STUDY PROTOCOL WITH SAP

Official Title: Evaluating the Impact of Digital Media on Patient-Reported Experience and Outcomes in Pediatrics

Date: 6/13/2025

Scientific Abstract: Fifty percent of children experience pre-procedural anxiety. Unchecked, pre-procedural anxiety can have both short- and long-term negative impacts. One approach to reduce pre-procedural anxiety is through exposure and education, whereby children are oriented to the different components of the procedure, reducing uncertainty and increasing self-efficacy. This process includes describing or showing the environment, routines, medical instruments, and the procedure itself to the child. However, it is impractical to provide all patients with in-person orientation and training sessions. Various forms of media and technology can be used as an adjunct in exposing and educating patients to their scheduled procedure, from low-fidelity solutions (e.g. picture books) to engaging forms of new media (e.g. virtual reality [VR]). Here, we plan to expose and educate children on their upcoming medical procedure through different media types (2D video +_audio, 360 video + audio, or 360 video in VR + audio). Five hundred children (aged 6-18) scheduled for an upcoming procedure at BC Children's will be randomized to receive either 2D video -, 360 video-, or VR-based preparation. All groups will receive standardized base educational information in a visual and spoken format, with an aim to isolate whether the type of fidelity of supplemental media has an impact on periprocedural disposition. Preparation will include information regarding hospital environment, staff, instruments, and a step-by-step process of the each patient's procedure. Irrespective of group, everyone will receive their procedure through a custom mobile app, answer a series of short surveys pre- and post-preparation and post-procedure. Surveys will focus on anxiety and pain. We expect that those who received VR-based preparation will have lower pre-procedural anxiety compared to those that received 2D and 360 video and audio-based preparation. We also expect that the frequency and duration of exposure to higher fidelity immersive media (i.e. VR) is inversely correlated with perioperative anxiety and pain.

Lay abstract: Children experience anxiety before medical procedures, which have negative effects. Educating them about what to expect can help reduce this anxiety. In this study, we aim to prepare children for procedures using 2D and 360 video and audioincluding virtual reality (VR). Children aged 6-18 will be randomized to receive either 2D videoand audio-, 360 video and audio-, or 360 video in VR and audio-based preparation. They'll complete anxiety surveys before and after their preparation through a custom mobile app. We think that watching videos in VR, will lower anxiety compared to when patients only watch 2D or 360 videos about their procedure beforehand.

BACKGROUND

Pre-procedural anxiety and its negative impact

Pre-procedural anxiety is highly prevalent in children, with an estimated 50% of all children experiencing anxiety before undergoing a standard medical procedure (1). Unchecked, pre-procedural anxiety can include greater emotional distress, longer recovery times (2), lack of compliance during the procedure (3,4), and posttraumatic stress syndrome (5), which may lead to environmental- (i.e., hospital, operating room) or medical-specific phobias and overall healthcare avoidance (6). Interventions that can mitigate pre-procedural anxiety in children are needed.

The role of media in reducing pre-procedural anxiety

Pre-procedural anxiety is often rooted in the uncertainty surrounding an impending medical procedure (1). Unfamiliar environments, routines, medical instruments, and the nature of the procedure itself can exacerbate this anxiety. As such, patient education has emerged as a pivotal strategy in alleviating this form of anxiety. Various educational tools, including verbal briefings, written or pictorial materials, and even guided tours of medical facilities, have shown effectiveness in diminishing pre-procedural anxiety and pain among pediatric patients (7, 23). Diverse media formats play an integral role in enhancing medical compliance and potentially through anxiety. For instance, a study demonstrated that children who engaged with an interactive video about their upcoming imaging scan required fewer repeat scans due to reduced movement, achieving a 20% improvement over a control group (8). These findings underscore the value of utilizing media to familiarize and educate children about their medical procedures, potentially leading to decreased anxiety and enhanced patient care.

The utility of digital immersion in pre-procedural preparation

The exploration of digital immersion, notably virtual reality (VR), in preparing patients for medical procedures is gaining traction. Studies have pointed to the effectiveness of VR in both exposing and educating patients about their upcoming medical experiences. For example, pediatric patients who were acquainted with the process of chest radiography through VR reported significantly lower distress levels compared to those who did not use VR (9). Additionally, caregivers of children who received VR-based procedural education experienced less anxiety than those whose children prepared with traditional methods, such as paper manuals (10), but there was no difference in self-reported anxiety scores, likely attributed to a small sample size. Despite these promising results, the lack of significant differences in self-reported anxiety among the children suggests the need for further research. Broadening the scope of investigation to include a wider array of procedures and employing larger, more diverse sample sizes could better elucidate the potential of VR and other forms of digital immersion in reducing pre-procedural anxiety.

Knowledge Gaps

Despite the numerous studies that have used various media (e.g., photos, videos) on various mediums (e.g., paper, phones, and VR) to reduce pre-procedural anxiety in children, significant gaps remain. Studies that have attempted to reduce pre-procedural anxiety in children have had small sample sizes (9–13), increasing type 1 errors. Also, studies that have used media and/or VR to reduce anxiety have done so primarily for imaging (9,10) or for procedures that require general anesthesia (11,12,14). There is a significant gap in our knowledge in direct comparison of different forms of media (e.g., text vs photo), how

immersion moderates its effectiveness, and direct cross-context studies in pediatric populations. Finally, many studies that have explored using media to reduce pre-procedural anxiety primarily focus on in-person and on-site preparation. Exposure and education may be more or equally as effective in a familiar and safe environment, such as the patient's home, with significantly more time for repeated exposure, and a clear benefit of cost-effectiveness compared to in-hospital preparation (7). On-site training also has capacity limitations, costs, and logistical restrictions that make it prohibitive for many patients. On-site preparation is costly for both the patient as well as the hospital, with an estimated cost savings of 119 to 3,365 CAD for those who used at home compared to on-site preparation (15). Therefore, our project aims to primarily understand the effect of remote procedural preparation from a clinical effectiveness perspective, but also to explore enablers and barriers to technology adoption for children, families, and as a healthcare institution.

OBJECTIVES

This project aims to investigate how exposure and education using immersive media can influence periprocedural anxiety, pain, and patient experience in children. To discern whether there is a moderating effect of immersive fidelity on these outcomes, we will compare various media forms—ranging from 2D video and audio to immersive media (i.e. 360 videos, VR).

Hypothesis: We expect that immersive media (i.e. 360 video in VR) preparation will be more effective in reducing pre-procedural anxiety compared to photo and audio- and text-based preparation groups. Furthermore, we predict an inverse correlation between media fidelity and patient-reported anxiety and pain. Similarly, we expect that the frequency and duration of exposure will moderate the effect size in all groups, but with a greater degree of magnitude with immersive media

METHODS

Trial design

This study will be a single-blinded, stratified, prospective randomized clinical trial. Participants will be stratified by procedure and randomly assigned to one of three preparation groups (2D video and audio, 360 video and audio, 360 video in VR and audio) using a 1:1:1 allocation ratio. The study includes 5 timepoints: baseline (T0), up to one week before the procedure but before preparation (T1), immediately after preparation (T2), plus three post-procedure follow-up periods (T3, T4, and T5) at 1-, 7-, and 30-days, respectively. All participants will be asked to prepare for their procedure at least once, within one-week of their procedure. In-app, text, and/or email reminders will be sent prior to their scheduled appointment, with the opportunity to defer and reset in the event of delays. See Figure 1 for an overview of the study design.

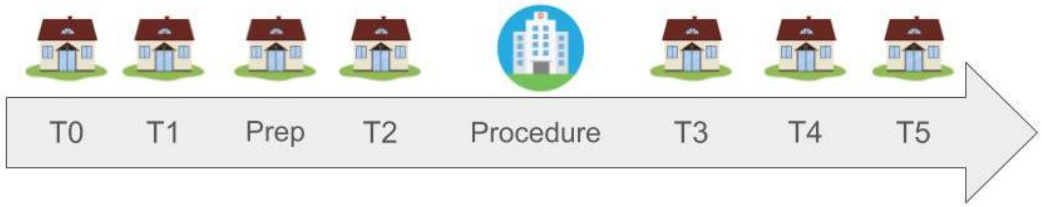

Figure 1. Study design overview. House icons indicate surveys and exposure / education will take place at home, whereas the hospital icon indicates that the procedure takes place on-site at BC Children's Hospital.

Eligibility Criteria

Patients will be recruited through participating divisions and clinics at BC Children's Hospital clinics including: Allergy, Dental, Surgery, Orthopedics, Oncology, Gastroenterology, Radiology and the Emergency Department. All children and their parents/guardians will be informed about the goals and methods of the study. Participants who meet the inclusion criteria (below) and agree to participate in the study will sign informed consent and assent.

Inclusion criteria

To be considered eligible, participants will be 1) between the ages of 5 to 23; 2) able to communicate in English and follow instructions; 3) own or have access to a smartphone; and 4) be scheduled for an upcoming procedure within one of the participating clinics.

Exclusion criteria

Participants will be ineligible if they 1) are under the age of 5 or older than 23; have 2) vision, hearing, cognitive, or motor impairments;.

INTERVENTIONS

360 and VR video-based preparation

Video/VR update: In our previous study, we found that caregivers wanted to explore VR with their child (10). Children also reported that the training element was too difficult (10) - given the primary focus on preparation for medical imaging. In consultation with our product advisory group (including patients), we revised the current protocol to address these issues, and the gaps identified in the literature since our original study. We eliminated the positional training component (i.e., training children to lay as still as possible), focusing exclusively on exposure and educational preparation, allowing us to better generalize our intervention to other healthcare encounters, most of which do not necessarily benefit from positional training. Second, media will be displayed on participants' smartphones, allowing for broader access at-home, and without the direct support of a researcher or clinician. Participants randomized to the immersive arm of the study, will be enabled to view immersive 360 videos of the procedure, including in VR, if not contraindicated.

For those randomized to receive either the 360 or VR video-based preparation, participants and their families will receive standard-of-care specific to the division/clinic that scheduled their procedure, audio-based descriptions of their upcoming procedure, as well as 360 videos. 360 videos will contain a first person, live action tour, and procedural experience (Figure 2), specific to the participant's procedure, including an orientation to the hospital environment, staff, equipment, and / or each procedural step specific to their procedure. Thus, there will be multiple 360 video and audio-based exposure and education videos, each one specific to the procedure the participant is scheduled to have.

Participants will access the media via a mobile app. Participants randomized to the immersive arm of the study, will be able to view video content directly on their device and in VR with the

use of a cardboard VR-viewer/headset that utilizes their existing mobile phone (i.e., the phone slips into a cardboard headset which goes over the head).

The VR headset will be provided to participants at the time of recruitment or sent to them through mail. The package will contain information about how to properly and safely use VR and where to access troubleshooting support (they will be given a recruitment poster with our contact info: email, phones). All participants who use will complete the Child Simulator Sickness Questionnaire (16). We will also include a disclaimer (in the screening, in the demographics, and in the e-mail when participants receive app download / installation instructions) that those with epilepsy or history of seizures should skip the VR tutorial. They will also not be randomized into the VR portion of the study.

Figure 2. Screen shot of 360 video from MRI room.

Figure 3. Screen shot of the gamified hospital (left) and the 2D video from the MRI room (right)

Figure 3. Preliminary model of the VR BCCH environment (left) and a first person live action tour (right).

2D video and audio-based preparation

Participants in the 2D video-based group will receive standard-of-care specific to the division/clinic that scheduled the procedure, audio-based descriptions of their upcoming procedure, as well as 2D video. The video will be close-ups of medical equipment or objects specific to their procedure (see Figure 3 right). The videos that the participants will see will be pictures of the environment, staff, equipment, and / or each procedural step. Therefore, persons that are in the 2D video-based preparation group will receive the same information as the other groups, however, all exposure and education will be in 2D video and audio form, specific to the procedure the participant is scheduled to have. Therefore, there will be multiple 2D video and audio-based exposure scenarios, each one specific to the procedure the participant is scheduled to have. Participants will use a custom mobile app to access their 2D videomedia.

APPLICATION (APP)

All study materials will be available in a custom made application, or app. Once participants complete the screening questionnaire, consent and assent on Qualtrics, followed by the collection of baseline measures, Qualtrics will forward and / or provide a link to the user to download the app where they will be asked to register (providing a unique name, password, and e-mail address) to access the study materials. In this way, data collected in the app will be de-identified but linked to the consent form data that is collected on Qualtrics via a randomly generated number that will be recorded by the app in the automatic forwarding process between Qualtrics and our app. Therefore, all intervention media (2D, 360 video and audio-preparation materials) will be accessed through the secure application.

Once a participant is ready to begin their preparation, our app, that is linked to Qualtrics, will have participants complete the pre-intervention (T1) survey within the app. Once the pre-intervention surveys are completed, users will be able to access and complete their preparation / education (based on their procedure). Once completed, participants will complete the post-intervention (T2) surveys via Qualtrics inside the app. Thus, participants will go to Qualtrics, complete a brief screening form, agree to the study (i.e., consent & assent), complete baseline measures all on Qualtrics (data stored on Canadian servers), be forwarded / click on a link to the app, download, register, and then sign in to the app to access the app materials. Once participants are ready to begin, users will complete pre-intervention surveys within the app but collected via Qualtrics, see their intervention materials, then complete the post-intervention surveys on Qualtrics but within the app. Users of the app will be participants (i.e., children), and their caregivers. Participants and their caregivers will only have to create one account.

Data storage and management will be handled by PostgreSQL database, an open-source relational database system. PostgreSQL's strong standards compliance make it suitable for storing data collected in this study. PostgreSQL database is hosted on Microsoft Azure with Canadian servers. The servers used have undergone privacy impact assessments as part of the base technical infrastructure used by the development team. Security measures include the implementation of Content Security Policies, input sanitization, and the use of HTTPS protocols to mitigate cross-site scripting and injection attacks. The following below details our security measures.

Deployment Security & CI/CD Practices. Deployment via Vercel integrates Continuous Integration/Continuous Deployment (CI/CD) practices, automating the deployment of updates and security patches. Vercel's deployment model ensures that SSL/TLS encryption is applied to all traffic, with automated certificate management facilitating secure connections. Additionally, Vercel employs edge network security features, including DDoS protection and rate limiting, to protect against network-level attacks.

Database Security & Encryption. The application's PostgreSQL database, hosted on Microsoft Azure, incorporates AES-256 encryption for data at rest, aligning with industry standards for secure data storage. Data in transit between the application and database is secured using SSL/TLS encryption, ensuring that sensitive data is encrypted over the network. Azure's hosting environment further enforces security through network security groups and firewall rules, limiting access to the database servers to authorized entities only.

SSL/TLS for Browser Security. All interactions between the web application and user browsers are secured using SSL/TLS encryption, establishing a secure channel that prevents eavesdropping, tampering, and forgery. The implementation adheres to TLS 1.2 and above, ensuring the use of strong cipher suites and key exchange mechanisms. SSL certificates are managed and renewed automatically, maintaining the integrity of the secure connection over time.

Both the Qualtrics and the web-based app accounts used will be password protected and only members of the study team will have the passwords, mitigating risks of the data being copied. Passwords will be changed every 3 months. Both Qualtrics and our web-based app have features that allow the account owner to see when the data has been downloaded. This will be monitored to ensure that no downloads are occurring by persons other than the research team.

Data that are transferred from the secure Microsoft servers and downloaded on work computers will be encrypted and stored on a computer with restricted access to study personnel only.

OUTCOME MEASURES:

Primary Outcomes: Primary outcome measures will be participant self-report state anxiety measured using the Numeric 0-10 State Anxiety Scale (17) and the . Anxiety will be assessed at baseline (T0) before (T1) and after (T2) exposure. Anxiety will also be measured at follow-up timepoints (T3, T4, T5). Secondary outcomes measures include self-report pain as measured by the NRS-11 (19) measured pre-procedure (T2) and during the three follow-up periods post-procedure (T3, T4, T5). Tertiary outcomes include caregiver state anxiety as

measured by the Short State Trait Anxiety Inventory - State form (S-STAI) and Numeric 0-10 State anxiety, participant satisfaction surveys before (T2) and after (T3) the procedure. See Table 1 for the study timeline and assessments used at each timepoint.

Baseline

Demographics***:*** A general intake form will be administered to parents at baseline to identify personal details of parents and children. The following data will be collected at baseline from the participant: age of the patient at enrollment, gender, when and what procedure the child is having, previous exposure to procedure, reason of procedure, disability status, ethnicity, first language, age of caregiver, relationship of caregiver to the child, gender of caregiver, highest level of education of the caregiver, address (for shipping materials)

Anxiety. We will also administer a comprehensive questionnaire regarding trait anxiety and hospital-specific phobia using the Screen for Child Anxiety Related Disorders (SCARED) (21). We will also collect the caregivers' trait anxiety using the State-Trait Anxiety Inventory - Trait form (STAI-T) (17). Subgroup analysis on these variables will occur, where possible.

Table 1. Measures and study timeline. FPS-R = Faces Pain Scale Revised; NRS = numeric rating scale (for pain); NSAS = Numeric State Anxiety Scale; S-STAI = Short State Trait Anxiety Inventory; S-STAIC = Short State Trait Anxiety Inventory Children; STAI-T = State-Trait Anxiety Inventory, Trait form; Pediatrics Simulator Sickness Questionnaire (PSSQ); SCARED = Screen for Child Anxiety Related Disorders;; VAS-pain = Visual Analogue Scale for worst pain and time thinking about pain.

Measure	T0 (upon consent / assent)	T1 (1-7 days before procedure)	Exposure (1-7 days before procedure)	T2 (1-7 days before procedure)	T4 (1 day after procedure)	T3 (1 week after procedure)	T4 (1 month after procedure)
Demographics (parent, child)	**X**						
SCARED (child)	**X**						
STAI-T (parent)	**X**						
NSAS (parent)	**X**						
NSAS (child)	**X**	**X**		**X**	**X**	**X**	**X**
NSAS procedure (Child)					**X**	**X**	**X**
NRS (child)		X			**X**	**X**	**X**
NRS procedure (child)					**X**	**X**	**X**
CCSQ (child)		**X**		**X**			
Procedure quiz		**X**		**X**			
Satisfaction (parent, child)				**X**	**X**		

Sample Size: Given the variation in the number of potentially eligible participants across divisions/clinics, and with a conservative recruitment rate, we anticipate recruiting approximately 500 patients per year. Using G*Power and a medium effect size of 0.23, an alpha of 0.01 (correcting for multiple comparisons), 95% power, and Df of 4, it is estimated that we need a total of 450 participants to detect a difference in self-report anxiety. Given the timeline of ~1 year of data collection, and 8% dropout rate, our estimated pool of participants is 450 or 150 per group.

Recruitment:
Participants will be recruited through the Digital Lab's website (https://www.digitallab.org/), social media, UBC recruitment boards, hospital recruitment boards, through recruitment posters posted in each participating division/clinic, scheduling slates, Reach BC, and/or through word of mouth in each participating division/clinic. Please note, while we have listed social media as one potential way to recruit participants, we plan to primarily recruit from more reliable sources such as word of mouth from each participating clinic / division, recruitment

materials that will be posted at BC Children's and/or UBC, and/or through the Digital Lab's website. Most potential participants will indicate their interest in the study by scanning a QR code or clicking a link found on recruitment materials (e.g., posters located throughout the hospital including each participating division/clinic). However, it is possible that some participants may be recruited via word of mouth at each participating division/clinic and/or through a scheduling slate. For example, during a standard clinic visit, or the scheduling of an upcoming procedure, or it is evident that they are already scheduled for a procedure from medical records, or at a point in which they may receive pre-procedural information, etc., some participants may be asked by their existing healthcare team / hospital staff whether they would like to learn more about this study. If the potential participant is interested, they will be directed to the study's QR code and/or link. If the QR code and/or link is not working, and consent for sharing contact information is obtained from the potential participant, contact information (e.g., first name and email) will be forwarded to the research team. In some instances, we will use scheduling slates to identify and contact via phone and/or email potential participants. A team member will review the scheduling slate to determine whether an individual is scheduled to receive a study approved procedure (e.g., MRI, surgery, etc.), whether they are within the approved age (e.g., 5-23), and whether the timeline allows for participation (i.e., procedures scheduled too soon may not allow time to ship the VR headset to the potential participant). If all criteria are met, a team member will then contact the potential participant to invite them to the study.

In circumstances where the research team is reaching out to the potential participant via email, an introductory letter about the study, including a way to contact the study team for more information or to decline being contacted further will be included. If no response is received, follow-up emails will be sent on a weekly basis for up to 3 weeks. After this, if no response is received, we will assume the participant has refused to be part of the study. However, the majority of participants will be able to scan a QR code (from recruitment materials) and be directed to the consent and assent form through Qualtrics. Note that within the proposal we plan to recruit from other clinics including Allergy, Dental, Surgery, Oncology, Gastroenterology, Radiology, and the Emergency Department.

Randomization: We will enroll a convenience sample into a parallel group design. Participants will be stratified by procedure type and randomly assigned to one of three conditions: 2D video-, 360 video-, 360 video in VR-based preparation. Each group will receive the intervention unique to that group plus standard-of-care. Randomization will be achieved using internal Qualtrics Randomizer function. Though, it is possible that if there are biases found within Qualtrics Randomizer function, we will use randomizer.org.

Allocation concealment and implementation: The allocation sequence will be generated by Qualtrics (or Randomizer.org) and thus will be impartial. Once participants are consented they will be randomly assigned into one of three groups from the list. Allocation will be uploaded and integrated into the app and concealed from the majority of staff working on the project, however at least 1 or 2 personnel (e.g., research assistants, project manager) will be aware of assignment, but blinded during data preparation and analysis.

Blinding: A double blind design is not possible given the nature of the intervention. However, most staff involved with the project will be blind to each participant's condition including the individuals responsible for analyzing the data.

Data collection: Data collection (surveys, questionnaires, etc.) will be collected digitally, through a custom web-based mobile app. Regular monitoring and additional feedback will be asked of all participants and caregivers (i.e., parents/guardians) to address any issues or concerns that may arise during the study. All feedback will be used for the improvement of the preparation materials, surveys, VR, the app's functionality, and user experience. In-app reminders will be sent prior to their scheduled appointment, with the opportunity to defer and reset in the event of delays.

The following procedures will be followed to carry out the research:

1. The participant will be screened for eligibility.
2. Consent and assent will be obtained.
3. Email sent to participants detailing instructions on the app
4. Participants register for access to app.
5. Participants are enrolled and randomly assigned to receive 2D video-, 360 video-, or 360 video in VR-based preparation.
6. At baseline (T0), surveys will be administered to participants via Qualtrics. The baseline survey includes demographic questions (to be completed by the caregiver), and trait anxiety questionnaires for the patients/children.
7. Materials will be shipped (if applicable) to the participant.
8. At T1, a survey will be administered to participants via Qualtrics. The T1 survey includes state anxiety and a VR side effects questionnaire..
9. At T2, a survey will be administered to participants via Qualtrics. The T2 survey includes state anxiety and side effects surveys as well as a satisfaction survey for both child/patient and parent.
10. After the procedure, at T3, T4, and T5 we will assess state anxiety and pain, as well an overall satisfaction survey (completed on Qualtrics).

Statistical Analysis Plan: Chi-square tests will be used to compare the proportion of participants that decreased, increased, or stayed the same on the self-report anxiety from T1 to T2, T1 to T3, T1 to T4, T1 to T5, self-report pain between T1 and T3, and T1 to T4, and T1 to T5. Primary comparisons will include 360 video in VR vs. 2D video, 360 video without VR vs. 2D video, and 360 video with VR vs. 360 video without VR group comparisons. Univariate and multivariable regression analysis will be performed to assess the factors associated with increased pre-procedural anxiety and increased post-procedural pain. A p-value cut-off of 0.15 from the univariate regression analysis will be used to determine which variables to include in the multivariable regression analysis. The following predictor variables will be considered in the model: sex, age, type of procedure baseline (T1) self-report anxiety state, and baseline (T1) self-report pain. Subgroup analysis for the different divisions/clinics will also be carried out. All p-values will be set at $p<0.05$. We will perform Spearman's correlations between the NSAS (e.g., anxiety) and between and post-procedural pain.

Data monitoring: Trial monitoring will be conducted at the initiation visit, at an interim monitoring visit, and a close-out visit to ensure the appropriate conduct and documentation of the study. Additional monitoring visits may be scheduled based on identified risk exposure to participants and the institution. Interim analyses will be conducted twice, once when 30

participants' data have been collected (10 from each group; end of pilot testing see **Gantt Chart**), then again when 25% of the data has been collected (i.e., N = 125, n = ~41). The main purpose for the first interim analysis will be to update our recruitment sample by performing a power analysis on the preliminary data, using the self-report anxiety measures at the dependent variable. Once the power analysis has been completed we will adjust our sample size accordingly. Adverse events will be regularly monitored, and if there are concerns with the use of VR, the study could be stopped early. If such were to occur, all participants will be informed by notifications through the app and through email. Participants will also be given the option to speak with the study staff if they desire.

Harms: This is a minimal risk study. Overall, VR has been shown to be safe in pediatric patients (16,22). However, there is a small change that the use of VR can result in short-term, reversible and limited effects.

- Exposure to virtual reality can disrupt the sensory system and lead to symptoms such as nausea, dizziness, sweating, pallor, and loss of balance, which are grouped together under the term "virtual reality sickness". In sensitive individuals, these symptoms may appear within the first few minutes of use.
- Following a session, VR can also induce a temporary change in a person's sensory, motor and perceptual abilities, affecting their manual dexterity or ability to orientate their body. Furthermore, devices use LED screens that potentially have a high blue light content, which can disrupt biological rhythms when viewed in the evening or at night (delayed sleep onset, disrupted sleep, etc.)
- Exposure to the temporal modulation of the light emitted by these LED screens – flashing light that is sometimes imperceptible to the eye – can trigger epileptic seizures in susceptible people.

The current study will be based on our prior VR work, where we found that VR exposure was safe and comparable to standard-of-care (i.e., Child Life Programming) in children scheduled to receive a medical imaging scan (10). Participants will be prompted to report on any side effects before and after VR use. If participants experienced any adverse events they will be asked to call a study team member. All adverse events will be recorded on an Adverse Event Form in electronic format using participant ID by a study team member. All adverse events experienced by the participant from the start of the trial to the end of the study will be reported. Additionally, disclaimers and warnings will be shown to the participant and their family: 1) upon consent, 2) printed on the instructional sheet that is included in the VR package, 3) and before using VR within the mobile app.

In the extremely unlikely case of serious and unexpected adverse events, all serious and unexpected adverse events will be reported to the investigators and RRB within 48 hours of our study team's knowledge. In the unlikely case of a death, reports will be expedited by 24 hours. A written serious adverse event report will be written for all serious adverse and unexpected events.

Auditing: No audits are currently planned.

Protocol amendments: Protocol amendments will be communicated to all relevant stakeholders by email, telephone, or through the mobile app, when urgent.

Consent or assent: Consent and assent will take place online on Qualtrics and follows UBC Article 13.2.4 and The US Food and Drug Administration and the Office for Human Research Protections' joint guidance on the Use of Electronic Informed Consent as detailed here: https://www.fda.gov/media/116850/download. A link to the consent and assent agreement materials will be made available to participants once they have successfully completed screening (data not collected). Upon successful screening, participants will then be provided a link to the consent and assent agreement, which will be collected on Qualtrics in that order. The UBC Qualtrics license is hosted on a dedicated server located in Canada.

Participants will be given as much time as necessary to review the documents and decide to participate, however, practically speaking the participant must provide their consent with enough time to complete the study procedures before their scheduled procedure. If participants have any questions, we encourage them to reach out to us (i.e., research staff) in charge of the study. We provide contact information in recruitment materials, the screening form, the consent and assent pages, the registration page, and throughout the web-based app. This allows for adequate opportunity for the participants to ask questions per 45 CFR 46.116 and 21 CFR 50.20. We also offer all participants and their families an informal meeting (either on the phone or Zoom) should they want to discuss components of the study before consenting and assenting. However, we anticipate that most participants will not have any questions.

Young people aged < 19 years old will be included in this study. The capacity to consent will not be solely based on age, but on whether they have the capacity to understand the significance of the research and the implications of the risk and benefits to themselves. In cases where the participant does not have capacity to give fully informed consent, one parent/guardian will substitute decision making. For these participants < 19 years old, an assent form will be administered through the Qualtrics.

In order for the participants (e.g., patients and their caregivers) to gain access to the web-based app and the materials therein, both the caregiver and the patient will have had to complete the consent and assent agreement, respectively. Thus, once screening is passed, the caregiver will complete the consenting process on Qualtrics. Only if the caregiver consents (i.e., clicks "yes" box, provides name and e-signature, and date and hits the submit / next button) will Qualtrics advance to the assent agreement, where the patient can read and agree to the assent. If participants do not pass screening, or the caregiver does not consent, or the patient does not assent, participants will be directed to a "thank you for your time" screen and the study will end. It is only when participants pass screening and the caregiver and patient both provide consents and assents will they then be able to gain access to the web-based app registration page. Caregivers and patients will only use one account for this process.

After full consent has been achieved, the participant will be enrolled in the study. Consent will be ongoing through the project and participants will be updated with relevant information as the project proceeds.

Confidentiality: This project will have access to personal identifiers and we will make specific efforts to de-identify the data as soon as possible. Identifying information (eg, MRNs) included in the study will be coded by stripping identifying information and replacing it with a code. This number will not include any personal information that could identify them (eg, it will not include

their Personal Health Number, SIN, initials, etc). Only this number will be used on any research related information collected about the participants during the course of the study, so that their identity will be kept confidential. The list that matches identifying information will remain only with the Principal Investigator and/or designate. The list that matches identifiers to the unique study numbers used in research will not be released without participants' consent unless required by law. This information will be stored separately from the other study data. To further protect participant anonymity and ensure safeguarding of private information, records will be stored securely on an encrypted file, and password protected computer only accessible by authorized personnel on the research team.

The reason and result of each medical procedure is personal health information that will be retained as part of the dataset. Doctors refer patients for each procedure for a variety of reasons, including to help make a diagnosis or to monitor treatments. The length and requirements for procedure can vary, therefore it is important to know if the investigational intervention is trending to be more effective for certain situations more so than others. The MRN is required to locate the result of the procedure in medical records, which is required to know to determine if the intervention is effective.

Declaration of interests: No conflicts of interests to declare.

Access to data: Study data will be accessible to the study team members at all stages of processing and analysis. The current list of names of study personnel and their delegated tasks will be maintained in the study file. All information will be recorded, handled and stored in a way that allows for accurate reporting, interpretation and verification. When data is stored by paper, it will be stored on a locked filing cabinet accessible only by study staff. When data is stored electronically, files will be password protected, stored on a backed-up, password protected computer or hard drive accessible by only study staff.

Ancillary and post-trial care: None.

Description of investigators and partners: Our team is a multi-disciplinary partnership between various divisions/clinics and the Digital Lab, a multidisciplinary technology research and development lab at BC Children's Hospital. This partnership along with the diversity and skillset of our team will contribute to the continued execution of our project into operational contexts, as well as dissemination of research findings across interdisciplinary research communities. The study PI (JJ) is the Head of the Digital Lab and the Executive Director, Strategy and Operations for BC Children's & Women's Health Centre. The Digital Lab is a technology partner that is composed of a diverse and multidisciplinary team aiming to improve the lives of patients through digital innovation and technology. JJ has collaborated with clinical stakeholders on over 50 projects to design, build, and test novel digital solutions that address real-world challenges. As an Early Career Investigator with the BCCHRI E2i theme, JJ's research spans health services management, health policy, economics, and the development and evaluation of digital health innovation and emerging technologies. JJ will manage the integrity of the design, conduct, and reporting of this project. JC (Co-I) has been a Paediatric Anesthesiologist at BCCH for 15 years, is a Clinical Assistant Professor with UBC Faculty of Medicine, and is the current President of the C&W Medical Staff Association. JC is engaged in patient safety during procedures, advocating for frontline clinicians, and streamlining workflow at C&W. JC is well equipped to provide clinical oversight and management for this project. SZ (Co-I) is a Program Manager and Lead Engineer in the Department of Pediatrics

at UBC. SZ has been with the Digital Lab since 2018 and has ample experience providing project oversight and supervision. BG (Co-I) is a Project Manager and Research and Evaluation Specialist at BC Children's. BG has over 12 years of experience managing and overseeing projects in both healthy and clinical populations with 20 peer-reviewed publications. BG's skill set and experience will contribute to this project's success. Our other project team members, including clinicians, child life specialists, trainees, managers, operational and clinical leads, patient partners, and research assistants will work collectively with leadership to carry out the study design, data collection, and knowledge translation activities proposed. The inclusion of the Youth Advisory Committee as our patient partner ensures that patient engagement is in line with best practices at BCCH and that there is a large diversity in patient perspectives contributing to the project objectives. All team members, regardless of background, will have access to mentoring opportunities, especially with the senior researchers. Our team demonstrates proficiency in specific knowledge and skills in lived, clinical trial, medical, and operational expertise that will ensure future implementation and sustainability. In brief, this project is feasible given the strength of our team.

Sustainability plan: The sustainability of this project will be achieved through dissemination as a part of the clinical integration program within the Digital Lab. In close partnership with multiple BCCH divisions/clinics, we will raise awareness of remote, technological interventions to reduce pre-procedural anxiety through structured orientation and support programs enabled with resources that can support the sustainment of scale – building on the awareness and interest that was developed through our initial study. The hospital executive, operational leaders, and patients have a desire for using media and technology and have supported the project since the early pilot phase, as it was initially driven by needs that emerged during 2018/19 when wait times were at an all-time high. Though significant progress has been made since then, increasing capacity across multiple divisions/clinics remains a key priority for the government. To ensure staff are knowledgeable about the role of media and VR in pre-procedural anxiety, we plan hosting in-service training using a train-the-trainer model before and after the project concludes**.** Results of patients will be fed back to care providers using data analytics to reinforce use. As challenges associated with technical support and administrative work are common in digital health implementation, our trial will be designed to be pragmatic in its administration to remedy issues that may present when operationally integrated. Our project will ensure resources are deployed to ensure implementation is sound prior to investment in larger efficacy testing.

Expected Impact: This project will improve patient experience and well-being, reduce costs, and be accessible for all populations. While our hospital has Child Life Specialists to prepare patients and families for procedures, capacity limitations exist, and this is not available at all sites in the province. There are also socioeconomic costs and logistical considerations of only having preparation available on-site at a tertiary care facility, especially as the facility provides care for children across the province, some of whom must travel over 1000 km to reach the facility. We found that children who could prepare at home resulted between $119 to $3,364 total costs savings per patient (15). Additionally, distress during medical procedures due to pre-procedural anxiety can have negative, long-term impacts resulting in healthcare avoidance. Targeting pre-procedural anxiety with remote immersive technology has the potential to reduce distress and increase well-being for patients and their families who do not have the time or resources for on-site training. If effective, it is assumed that immersive media (videos and VR) and our team will make significant efforts to improve equity in the experience

of children undergoing a variety of medical procedures, by improving access to quality preparation.

Dissemination plan: This study will be posted on clinicaltrials.gov after ethics approval but before enrollment begins. A lay summary of the trial will be sent to the participants, with their consent form. We plan to share the results of our trial through the Digital Lab website, and through various multidisciplinary conferences to encourage collaboration with other sites and investigators. We also plan to submit at least two publications in an open-source peer-reviewed journal to share the findings within our research community. Authors of manuscripts must have contributed significantly to at least 2 of: protocol design, data collection, data analysis, and manuscript writing/edits. All dissemination should have funding acknowledgement included for the BC Children's Hospital Research Institute's Digital Health Research Accelerator. All dissemination should have technology development acknowledgment included for the Digital Lab.

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