immersive VR technologies in their treatment?", is answered in the following. In general, both forms of VR resulted in predominantly positive patient reactions stating its perceived beneficial effects and their willingness to use and recommened it. The results showed no obvious differences in reactions toward non-immersive and immersive VR. The predisposed assumption that immersive VR produces feelings of presence was not addressed by any patient. One patient rather complained about the nonessential 3D effect (Nilsson et al., 2009). Additionally, patients from non-immersive studies experienced and described similar effects to the ones of immersive studies.

To answer the second research question "What are the differences and similarities in patients' perception and acceptance regarding distraction and psychoeducation interventions delivered through VR technology?", patient reactions were compared. Both kinds of interventions received mainly positive patient reactions regarding their purpose and level of helpfulness. Nevertheless, a few negative comments lead to the assumption that the interventions need to be individual tailored to increase chances for satisfying all cancer patients' needs during their treatment (Nilsson et al., 2009). The most obvious difference was encountered in patients' feelings that were caused by the interventions. In the case of psychoeducation interventions, patients felt prepared for their future cancer treatment sessions, which helped them deal with feelings of uncertainty and fear. In contrast, distraction interventions affected patients in the current moment, in which the intervention took place. Patients reported decreased feelings of pain and anxiety, with lower levels of focus toward the painful procedure due to the distraction.

The effects of presented interventions are supported by the stress and coping model of Lazarus and Folkman (1984). The mechanism in which psychoeducation produces favorable outcomes for patients can be related to problem-focused coping strategies. Problem-focused can be defined as "actively or behaviorally altering the external person–environment relationship […] as channeling efforts to behaviorally handle distressing situations, gathering information, decision making, conflict resolution, resource acquisition (knowledge, skills, and abilities) […]" (Matthieu & Ivanoff, 2006, p. 7). This means cancer patients who receive psychoeducation via VR can make use of the new information and gain further resources to

handle future stressful events like chemotherapy (Northouse et al., 2014). The other way of coping stated by Lazarus and Folkman (1984) is emotion-focused coping. This is where people focus on mental or behavioral disengagement, namely, some sort of distraction (Penley, Tomaka, & Wiebe, 2002). Distraction interventions using VR, fulfill their intended purpose by providing patients with an opportunity to mentally escape the stressful situation during cancer treatment. Meaning, both interventions are relatable to the ways of coping defined by Lazarus and Folkman (1984).

The use of VR technologies poses some risks to patients that need to be respected in future interventions. For example, in everyday life, human beings decide unconsciously and intentionally which coping strategies to employ in distressing situations (Matthieu & Ivanoff, 2006). Thus, some patients who received a VR psychoeducation intervention might have intentionally chosen a distraction intervention, because they cope emotionally-focused with a stressful situation. The possibility exists that some cancer patients might have received an intervention that was not perfectly suitable for them. That is because none of the previously presented studies left them a choice to decide for an intervention. If an intervention is not suitable for a patient it will not be supportive and treatment adherence will not be increased (Beck et al., 2010).

Next to attending unsuccessful interventions, patients are at risk to experience cybersickness during and after the interaction with immersive and non-immersive environments (Tiiro, 2018; Vinson, Lapointe, Parush, & Roberts, 2012). Literature about the relationship between cybersickness and virtual reality is contradictory. While some studies state that there is no relationship between cybersickness and virtual environments, others claim that 30%-80% of participants experience cybersickness in exposure to virtual VR (Rebenitsch & Owen, 2016; Shahrbanian et al., 2012). Since cancer patients are already in weak conditions, an additional burden of cybersickness should not risk disturbing their treatment. It is assumed that various factors like hardware quality, design of software content, and patient characteristics can influence the possibility of experiencing cybersickness. One solution is suggested by Sharples, Cobb, Moody, and Wilson (2008), where some tests can be conducted to increase the certainty of patients' safety before the VR intervention. These tests analyze the design of VR, circumstances of use, and individual participant characteristics; further, they require medical professionals for evaluation. Thus, with the goal to extend treatment adherence and improve cancer patients' conditions, VR technologies should be used in a secure environment where nurses and medical professionals are available for help in case of experienced cybersickness.

Strengths and Limitations

This review gives a good overview of a specific topic which is of importance in the current speed of technological developments and the growing trend of implementing new technology into medical treatment processes. Additionally, qualitative data of this review gives more depth of understanding of why rates of anxiety and pain were decreased in previous VR studies (Minichiello, 1990). The summary of multiple patient reactions can be used to explain decreasing pain and anxiety rates in cancer treatment with the addition of VR.

Limitations of this review need to be considered to improve future investigations. One aspect, limiting the informative value, is the quality of selected studies (Almeida, & Goulart, 2017). The small, selective sample sizes of the intervention studies lead to the assumption that only patients participated who were available and interested in the implementation of VR during their treatment (Baños et al., 2013; Reichlin et al., 2011; Wint et al., 2002). Consequently, some cancer patients, opinions, and reactions were omitted from the experiments, which decreases the chances of valuable generalizability of the research results. Further, it has to be considered that the majority of positive patient reactions might be expressed by people who feel fit enough to try out new technology. In contrast, cancer patients with history of seizure, motion sickness, or acute physical problems were usually excluded from participation (Nilsson et al., 2009; Schneider et al., 2004; Wint et al., 2002). Nevertheless, this study' s results show that a majority of participating cancer patients perceive VR as favorable addition; thus, future research can use this information as a reason for inviting a broader patient population to participate.

The provision of interview extracts and codes instead of entire interviews led to two limitations. Firstly, due to the protection of data and privacy, complete patient interviews are not available to be viewed and only pre-selected examples of patient reactions that were subjectively chosen by the study authors to answer their research questions. Secondly, this review demonstrated a conceptual problem in the qualitative scientific field where many researchers examine the same topics, concepts, or theories but term it differently (Kalu, 2019). In this case, a new coding scheme had to be created because the topics that were mentioned in selected studies were all similar but described and interpreted in another way. As a result, researchers' subjective interpretations of patient reactions limit the significance of the results.

By considering both types of psychosocial interventions that were chosen to compare in this review, it can be recognized that psychoeducation and distraction are different concepts with distinctive mechanisms and goals (Kato & Beale, 2006). Therefore, a comparison between

the two may not be informative and hence viewed as a limitation. Nevertheless, they should be reviewed next to each other; giving each cancer patient a choice between either distraction or psychoeducation VR interventions. Further limitations concern the methods of this study. The inclusion of only one language, English, and only one database used for searching VR intervention studies, might be criticized. It might be assumed to limit the number of studies that were scanned by the author. Many articles were also found with other sources, for example via reference lists, the last point can be contested.

Scientific implications and future research

In general, the majority of studies researching the implementation of VR in cancer treatment focus on how VR technology affects negative emotional and poor physical states. Measuring instruments for positive effects, like induced states of emotional wellbeing, are not prominently measured in this field compared to anxiety or pain rates. This review demonstrated that VR can elicit many positive patients' reactions during their oncological treatment. Further, Baños et al. (2013) stated that "emotional wellbeing is not only related to the decrease of negative emotions, but also to the intensity and frequency of positive emotions" (p. 263). Even though positive characteristics are linked to a person's coping in stressful situations, beneficial outcomes are mainly illustrated through the reduction of negative emotions and physical illness (Wood & Tarrier, 2010). Future research on VR interventions during cancer treatment should implement measurements of positive emotions because they can have direct effects on research results.

The implementation of technology into medical contexts is a complex and important topic that should be researched extensively. Some studies have already started using mixed methods to amplify both research methods, qualitative and quantitative, on the subject (Nilsson et al., 2009; Windich-Biermeier et al., 2007). This review showed that the majority of reactions toward VR were positive but this proposition should be additionally supported by quantitative measurement to strengthen the research value. Thus, patients' acceptance of the relatively new approach should be examined by using qualitative and quantitative measurements for one sample to gain a better understanding of possible contradictions of the results.

The conceptual problem that researchers study similar theories and topics but term it differently due to their subjective interpretation is a general challenge in the qualitative scientific field (Kalu, 2019). One reason for this situation could be that researchers have slightly different interpretations of their research concepts (Malterud, 2001). As a result, findings are more challenging to compare. One possible approach to solve this problem is the consistent use

of standard guidelines for qualitative research and coding (O'Brien, Harris, Beckman, Reed, & Cook, 2014; Saldaña, 2015).

Clinical implications and future steps

From previously stated results, it can be understood that VR is a favorable tool with beneficial results in patients' perceptions of the cancer treatment. To gain more certainty about the actual effects, it will be important to include broader patient populations. The effective implementation of interventions in hospital settings are affected by some barriers like staff shortage and intervention complexity (Geerligs, Rankin, Shepherd, & Butow, 2018). By considering the hospital system, an intervention concept with clear guidelines can be created. A description of VR use, possible difficulties, or questions could assist to successfully conduct VR interventions in multiple hospitals. Another advantage of an overall concept for the VR implementation would be similar conditions for a broad cancer patient population. Meaning, VR effects and patients' experiences would be more reliable to compare.

Next to a general concept that would be available to multiple hospitals, a choice for patients should be created, where they decide between a psychoeducation- and a distraction intervention. Even though this is a very important step no current study has implemented it. By leaving this choice up to the patient, individual preferences are respected which foster patients' interest in participation (Clark et al., 2008).

Conclusion

The present study compared patients' verbal reactions in regard to the implementation of VR concerning its type of hardware, non-immersive or immersive, as well as the intervention content, namely psychoeducation or distraction. Overall, positive patients' perceptions predominated, inferring that the relatively new technology improved their treatment conditions. While findings of this review favor VR-based interventions, they still need to be considered carefully and in light of its limitations. Further exploration of the complex topic is important to improve the psychological situation during oncological treatment for all patients, including a more suitable individual fit of the intervention. For instance, by involving a reasoned concept for VR implementation in hospital settings as well as a sample of cancer patients in a mixed-method approach, the scope of the subject would increase. Further, a broader perspective could be gained and more certain recommendations can be stated about VR effects. Nevertheless, this

review serves as a basis for future research and encourages further development and the use of VR technology in oncological treatment situations.

Take home message

Substantial research has been conducted around VR, how it can be used in medical contexts, and improves patients' wellbeing. The majority of the results are in favor of the additional use of VR as it has improving effects on a patient's treatment. Furthermore, a VR technology intervention is a tool that can be adapted to individual preferences, like the content of the software and the choice between distraction or psychoeducation. This advantage should be used in further research and medical treatments to design the intervention as perfectly suitable as possible for the individual patient. In this way, treatment conditions can be enhanced, leading to improved adherence, and finally to higher chances of successful recovery from cancer disease.

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