Feasibility, acceptability and clinical implementation of an Immersive Virtual Reality intervention to address psychological wellbeing in children and adolescents with cancer

Authors

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Abstract

Objective: Virtual Reality (VR), a novel and highly immersive technology, offers promise in addressing potential psychological impacts of cancer treatments and hospitalization. The primary aim of this study was to examine multiple key user perspectives on the acceptability and feasibility of an Immersive VR therapeutic intervention for use with hospitalized oncology patients. Secondary aims were to identify issues and opportunities related to the adoption and clinical implementation of VR in pediatric oncology settings.

Methods: The study was conducted at the Royal Children's Hospital, Melbourne, Australia. Thirty multidisciplinary oncology healthcare professionals (HCPs) participated in an initial test of VR intervention usability (Stage 1). Ninety oncology inpatients (7-19 years) and their parent caregivers participated in a pilot randomized controlled study to examine the effectiveness of an Immersive VR therapeutic intervention (Stage 2). This mixed methods study reports Stage 1 & 2 quantitative and qualitative data related to VR feasibility and acceptability.

Results: Results indicate favorable perceptions from HCPs with respect to ease of use and usefulness of VR, and had positive intentions to use it in the future. Parent caregivers reported highly acceptability of VR for their hospitalized child. Patients reported high satisfaction of the VR intervention within minimal adverse effects. Barriers and facilitators to VR use with seriously ill children and specific recommendations for content development were elicited.

Conclusion: This study shows there are several potential clinical uses for Immersive VR intervention, beyond medical procedural distraction, to support psychological adjustment to hospitalization and patient quality of life.

1 Background

Treatment for childhood cancer is typically prolonged and intensive, presenting numerous challenges and sources of stress for patients ranging from repetitive medical procedures (e.g., port access, surgeries, chemotherapy, radiation) and physical effects (e.g., pain, nausea, vomiting, fatigue), to dramatic changes in appearance (i.e., hair loss, weight loss). Furthermore, cancer treatment removes children from their everyday social environment and previously enjoyed activities. The emotional toll of treatment on the wellbeing of patients has been widely demonstrated, with evidence that global psychological distress, symptoms of anxiety, fear, pain, low mood, feelings of isolation, loneliness and boredom are universal experiences for pediatric cancer patients (Dejong & Fombonne, 2006; Kazak & Noll, 2015; Rourke, Hobbie, Schwartz, & Kazak, 2007; Rourke, Samson, & Kazak, 2015). Untreated psychological distress during treatment has been linked to reduced quality of life, poorer adherence to treatment, functional impairment and greater risk of "psychological late effects" such as depression and posttraumatic stress symptoms (PTSS), well into the survivorship years (Rourke et al., 2007; Rourke et al., 2015; Rourke, Stuber, Hobbie, & Kazak, 1999).

In recent pediatric cancer guidelines, providing children and adolescents with access to psychological interventions throughout their cancer trajectory has been described as a necessary standard of care (Wiener, Kazak, Noll, Patenaude, & Kupst, 2015). While traditional, in-person psycho-oncology services have been shown to be effective in pediatric settings to support patients and their families, high service demands or insufficient resources means large numbers of patients needing psychological care may be neglected (Bultz et al., 2013; Kazak & Noll, 2015). Perceived stigma or lack of developmentally appropriate therapies can also be a barrier to engaging young hospitalized patients in psychological treatment. Importantly, recent developments in digital technologies have created new

opportunities to develop novel methods of intervention to address psychological wellbeing among hospitalized children, with potentially greater appeal and reach (Hollis et al., 2015; Rizzo & Koenig, 2017).

Virtual Reality (VR) is an advanced technology currently being explored for its therapeutic value with children with severe or chronic illness in tertiary care settings. VR is a uniquely immersive and interactive technology, interchangeably referred to as VR or Immersive VR, that simulates reality via perceptual stimulation (e.g. visual cues, sounds, touch), potentially evoking a sense of 'presence' in a virtual environment (Cummings & Bailenson, 2016; Malloy & Milling, 2010). VR distraction therapy was the first medical application of this technology, with demonstrated effectiveness in redirecting patients' attention from the feared stimulus or symptoms (e.g. needle; pain) towards more pleasant or interesting stimuli presented in VR; resulting in lowered pain perception and pain behaviour (e.g. grimacing, crying, moaning, moving) (Malloy & Milling, 2010; Won et al., 2017). These effects have been demonstrated in children undergoing various medical procedures such as intravenous cannulas (Gold, Kim, Kant, Joseph, & Rizzo, 2006), cancer treatments including chemotherapy, lumbar punctures, and port access (Gershon, Zimand, Pickering, Rothbaum, & Hodges, 2004; Sander Wint, Eshelman, Steele, & Guzzetta, 2002; Schneider & Workman, 1999, 2000; Wolitzky, Fivush, Zimand, Hodges, & Rothbaum, 2005), burn-wound cleaning (Dascal et al., 2017; Jeffs et al., 2014) and traumatic wound care (Hua, Qiu, Yao, Zhang, & Chen, 2015). VR has also been utilized in pediatric rehabilitation environments, with studies demonstrating superior clinical effectiveness of VR over standard rehabilitation approaches for reducing pain/distress symptoms, and increasing mood and engagement among patients with chronic illness and daily physical therapy needs (Parsons, Rizzo, Rogers, & York, 2009; Ravi, Kumar, & Singhi, 2017).

Less research has directly explored the potential benefits of using VR to assist children to cope with the general stress of hospitalization. Specific to pediatric cancer, only one study has explored the effects of daily exposure to a VR play-based intervention and found marked reductions in depressive symptoms among children on day seven of an inpatient admission when compared to child receiving usual hospital care (Li, Chung, & Ho, 2011). Further investigation of the clinical utility of VR as a supportive care intervention in pediatric inpatients settings is warranted. Importantly, despite the encouraging findings shown thus far, the feasibility and acceptability of VR technology in complex healthcare environments remains largely unexplored (Glegg & Levac, 2018). With VR implementation research at an early stage, there is demand for more research investigating its safe and effective application in these environments (Rizzo & Koenig, 2017) and more recently, factors influencing VR technology adoption as they directly impact intervention success (Bertrand & Bouchard, 2008; Glegg et al., 2013; Glegg & Levac, 2018; Markus et al., 2009). A notable limitation of nearly all current clinical VR research has been the lack of significant end user involvement from intervention design, to acceptance and implementation of VR technology. Previous research has established that initial testing of technology innovations in healthcare settings, including the opportunity to trial and provide feedback is a crucial step in the development of relevant and effective interventions that meet the needs of patients and HCPs (Glegg & Levac, 2018; Langhan, Riera, Kurtz, Schaeffer, & Asnes, 2015; Lyon et al., 2016). This collaborative process also encourages "buy-in" from patients and HCPs, which has been shown to have a positive influence on adoption (i.e. initial decision to use) and implementation (i.e. actual use) of new bedside technology in clinical care (Glegg & Levac, 2018; Langhan et al., 2015). Conversely, failure to engage key product end-users in this way may result in discrepancies between their needs and beliefs about what the new technology can offer, and risk intervention disuse (Glegg & Levac, 2018).

The primary objective of this study was to:

1. To evaluate the acceptability and feasibility of implementing an Immersive VR therapeutic intervention in an inpatient pediatric oncology setting, from the perspective of key stakeholders (i.e., oncology HCPs, patients and parent caregivers).

Secondary objectives, aimed to inform future implementation strategies, were:

2. To examine factors influencing VR adoption by HCPs, including barriers/facilitators to VR use with children who are seriously ill.
3. To explore users-perspectives regarding the potential clinical utility of VR as an intervention to support psychological adjustment to hospitalization, including child VR content preferences.

2 Methods

2.1 Study Design

This pilot study was conducted over a 24-month period between 2017 and 2019, at The Royal Children's Hospital, Children's Cancer Centre (RCH CCC) in Melbourne, Australia. First, a mixed methods approach was used to undertake usability testing and evaluation of the VR intervention with oncology HCPs (*Stage 1*). Second, a pilot evaluation was conducted of a VR intervention with hospitalized children with cancer and their parent caregiver (*Stage 2*). This two-stage design followed established usability testing methods for refining new technology interventions (Lyon et al., 2016). HCPs feedback from *Stage 1* was used to explore attitudes and associated compatibility of the VR intervention with the intended deployment setting (i.e. hospital-based oncology wards), while gathering contextual information relevant to then improve the intervention before *Stage 2* large-scale piloting with inpatients (Lyon et al., 2016). This paper presents the acceptability and feasibility findings

from the perspective of oncology HCPs, and patients and parents involved in the intervention arm of the larger randomized control trial (RCT) examining the effectiveness of VR in the hospital setting. For the results of the larger RCT (n = 90) are presented elsewhere (see (Tennant et al., 2020). Ethics approval was obtained from the RCH Human Research Ethics Committee in 2017 (HREC #36345). Informed written consents were obtained from parents and patients' over 18 years, with verbal assent obtained from all other participants.

2.2 Participants

Stage 1 eligible participants were multidisciplinary oncology HCPs directly involved in the clinical care of patients at the RCH.

Stage 2 eligible participants were oncology inpatients (7–19 years and at least one month post diagnosis) and a primary caregiver, who were consecutively recruited from the RCH oncology ward. Patients receiving palliative care, or who had significant neurological or developmental difficulties or were medically unstable were excluded. Parents required sufficient English to provide informed consent.

2.3 Study Procedures

Stage 1 usability testing of the VR intervention was conducted with HCPs in groups of up to eight. Convenience sampling methods were used with participants responding to email invitations with session times and dates. Participants were led through a demonstration on how to fit and operate the VR system. They then viewed sample intervention content (4 x 2.5-minute 360^{o} videos). Participants were required to launch each virtual experience sequentially using the mobile device, while researchers took field notes where participants encountered usability issues, required operational assistance, or experienced technical failures. A written evaluation survey of the VR intervention was then completed. At the completion of *Stage 1*, relevant user-feedback and field notes were used to improve the intervention (i.e. user-friendliness; suitability of the content for children) and provide

direction for expanded content design. In *Stage 2*, user-testing was conducted with patients recruited from the oncology ward as part of the larger RCT. Participants were approached and consented at their bedside by trained members of the research team. In most cases piloting of the intervention was conducted immediately following the consent procedure, or at a more suitable time on the day of consent. Participants who had been randomized to the VR condition, a 10-minute Immersive VR experience, completing post-intervention measures of acceptability, enjoyment and engagement with VR. Parent caregivers also completed measures. Child and parent measures were administered using iPads that imported data directly into a REDCap database (Harris et al., 2009).

2.4 Measures

2.4.1 Oncology Healthcare Professionals

Oncology HCPs completed a VR evaluation survey developed by the research team, based on the Technology Acceptance Model (TAM) (Davis, 1989; Holden & Karsh, 2010) and usability literature (Lyon et al., 2016). The survey included four demographic items; eight items from the TAM that measured HCPs attitudes toward using and accepting the VR intervention based on its two underlying constructs (i.e., Perceived Ease of Use Scale [PEOU; 4-items], Perceived Usefulness Scale [PU; 4-items]) using a 7-point Likert scale to respond (1 = *"Extremely Unlikely"* to , 7 = *"Extremely Likely"*); two items that assessed perceived applicability of VR (*"I think patients would enjoy a VR experience"*, *"I think there would be therapeutic benefit in using VR with patients"*) using a 7-point Likert scale (1 = "*Strongly Disagree"* to, 7 = *"Strongly Agree"*). Two qualitative items allowed for further assessment of HCPs perspectives on the feasibility and acceptability of VR, focused on elucidating issues regarding implementation specific to the inpatient ward environment: "*Who do you think is best placed to provide VR experiences to patients?"; "Please comment on what factors you*

think are important when choosing to use, or not to use, VR intervention/technology with patients".

The adapted TAM questionnaire items and descriptive data are presented as supplementary material.

2.5 Child and Adolescent Participants

Following bedside administration of the VR intervention, participants completed a set of measures assessing the feasibility and acceptability of the intervention, including enjoyment, adverse events and uptake (i.e. intention to use). A subjective rating of enjoyment with VR intervention was given using an "enjoyment thermometer" (0 = *"It didn't interest me at all"*; 10 = *"I really enjoyed it, it was the best"*). Adverse physical effects were measured using the Child Simulator Sickness Questionnaire (CSSQ; 7-items) (Hoeft, Vogel, & Bowers), with patients rating the occurrence and intensity of symptoms experienced in response to VR use, selecting from three response options: (0 = "*No*"; 1 = "*A little*"; 2 = *"A lot*"). Scores are tallied under three subscales of nausea, dizziness, and eyestrain. A total score of 3 or more in any category indicates symptoms of simulator sickness. To assess uptake of the VR intention, we asked children to indicate: "*Would you like to try using this technology again while you are in hospital*?" (yes-no response options).

Open-ended questions were utilized to allow for qualitative assessment of the feasibility and acceptability of VR. Patient perspectives on the usefulness of VR intervention were explored: *"When do you think is a good time in hospital to have experiences like the one you just had?"*. In addition, preferences for intervention content relevant to the inpatient environment were explored: *"What other types of experiences/adventures would you like to have using this technology"*.

2.6 Parent Participants

The Abbreviated Acceptability Rating Profile (AARP; 8-items) (Tarnowski & Simonian, 1992) was used to evaluate parents' perceptions of the acceptability, helpfulness and effectiveness of the VR intervention. Minor modifications were made to address the study aims (e.g. "*This technology is acceptable for use with children with cancer"; "The technology was a good way to help my child's overall well-being"*). Reponses are given on a 6-point Likert scale (1 = "*Strongly disagree"* to, 6 = *"Strongly agree"*). The AARP is scored by summing all items (range 8 to 48), with a score of 24 or greater indicating overall intervention acceptance. A qualitative item asked parents to add *"any comments / opinions about using this technology"* with children with cancer.

2.7 Virtual Reality Intervention

Immersive VR experiences were provided using a smartphone (Galaxy S7®; Samsung) and VR headset (Samsung Gear VR® first-generation mobile HMD; released November 2015) and headphones. Equipment was cleaned as per guidelines developed in consultation with the institution's infection control department. The intervention content involved original 360^{o} video content (i.e. 360-degree spherical video recordings), produced in collaboration with a VR production company (*Phoria*, Melbourne, Australia). Participants viewed one of three virtual simulation experiences, including simulated travel to Australian national parks (i.e. nature experience), Australian zoos (i.e. animal experience), or global city tourist spots (i.e. travel experience). The developers considered applicability of content to seriously ill children of varying ages, and gender with feedback incorporated from stage 1 usability testing (e.g. eliminating fast movements perceived to be nausea-inducing). Head movements allowed for interaction within a 270^{o} field of view and corresponding soundscape, designed to account for patients' receiving VR intervention whilst resting in bed.

2.8 Data Analysis

Descriptive statistics (means, SD; number, %) were used to analyze demographics and post-intervention quantitative measures conducted using Microsoft excel and Stata version 13. Qualitative data obtained from written or typed post-intervention survey responses were analyzed using inductive content analysis, guided by grounded theory (Strauss & Corbin, 1990), to identify emergent themes in the data. This involved a systematic process of familiarization with the data, identifying like responses, conceptualizing and coding participants' responses into groups to examine differential responses to the question of interest (Strauss & Corbin, 1990). Coding was undertaken by the lead author. Coding was reviewed with other authors (TJC and MM) and consensus was achieved on any differences.

3 Results

3.1 Sample Characteristics

Stage 1 participants were 30 multidisciplinary pediatric oncology HCPs, including 16 nurses (53.3%) and 14 allied health professionals (46.7%) (e.g. social work, art therapy, mental health), predominantly female (29; 97%), mean age 31.5 years (SD = 8.13; range 20 – 51) and mean years' oncology experience 6.1 (SD = 4.66; range 0.5 – 20). Prior experience with VR was low among participants; most reported they had never used VR (24/30; 80%), had *"None"* or *"Basic"* knowledge of VR (28/30; 93.3%), and indicated low self-confidence with operating VR technology (19/30; 63.3%).

Stage 2 participants randomized to the VR condition were 61 oncology inpatients (7-19 years and at least one month post diagnosis) and their parent caregiver. The majority of patient participants were male (37; 60.66%), with a mean age 11.58 (SD = 3.61). A summary of the sample characteristics is provided in Table 1. Most patient participants reported they had *"None"* or *"Basic"* knowledge of VR (49/61; 80.3%), with just over half reporting never

having used VR before (34/61, 55.7%), however the majority indicated high self-confidence with operating VR technology (41/61; 67.2%).

3.2 Intervention feasibility

Recruitment uptake and retention. Study response rate was 93% (number approach/number consented), demonstrating very high acceptance of VR intervention. Among those children and adolescents who declined to participate (7%), parents gave verbal consent to researchers.

Technical issues. The VR technology was found to be highly reliable across the intervention trial. Only one participant (1.6%) did not receive the VR intervention after randomization due to technical failure. This individual was excluded from analysis.

Adverse Events. Child simulator sickness data for patients completing the intervention is presented in Table 2. Only three children reported symptoms indicative of simulator sickness following a 10-minute VR experience. Of these, two children experienced eyestrain (2/61; 3.28%), and one child reported dizziness (1/61; 1.64%). No children experienced significant nausea. Only one participant did not complete the intervention after randomization due to complaint of eye-discomfort and was excluded from further participation.

3.3 HCP outcomes

Technology Acceptance. The mean score for the Perceived Ease of Use Scale (PEOU) was 5.73 (SD = 0.78) (maximum score is 7 = *"Extremely Likely"*); the highest scoring item was *"Learning to operate the VR headset would be easy for me"* (Mean = 5.90, SD = 0.80)*;* the lowest scoring item was *"It would be easy for me to become skilled at administering VR with a patient"* (Mean = 5.47, SD = 0.97). The mean score for the Perceived Usefulness Scale (PU) was 4.81 (SD=1.00); the highest scoring item was *"Using VR experiences with my patients would make it easier to do my job"* (Mean = 5.63, SD = 0.81)*;* the lowest scoring

item was *"Using the VR experiences with my patients would enhance my effectiveness on the job"* (Mean = 4.33, SD = 1.34). The overall mean total TAM score (PU and PEOU scales combined) was 5.28 (SD=0.72). Positive responses (i.e. >4) on the TAM and underlying constructs (Davis, 1989) indicated HCPs formed favorable beliefs about the VR intervention as both *easy to use* and *useful,* and showed acceptance of VR intervention, which according to previous studies that have validated the TAM(Holden & Karsh, 2010), indicates behavioral intent to use VR in practice.

Additionally, most HCPs formed highly favourable beliefs that patients would *enjoy* a VR experience (90%), and that there would be *therapeutic benefit* from using VR with patients (76.67%), indicated by the top two response categories (i.e., *"Agree"*, *"Strongly Agree"*).

Perspectives on Implementation. HCPs reported mixed preferences when nominating who would be "*best placed*" to deliver VR intervention with patients. Up to five responses were given by each respondent. Overall, nurses (23.7%) and child life therapists (21.1%) were viewed as the most appropriate. Other responses included "*all/any*" HCPs on the ward "*who are trained*" or "*have interest*" (15.8%), followed by "*mental health*" or other clinicians "*who understand the needs of the child*" (7.9%).

The main themes and subcategories identified from qualitative analysis of HCPs perspectives on important influencing factors on VR adoption in practice are summarized in Table 3. Six main themes were identified with insight provided on potential facilitators and barriers to intervention uptake and sustained use. Perceived benefit to patients was regarded as one of the strongest influencing factors affecting VR adoption by HCPs. Within this theme, there was consensus that VR would be beneficial to use with "*teenage*" patients, as well as "*isolated*" and "*long stay patients*" that might "*feel disconnected*". Additionally, they saw benefit in using VR during medical procedures as a distraction tool (e.g. "*Would have real*

benefit to aid with painful procedures - great multi-sensory distraction"), or as a clinical simulation tool (e.g. "*to explain procedures*"). Many HCPs also identified potential therapeutic uses for VR on the ward, including symptom reduction (e.g. "*distraction for patients experiencing pain*"), engagement (e.g. "*ability for the patient to discuss the experience would be valuable input*") and improved quality of life (e.g. "*relaxing to use and beneficial to patient wellbeing*"; "*potential for mental health and learning*"; "*give patients a sense of the outside world*").

Other identified themes relating to VR adoption, included *Education*, *Usability* and *Content variety* (see Table 3). Under education, HCPs emphasized knowledge building in understanding "*how*" to use the technology, but also "*why*" (e.g. "*clear goals*") and whom to use it with (e.g. "*key indicators to flag its appropriate*"; "*screening tool*"; "*would need to consider age, illness symptoms*"). Under usability, participants emphasized ease of use, reliability and convenience of equipment (e.g. "*easy to use*", "*doesn't fail*", "*quick to set up*"), which one participant linked to enhanced confidence "*to then teach patients*". Under content variety, access to child-friendly VR content (e.g. "*familiar scenes*"; "*engaging for children*") and variety (e.g. "*a multitude of experiences*") was identified as enablers to VR use.

Two emergent themes of Patient safety concerns and Safety concerns with VR equipment were considered to be strong deterrents of VR adoption (see Table 3). Regarding patient safety, most HCPs identified some uncertainty about the suitability of using VR with more vulnerable patients, including those with developmental issues (e.g. "*sensory issues*"), high anxiety, poorer health status (e.g. "*nauseous*"), vision-impairment, or highly medicated patients (e.g. "*if on opioids that could cause hallucinations"*). Regarding VR equipment concerns, many HCPs perceived a level of risk for inducing motion-sickness (e.g. *"Some patients might get nauseous if it moves too much"*), while one participant noted a level of "*infection control*" risk.

3.4 Child outcomes

Acceptability. The mean enjoyment rating for patients receiving VR intervention was 8.67/10 (SD = 1.95), indicating very high child satisfaction with the VR intervention. High enjoyment with VR was observed to be independent of content type: Nature (M=8.59, SD=2.59), Animals (M=8.59, SD=1.50), Travel (M=8.85, SD=1.53). In terms of intervention uptake, 89.83% of patients indicated they would like to try using VR technology again while they are in hospital (53/59; 2 = missing data). ***Perspectives on Implementation.*** Table 4 summarizes patients' perspectives on the usefulness of the VR intervention, presented as main themes and excerpts of patient responses on the qualitative survey question, *"when do you think is a good time in hospital to have experiences like the one you just had?".* Five main themes were identified, providing insight into the potential therapeutic application of VR in pediatric inpatient oncology care settings from the patient perspective. Three themes related to the capacity of VR to potentially shift negative psychological states, with a consensus that VR intervention would be useful for Coping with strong emotions (e.g. "*when you're feeling upset and need to calm down*"), Coping with boredom or low mood (e.g. "*when you are not feeling great and you need a boost in your feelings*"), and Coping with procedural anxiety or pain (e.g. "*before surgeries when children are anxious*"). Furthermore, many patients viewed VR as a potentially useful tool for Coping with isolation, through the provision of virtual escape from hospital during long stays (e.g. "*when you're in for a while and wanting to go somewhere*"; *"when I am in BMT"*). A further theme involved Timing of intervention use, with mixed feedback. Some patients viewed VR as more useful when their health status is improving (e.g. "*when I'm feeling ok, can move well, have energy"*), while others felt it would be beneficial to them when they were unwell (e.g. *"when I'm not feeling well because it distracts me from my tummy pain"*).

Content Preferences. We collected user-feedback on *'other'* types of virtual experiences they would like to have during inpatient hospital admissions for cancer treatment, with five content themes emerging from participant responses. Exploring nature was the most popular category (27.9%); with frequent responses including natural holiday destinations (e.g. *"the Grand Canyon"*; *"Fiji"*), swimming through underwater reefs and space travel. Sport was the second most popular category (20.6%); with patients' responses emphasizing virtual participation in an activity (e.g. *"running on the field"*, *"racing cars"*, *"riding a horse"*). Other content categories included Theme parks (16.2%; e.g. *"Disneyland"*; *"roller coasters and other rides"*); Animals (14.7%; e.g. *"the zoo"*; *"anywhere there are live animals"*), and Travel (14.7%; e.g. *"learning about different cultures"*; *"different countries, Europe- all of them!"*; *"New York City"*; *"Eiffel tower"*).

3.5 Parent outcomes

Acceptability. The mean acceptability rating for parents was 43.40/48 (SD = 7.10; median = 48), indicating very high parent acceptability of VR intervention (AARP). Qualitative responses indicated parent endorsement of VR in improving child mood (e.g. "*My daughter was so animated and excited. Would love her to be able to do this again*"), providing relief from hospital isolation (e.g. *"Fantastic way for kids to feel like they've been able to leave the hospital bed"*); and as a distraction technique to cope with medical procedures or treatment related side-effects (e.g. *"port-access"*, *"needles"*, *"chemotherapy"*). As presented in Table 4, these themes converged with three of the five themes from the patient perspectives regarding the perceived usefulness of VR in the clinical care of children with cancer.

4 Discussion

This study aimed to elucidate oncology HCPs', patients' and parents' perspectives on the acceptability and feasibility of clinical implementation of an Immersive VR intervention in an inpatient pediatric oncology environment. As application of VR to clinical healthcare is rapidly gaining momentum, this study provides crucial information on what key stakeholders perceive to be facilitators and barriers to the successful introduction and adoption of VR interventions with seriously ill children in acute care settings, with the aim to inform prospective implementation strategies. User-feedback from patients provide insights for the clinical utility of Immersive VR intervention in hospital, beyond medical procedural and rehabilitation settings, while patients' VR intervention content suggestions provide direction for future content creation that is tailored to patients' needs, and thus may increase VR intervention effectiveness.

Overall, we found the VR intervention was acceptable to all users. It was also feasible to implement with commercially available technology and cleaning protocols that adhered to institution-specific infection-control standards. In line with other research, children and adolescents in this study reported very high satisfaction with VR intervention (Birnie et al., 2018; Gold et al., 2006; Sander Wint et al., 2002; Schneider & Workman, 2000). High overall 'enjoyment' ratings indicated strong engagement with VR. In addition, nearly all patients (89.83%) indicated they would like to use VR again while they are in hospital. These findings extend the existing evidence for VR in oncology medical procedural settings, in which patients' have shown a preference for and interest in using VR distraction during future medical procedures (i.e., chemotherapy, lumbar punctures) over usual care strategies among adolescents (Sander Wint et al., 2002; Schneider & Workman, 1999, 2000).

In considering feasibility of VR in the inpatient setting, the research team conceptualized parents as well HCPs to be direct mediators of patients' access to VR

intervention. Overall parents were highly positive about their child's VR experience, and demonstrated very high levels of intervention acceptance. Of note, 100% of parents approached in the ward gave consent for their child to participate prior to gaining children's assent. Parent satisfaction and acceptance with VR has been found previously with children undergoing burn wound care (Das, Grimmer, Sparnon, McRae, & Thomas, 2005) and intravenous placement (Gold et al., 2006). Only one other study conducted in a pediatric oncology ward in Hong Kong has reported results on parent acceptability of VR. These parents were reluctant to let their children join the VR intervention due to the view that bed rest was more appropriate than play for recovery, as well as a fear of infection (Li et al., 2011). This was clearly not the case in our study, suggesting there may be cultural differences in the acceptability of VR interventions and warrants further investigation. Alternatively, higher parent acceptability found in our study may be due to the individual bedside delivery format, when compared delivery via group format (Li et al., 2011).

Our results also indicted HCPs had positive attitudes towards the VR intervention, describing it as easy to use, and expressing future intent to use VR as a therapeutic tool (Davis, 1989). HCPs attitudes toward perceived usefulness of the intervention (i.e. the capacity to increase job effectiveness) were, however, relatively weak and reflected varying levels of appeal and view on relevance across the multidisciplinary sample. This is in contrast to the increased job effectiveness that has been reported among nurses when VR has been used as a distraction during medical procedures (Chan, Chung, Wong, Lien, & Yang, 2007; Das et al., 2005; Hua et al., 2015; Kipping, Rodger, Miller, & Kimble, 2012; Mahrer & Gold, 2009). Interestingly, previous studies have demonstrated perceived usefulness may be a stronger determinant of intervention uptake compared to perceived ease of use of technology innovations in healthcare settings (Bertrand & Bouchard, 2008; Davis, 1989; Sun & Zhang, 2006). Our findings suggest improved understanding of VR capabilities and expected patient

outcomes via knowledge translation strategies could play a role in promoting VR adoption by HCPs, as has been recommended previously in feasibility studies in VR rehabilitation settings (Glegg et al., 2013). Feedback from HCPs in this study endorsed this view, suggesting VR use in practice could be facilitated by through access to education or a manual (e.g. “screening tool”) to identify suitable patients and establish goals for use (Table 4).

Safety is an important issue when choosing to use VR with vulnerable groups, as validated by HCP-report in this study (Table 4). Evidence to date regarding safety is still limited due to small sample sizes and inconsistent reporting of adverse events (Gershon et al., 2004; Li et al., 2011; Sander Wint et al., 2002; Wolitzky et al., 2005). In this study, one child did not complete the intervention due to “eye discomfort”, with only three of the 61 patient participants reporting mild eyestrain or dizziness, and none reporting nausea. These findings appear consistent with the very mild or infrequent side-effects observed in other VR distraction studies with pediatric hospitalized patients (Gold et al., 2006; Hoffman, Doctor, Patterson, Carrougher, & Furness Iii, 2000; Jeffs et al., 2014; Schmitt et al., 2011; Schneider & Workman, 2000; Sharar et al., 2008). Notably, we found no adverse events associated with infection transmission following cleaning of VR equipment and use of disposable hygiene covers between uses. Collaboration with institution-specific infection control departments to develop cleaning protocols specific to the VR equipment being used is thus an important safety measure that may positively influence intervention uptake by HCPs.

4.1 Study Limitations

Most participants had minimal knowledge or exposure to VR before the opportunity provided by this study. Though possibly representative of the relatively novel nature of VR, the involvement of mostly novice VR users may impact the generalisability of findings regarding intention to use. As VR becomes more widely accessed, further research with

patients and HCP's will be needed to confirm findings and adjust implementation strategies accordingly.

4.2 Clinical Implications

Patients in this study along with their parent caregivers, endorsed strong satisfaction with VR intervention in clinical settings. Direct user-feedback from patients indicated that Immersive VR intervention may be used to support children's needs during active cancer treatment; including to help regulate strong emotion, alleviate boredom, enhance mood, provide a sense of escape from hospital, the experience of play, distraction from feared medical procedures, and physical symptom reduction. With few studies having explored the clinical utility of VR with children beyond procedural or rehabilitation settings, our results indicate there is potential utility for VR as a prevention-orientated psychological intervention to support adjustment and coping with various aspects of hospitalization. As evident in this study, an exciting VR application that is particularly suited to inpatient oncology settings are virtual excursions or adventures that provide an antidote to hospital isolation, through "*the feeling of having gone somewhere*". The notion of intentional escape into an Immersive medium for fun or imaginative play has previously been explored among VR gamers in non-ill populations, showing VR provides a means for coping with external stressors (Kuo, 2016). Parents shared enjoyment with watching their child immersed in VEs (see comments Table 4) suggest VR intervention could be used to temporarily alleviate family distress symptoms by evoking positive affect.

Of note, HCPs nominated nurses as best to deliver VR intervention with patients. Recent literature has demonstrated that oncology nurses spend up to three hours per day providing emotional support to patients and are willing to be trained in new psychological interventions that support child wellbeing (Weinstein & Henrich, 2013). In this study, HCPs perceived the Immersive VR intervention as something all patients would enjoy (i.e. provide

a boost in positive affect), but also saw therapeutic value in it as a tool to engage vulnerable patients (e.g. “withdrawn” or “isolated), and especially adolescent patients (Table 3). Thus, validating our predictions of VR adoption by HCPs, as well as perceptions about its usefulness in enhancing patients’ quality of life and potentially prevention of psychological symptoms. Furthermore, this study found no report of nausea associated with VR use suggesting this is not a concern regarding the safe use of VR with seriously ill patient. Future VR intervention studies should continue to measure adverse events to validate these findings and build the evidence base regarding risk to patients in clinical settings.

Finally, as acknowledged by HCPs in this study, lack of developmentally appropriate content is as a major hurdle to the success of VR as a therapeutic tool. Children in this study identified a preference for nature and interactive sports content, with user-feedback providing insight to suitable and developmentally appropriate content that may enhance intervention effectiveness when applied to inpatient settings. As VR content creation is an expensive undertaking, an important next step is to explore the differential effects of virtual content on patient outcomes (e.g. pain, anxiety, low mood), as well as content that may be able to teach adaptive coping skills (e.g. deep breathing and mindfulness for anxiety management) (Mahrer & Gold, 2009; Schneider & Workman, 2000).

Reference

Bertrand, M., & Bouchard, S. (2008). Applying the technology acceptance model to VR with people who are favorable to its use. *Journal of Cyber Therapy & Rehabilitation, 1*(2), 200-210.

Birnie, K. A., Kulandaivelu, Y., Jibb, L., Hroch, P., Positano, K., Robertson, S., . . . Stinson, J. (2018). Usability Testing of an Interactive Virtual Reality Distraction Intervention to Reduce Procedural Pain in Children and Adolescents With Cancer. *Journal of Pediatric Oncology Nursing, 35*(6), 406-416. doi:10.1177/1043454218782138.

Bultz, B. D., Waller, A., Cullum, J., Jones, P., Halland, J., Groff, S. L., . . . Lau, H. (2013). Implementing routine screening for distress, the sixth vital sign, for patients with head and neck and neurologic cancers. *Journal of the National Comprehensive Cancer Network, 11*(10), 1249-1261. doi:doi.org/10.6004/jnccn.2013.0147.

Chan, E. A., Chung, J. W. Y., Wong, T. K. S., Lien, A. S. Y., & Yang, J. Y. (2007). Application of a virtual reality prototype for pain relief of pediatric burn in Taiwan. *Journal of Clinical Nursing, 16*(4), 786-793. doi:10.1111/j.1365-2702.2006.01719.x.

Cummings, J. J., & Bailenson, J. N. (2016). How immersive is enough? A meta-analysis of the effect of immersive technology on user presence. *Media Psychology, 19*(2), 272-309. doi:10.1080/15213269.2015.1015740.

Das, D. A., Grimmer, K. A., Sparnon, A. L., McRae, S. E., & Thomas, B. H. (2005). The efficacy of playing a virtual reality game in modulating pain for children with acute burn injuries: a randomized controlled trial [ISRCTN87413556]. *BMC pediatrics, 5*(1), 1. doi:10.1186/1471-2431-5-1.

Dascal, J., Reid, M., Ishak, W. W., Spiegel, B., Recacho, J., Rosen, B., & Danovitch, I. (2017). Virtual Reality and Medical Inpatients: A Systematic Review of Randomized, Controlled Trials. *Innovations in Clinical Neuroscience, 14*(1/2), 14-21.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*(Sep 1), 319-340. doi:10.2307/249008.

Dejong, M., & Fombonne, E. (2006). Depression in paediatric cancer: an overview. *Psycho-Oncology, 15*(7), 553-566. doi:10.1002/pon.1002.

Gershon, J., Zimand, E., Pickering, M., Rothbaum, B. O., & Hodges, L. (2004). A pilot and feasibility study of virtual reality as a distraction for children with cancer. *Journal of the American Academy of Child and Adolescent Psychiatry, 43*(10), 1243-1249. doi:10.1097/01.chi.0000135621.23145.05.

Glegg, S. M. N., Holsti, L., Velikonja, D., Ansley, B., Brum, C., & Sartor, D. (2013). Factors influencing therapists' adoption of virtual reality for brain injury rehabilitation. *Cyberpsychology, Behavior, and Social Networking, 16*(5), 385-401. doi:10.1089/cyber.2013.1506.

Glegg, S. M. N., & Levac, D. E. (2018). Barriers, facilitators and interventions to support virtual reality implementation in rehabilitation: a scoping review. *PM&R, 10*(11), 1237-1251. doi:10.1016/j.pmrj.2018.07.004.

Gold, J. I., Kim, S. H., Kant, A. J., Joseph, M. H., & Rizzo, A. S. (2006). Effectiveness of Virtual Reality for Pediatric Pain Distraction during IV Placement. *CyberPsychology & Behavior, 9*(2), 207-212. doi:10.1089/cpb.2006.9.207.

Harris, P. A., Taylor, R., Thielke, R., Payne, J., Gonzalez, N., & Conde, J. G. (2009). Research electronic data capture (REDCap)—a metadata-driven methodology and workflow process for providing translational research informatics support. *Journal of Biomedical Informatics, 42*(2), 377-381. doi:10.1016/j.jbi.2008.08.010.

Hoeft, R. M., Vogel, J., & Bowers, C. A. (2003). Kids get sick too: a proposed child simulator sickness questionnaire. *In Proceedings of the Human Factors and Ergonomics Society*

Annual Meeting (Vol. 47, No. 20, pp. 2137-2141). Sage CA: Los Angeles: CA: SAGE Publications doi:10.1177/154193120304702013

Hoffman, H. G., Doctor, J. N., Patterson, D. R., Carrougher, G. J., & Furness Iii, T. A. (2000). Virtual reality as an adjunctive pain control during burn wound care in adolescent patients. *Pain, 85*(1-2), 305-309. doi:10.1016/s0304-3959(99)00275-4.

Holden, R. J., & Karsh, B.-T. (2010). The Technology Acceptance Model: Its past and its future in health care. *Journal of Biomedical Informatics, 43*(1), 159-172. doi:10.1016/j.jbi.2009.07.002.

Hollis, C., Morriss, R., Martin, J., Amani, S., Cotton, R., Denis, M., & Lewis, S. (2015). Technological innovations in mental healthcare: harnessing the digital revolution. *British Journal of Psychiatry, 206*(4), 263-265. doi:10.1192/bjp.bp.113.142612.

Hua, Y., Qiu, R., Yao, W.-y., Zhang, Q., & Chen, X.-l. (2015). The Effect of Virtual Reality Distraction on Pain Relief During Dressing Changes in Children with Chronic Wounds on Lower Limbs. *Pain Management Nursing, 16*(5), 685-691. doi:10.1016/j.pmn.2015.03.001.

Jeffs, D., Dorman, D., Brown, S., Files, A., Graves, T., Kirk, E., . . . Swearingen, C. J. (2014). Effect of virtual reality on adolescent pain during burn wound care. *Journal of Burn Care & Research, 35*(5), 395-408. doi:10.1097/BCR.0000000000000019.

Kazak, A. E., & Noll, R. B. (2015). The integration of psychology in pediatric oncology research and practice: Collaboration to improve care and outcomes for children and families. *American Psychologist, 70*(2), 146-158. doi:10.1037/a0035695.

Kipping, B., Rodger, S., Miller, K., & Kimble, R. M. (2012). Virtual reality for acute pain reduction in adolescents undergoing burn wound care: a prospective randomized controlled trial. *Burns, 38*(5), 650-657. doi:10.1016/j.burns.2011.11.010.

Kuo, A. (2016). Brave new World of Warcraft: a conceptual framework for active escapism. *Journal of Consumer Marketing, 33*(7), 498-506. doi:10.1108/JCM-04-2016-1775.

Langhan, M. L., Riera, A., Kurtz, J. C., Schaeffer, P., & Asnes, A. G. (2015). Implementation of newly adopted technology in acute care settings: a qualitative analysis of clinical staff. *Journal of Medical Engineering & Technology, 39*(1), 44-53. doi:10.3109/03091902.2014.973618.

Li, W. H., Chung, J. O., & Ho, E. K. (2011). The effectiveness of therapeutic play, using virtual reality computer games, in promoting the psychological well-being of children hospitalised with cancer. *20*(15-16), 2135-2143. doi:10.1111/j.1365-2702.2011.03733.x.

Lyon, A. R., Wasse, J. K., Ludwig, K., Zachry, M., Bruns, E. J., Unützer, J., & McCauley, E. (2016). The Contextualized Technology Adaptation Process (CTAP): Optimizing Health Information Technology to Improve Mental Health Systems. *Administration and Policy in Mental Health and Mental Health Services Research, 43*(3), 394-409. doi:10.1007/s10488-015-0637-x.

Mahrer, N. E., & Gold, J. I. (2009). The use of virtual reality for pain control: A review. *Current Pain and Headache Reports, 13*(2), 100-109. doi:10.1007/s11916-009-0019-8.

Malloy, K. M., & Milling, L. S. (2010). The effectiveness of virtual reality distraction for pain reduction: A systematic review. *Clinical psychology review, 30*(8), 1011-1018. doi:10.1016/j.cpr.2010.07.001.

Markus, L. A., Willems, K. E., Maruna, C. C., Schmitz, C. L., Pellino, T. A., Wish, J. R., . . . Schurr, M. J. (2009). Virtual reality: feasibility of implementation in a regional burn center. *Burns, 35*(7), 967-969. doi:10.1016/j.burns.2009.01.013.

Parsons, T. D., Rizzo, A. A., Rogers, S., & York, P. (2009). Virtual reality in paediatric rehabilitation: A review. *Developmental Neurorehabilitation, 12*(4), 224-238. doi:10.1080/17518420902991719.

Ravi, D. K., Kumar, N., & Singhi, P. (2017). Effectiveness of virtual reality rehabilitation for children and adolescents with cerebral palsy: an updated evidence-based systematic review. *Physiotherapy, 103*(3), 245-258. doi:10.1016/j.physio.2016.08.004.

Rizzo, A., & Koenig, S. T. (2017). Is clinical virtual reality ready for primetime? *Neuropsychology, 31*(8), 877-899. doi:10.1037/neu0000405.

Rourke, M. T., Hobbie, W. L., Schwartz, L., & Kazak, A. E. (2007). Posttrauamatic stress disorder (PTSD) in young adult survivors of childhood cancer. *Pediatric Blood & Cancer, 49*(2), 177-182. doi:10.1002/pbc.20942.

Rourke, M. T., Samson, K. K., & Kazak, A. E. (2015). Psychological Aspects of Long-Term Survivorship. *In Schwartz C., Hobbie W., Constine L., Ruccione K. (eds) Survivors of Childhood and Adolescent Cancer* (pp. 295-304): Pediatric Oncology. Springer, Cham. doi:10.1007/978-3-319-16435-9_20.

Rourke, M. T., Stuber, M. L., Hobbie, W. L., & Kazak, A. E. (1999). Posttraumatic stress disorder: understanding the psychosocial impact of surviving childhood cancer into young adulthood. *Journal of Pediatric Oncology Nursing, 16*(3), 126-135. doi:10.1177/104345429901600303.

Sander Wint, S., Eshelman, D., Steele, J., & Guzzetta, C. E. (2002). Effects of distraction using virtual reality glasses during lumbar punctures in adolescents with cancer. *Oncology nursing forum, 29*(1), E8-E15. doi:10.1188.02/ONF.E8-E15.

Schmitt, Y. S., Hoffman, H. G., Blough, D. K., Patterson, D. R., Jensen, M. P., Soltani, M., . . . Sharar, S. R. (2011). A randomized, controlled trial of immersive virtual

reality analgesia, during physical therapy for pediatric burns. *Burns, 37*(1), 61-68. doi:10.1016/j.burns.2010.07.007.

Schneider, S. M., & Workman, M. L. (1999). Effects of virtual reality on symptom distress in children receiving chemotherapy. *Cyberpsychology and Behavior, 2*(2), 125-134. doi:10.1089/cpb.1999.2.125.

Schneider, S. M., & Workman, M. L. (2000). Virtual reality as a distraction intervention for older children receiving chemotherapy. *Pediatric nursing, 26*(6), 593-597.

Sharar, S. R., Miller, W., Teeley, A., Soltani, M., Hoffman, H. G., Jensen, M. P., & Patterson, D. R. (2008). Applications of virtual reality for pain management in burn-injured patients. *Expert review of neurotherapeutics, 8*(11), 1667-1674. doi:10.1586/14737175.8.11.1667.

Strauss, A., & Corbin, J. M. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Thousand Oaks, CA, US: Sage Publications, Inc.

Sun, H., & Zhang, P. (2006). The role of moderating factors in user technology acceptance. *International Journal of Human-Computer Studies, 64*(2), 53-78. doi:10.1016/j.ijhcs.2005.04.013.

Tarnowski, K. J., & Simonian, S. J. (1992). Assessing treatment acceptance: The abbreviated acceptability rating profile. *Journal of Behavior Therapy and Experimental Psychiatry, 23*(2), 101-106. doi:10.1016/0005-7916(92)90007-6.

Tennant, M., Youssef, G. J., McGillivray, J., Clark, T.-J., McMillan, L., & McCarthy, M. (2020). Exploring the Use of Immersive Virtual Reality to enhance psychological wellbeing in Pediatric Oncology. doi:10.31234/osf.io/hujgz.

Weinstein, A. G., & Henrich, C. C. (2013). Psychological interventions helping pediatric oncology patients cope with medical procedures: A nurse-centered approach.

European Journal of Oncology Nursing, 17(6), 726-731. doi:10.1016/j.ejon.2013.04.003.

Wiener, L., Kazak, A. E., Noll, R. B., Patenaude, A. F., & Kupst, M. J. (2015). Standards for the psychosocial care of children with cancer and their families: an introduction to the special issue. *Pediatric Blood & Cancer, 62*(S5), S419-S424. doi:10.1002/pbc.25675.

Wolitzky, K., Fivush, R., Zimand, E., Hodges, L., & Rothbaum, B. O. (2005). Effectiveness of virtual reality distraction during a painful medical procedure in pediatric oncology patients. *Psychology and Health, 20*(6), 817-824. doi:10.1080/14768320500143339.

Won, A., Bailey, J., Bailenson, J., Tataru, C., Yoon, I., & Golianu, B. (2017). Immersive Virtual Reality for Pediatric Pain. *Children, 4*(7), 52. doi:10.3390/children4070052.

Tables

Table 1

Patient and parent sample characteristics (N = 61)

Socio-demographic, disease characteristics	Mean (SD) or n (% of sample)
Child Age	11.58 (3.61)
7-12 years	40 (65.57%)
13-19 years	21 (34.43%)
Sex	
Male	37 (60.66%)
Female	24 (39.34%)
Country of birth	
Australia	58 (95.08%)
Other	3 (4.92%)
Cancer/disease type	
Leukemia	23 (37.70%)
Lymphoma	8 (13.11%)
Brain tumor/CNS	3 (4.92%)
Bone	14 (22.95%)
Soft tissue	4 (6.56%)
Germ cell	4 (6.56%)
Melanoma	1 (1.64%)
Other immunodeficiency and haematological conditions	4 (6.56%)
Disease relapsed	
Yes	8 (13.11%)
No	53 (86.89%)
Parental marital status	
Single	4 (6.56%)
Married/defacto	50 (82.97%)
Separated/divorced/widowed	7 (11.48%)
Parental employment	
Full time	16 (26.2%)
Part time/ Casual	17 (27.9%)
Not currently employed/Home duties	27 (44.3%)
Parental education	
Low: Did not complete high school	8 (13.11%)
Medium: Completed high school/trade/certificate/diploma	35 (57.38%)
High: Completed tertiary education	18 (29.51%)

Table 2

Child-reported simulator sickness in VR condition (N = 61)

Total scores for each sickness category	n (%)
Nausea	
0 (No symptoms)	47 (77.05)
1-2 (Reported symptoms)	14 (22.95)
3> (Simulator sickness indicated)	0 (0)
Occulomotor (i.e. eye strain)	
0 (No symptoms)	36 (59.02)
1-2(Reported symptoms)	23 (37.70)
3> (Simulator sickness indicated)	2 (3.28)
Disorientation (i.e. dizziness)	
No symptoms	45 (73.77)
1-2 (Reported symptoms)	15 (24.50)
3> (Simulator sickness indicated)	1 (1.64)

Note. A total score of 3 or more for any category indicates the presence of simulator sickness within that category

Table 3

Summary of main themes and subcategories of influencing factors on VR technology adoption by HCPs

Main theme	Sub-category	Illustrative quotes
Perceived benefit to patients	Patient groups	*Only for older / teenage patients.* *Beneficial for social anxiety / withdrawn patients.* *Long stay patients.* *Good for BMT (isolation ward).* *Interstate / rural patients that feel disconnected.* *Adolescents.* *Beneficial for older kids.* *Very beneficial for teenagers/ older kids.* *Something different for the older kids.*
	Coping with medical procedures	*Would have real benefit to aid with painful procedures - great multi-sensory distraction.* *Use - distraction: fantastic for procedure distraction.* *It would be great if it could be linked with clinical environments to explain procedures.* *Useful to use for distraction during procedures.* *Would be good distraction during procedures.*
Access to education/ training	Goals for use	*Context.* *When to use and how.* *Understanding the technology from education.* *Clear goals: why are you using the tech.*
	Suitability to patients	*Key indicators to flag it is appropriate (i.e. age of the child and development, timing of using, purpose to use, outcomes).* *Would need to consider age, illness symptoms, otherwise think it should be offered to all patients (& potentially family members).* *Current health status, e.g. nurses, pain etc.* *Being very aware of their medical needs and presentation.* *Screening tool.*
Usability	Easy to use	*Easy to use.* *Easy to adjust headset.* *Easy to set up.* *Being confident to then teach the patients.*
	Reliable	*Technology works e.g. doesn't fail.*
	Convenient	*Quick to set up.*
Content	Suitability	*Having familiar scenes would be useful for kids e.g. zoo, Melbourne scenes, beaches, playgrounds etc.* *Range of experiences to explore that are engaging for children.*
	Variety	*Ensuring there are a multitude of experiences.* *Length of content.* *Choose music.*
Patient safety concerns	Developmental	*Developmental need.* *ASD/ADHD - sensory issues.* *Behaviour of the child.* *Sensory issues.*

		Coping skills.
	Anxiety	*Height perspective (phobias).* *Anxious person many want to know what's happening next.*
	Health status	
		Capacity illness. *Chemo and sickness.* *Nauseated.*
	Highly medicated	
		Assessing if the patient if on opioids that could cause hallucinations and virtual experiences non-enjoyable.
	Vision-impaired	
		Patients with bad/poor eye sight might struggle. *Some were blurry despite changing focus, especially due to me wearing glasses so I wonder if patients with vision impairment may struggle?*
Safety concerns with VR equipment	Infection control/risk	*Infection control.*
	Motion-sickness	*Movement – nausea inducing.* *Nausea: only the calming ones (animal and nature) as others too quick moving.* *Some patients might get nauseous if it moves too much.* *The fast-moving images made me feel slightly dizzy and nauseous.* *Some aspects caused motion sickness, especially the one with people buzzing past.*

Table 4

Patient and parent perspectives on the usefulness of VR intervention in paediatric inpatient oncology settings

Main themes (goal for use)	Patient quotes	Parent quotes
Coping with strong emotion/ physiological arousal (emotional regulation)	*When you feel stressed.* *When you're anxious or really upset.* *When I'm tired and grumpy.* *When you get given bad news.* *When you are feeling angry or upset.* *When you are feeling upset and need to calm down.*	-
Coping with boredom or low mood (mood improvement)	*When I'm bored during the day.* *Afternoon times, because there's nothing much on.* *When you're bored or feeling down, this could cheer you up.* *When you are not feeling great and you need a boost in your feelings.* *Maybe when I'm not feeling that good I can look at these scenes to cheer me up.*	*Seems to have put a smile on his face and was a pleasant distraction.* *I was watching my child and he enjoyed the experience very much. That made me happy.* *Definitely during times of boredom with hospital stays. She loved it ...so cool.* *(My daughter) was so animated and excited. Would love her to be able to do this again.*
Coping with isolation (escape from hospital/ virtual play)	*When you're in for a while and wanting to go somewhere.* *When I am in BMT.* *After a long day of lying in bed.* *When children have been in hospital for a while.*	*Being able to experience VR scenarios from outside the hospital is great when they are confined to a ward for long periods of time. Mixed in with normal play this is a positive experience. Be great to see how this can build into a collaborative space for children from different rooms or wards to visit different worlds together.* *Fantastic way for kids to feel like they've been able to "leave" the hospital bed even just for a short time!!* *Makes the kids feel like they had an outing and got out of the room.*
Coping with procedural anxiety or pain (symptom reduction)	*Distraction from medical procedures- port access.* *During chemotherapy.* *If you are feeling sick. Needing a distraction from needles.* *Before surgeries when children are anxious.* *When people are touching me and have needles.*	*Excellent technology to help distract my child especially if there is needles or treatment side effect.* *I can pinpoint a time this would have been useful to help my son through a tough patch during chemo.* *Samsung Gear VR was highly engaging and helped immensely in distracting my daughter from the pain she felt in her tummy at the time. I'm sure it would work as effectively as a Morphine Bolus!*
Timing of intervention use (optimum enjoyment)	*When I'm ok and I can move well, have energy.* *When I am not feeling sick or nauseous.* *When I'm feeling fresh and not sick and not sore in the tummy.* *When you feel close to your best or at your best.* *When you're comfortable.* *When I'm not feeling well because it distracts me from my tummy pain.*	

Supplementary material

Technology Acceptance Model questionnaire items

The questionnaire items, and their descriptive statistics [measured on 7 point Likert scale, "Extremely Unlikely" (1) to "Extremely Likely" (7)]

Construct	Measurement item	Mean	S.D	Range
Perceived Usefulness	Using the VR experiences with my patients would make it easier to do my job	5.63	0.81	4 – 7
	Using the VR experiences with my patients would increase my job productivity	4.83	1.29	1 – 7
	Using the VR experiences with my patients would enhance my effectiveness on the job	4.33	1.34	1 - 7
	Using the VR experiences with my patients would be useful in my job	4.47	1.22	1 - 7
Perceived Ease of Use	Learning to operate the VR headset would be easy for me	5.90	0.80	5 – 7
	I would find it easy to get the VR headset to do what I want it to do	5.90	0.80	5 – 7
	I would find the VR headset easy to set up for a patient	5.67	0.84	4 – 7
	It would be easy for me to become skilled at administering the VR headset with a patient	5.47	0.97	4 – 7

Abbreviated Acceptability Rating Profile (AARP) questionnaire items

Adapted questionnaire items and instructions [measured on 6 point Likert scale, "Strongly Disagree" (1) to "Strongly agree" (7)]

For each statement below, please fill the circle that corresponds to the answer that best describes your opinion about the use of this technology in clinical care to improve well-being with children cancer
1. This technology is acceptable for use with children with cancer
2. These experiences should be effective in helping children with cancer
3. Children with cancer need experiences like this
4. I would be willing to recommend this technology to other parents
5. Using this technology would not have bad side effects for my child or my family
6. I liked this technology
7. The technology was a good way to help my child's overall well-being
8. Overall, these experiences would help children with cancer
9. Please add any other comments / opinions about this technology: