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Virtual Reality for Pediatric Pain Management

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Imagine the fear that children experience when being held down as a stranger stabs them in the arm with a needle. Imagine the searing pain that results from the needle piercing through the skin and injecting its contents in the underlying tissues. What if we can remove that pain perception and reduce that fear? What if we can augment reality to change the stressful environment? Would it be possible to make getting vaccinations less dreadful and more…fun? Needle fear and pain can cause lasting trauma in the pediatric population causing anxiety and vaccine non-compliance that carries into adulthood. It is well studied that "inadequate pain management" is detrimental to the pediatric population because inadequate pain management can lead to "negative long-term consequences" and noncompliance when pertaining to needle sticks that can carry into adulthood (Hanrahan et al., 2017, p. 2). According to Ellerton et al. (2020), "one out of four adults is estimated to have a fear of needles which often develops in childhood" (p. 2). Evidence-based practice report that use of distraction is a simple and efficient method to minimize the trauma that some children feel when getting immunization or venipuncture. If this is truly the case, then why is distraction being underutilized when it comes to venipuncture in the pediatric population?

Problem Statement

Pain related to vaccination is one of the most common burdens faced by children (Althumairi et al., 2021). Needle procedures are highly feared by many children and is a common experience shared by both healthy and medically ill children (Birnie et al., 2014). The current practice for pain management with pediatric immunizations is not clearly defined, currently no guidelines exist for managing pain or needle fears. Some common methods of receiving vaccinations relies on guardian assistance and different reward methods like stickers or

candy after receiving immunizations. This band-aid method to immunizations heavily relies on the parent or guardian to control the child and does not help reduce the anxiety of needle sticks during the procedure. Thus causing "significant distress to both the pediatric patient and the parent" (Birnie et al., 2014, p. 783). Althumairi et al. (2021) reports some parents may even "delay their child's appointment due to this discomfort process" (p. 2625). This hesitancy in vaccination may lead to a decrease in immune response and increase susceptibility of certain diseases. This progression of negative attitudes, "if poorly managed, can lead to anxiety about future medical procedures, needle phobia and avoidance of future vaccinations and other medical treatment" (Ellerton et al., 2020, p. 2). Therefore, it is imperative to utilize effective pain management and fear averting techniques in the pediatric population for better adherence to vaccine schedules and to improve overall perception of healthcare. The aim of this proposal is to bring awareness and support the need for more research for the efficacy of using virtual reality for pain management in the pediatric population.

PICO

Current evidence suggests distraction methods during immunization are seeing a positive result in reducing pain, especially since some methods of distraction are inexpensive. There have been other methods that were studied like preparation, cognitive behavioral therapy and parental coaching, however, the efficacy of distraction for needle related pain and distress has shown strong positive outcomes (Tadio & McMurty, 2015). Kuo et al. (2018) studied the effects of distraction with venipuncture and reported that all children in their study experienced some distress but using distraction methods showed significant reduction in distress especially in 4- and 5-year-old children. Thanks to Hanrahan et al. (2018), there is a Distraction in Action Tool (DAT) being implemented to help teach parents and staff how to effectively distract the pediatric

patient using toys and books. DAT utilizes a survey that the parent and children fill out together prior to vaccination or other painful procedures that gathers information based on previous behavior outcomes. However, there are limitations with the current distraction methods. “About 15% of children do not respond to the distraction efforts of their parents” these children exhibit “high levels of distress behavior” during vaccination and other procedures (Hanrahan et al., 2018, p. 2). This could be attributed to the distraction not being immersive enough to effectively engage and divert the attention of the pediatric patient. Birnie et al. (2014) surmised that the “effective element of distraction is believed to be its ability to capture the child’s cognitive resources” (p. 784). The more immersive an environment, the more effective it can be to distract the pediatric patient from feeling pain and distress from immunizations. This train of logic aims to answer the question: Among pediatric patients in an outpatient setting, will implementing a virtual reality distraction method reduce pain during vaccinations?

Background and Significance

Managing pain in the pediatric population can lead to better adherence with vaccinations and may change the perception of visiting a medical facility away from dread. The use of distraction has been well studied as a pain averting technique when it comes to pediatric care. Both passive distraction like watching television or listening to an audio book and active distraction like interactive toys and electronic gaming “have been extensively studied and cause a decrease in pain and anxiety” (Arane et al., 2017, p. 932). However, there remains a significant amount of pediatric patients that continue to be distressed despite current distraction techniques. By engrossing the pediatric patient in a virtual world through visual and audio displacement, virtual reality can cover the holes left from the current distraction methods.

Although there are many positive implications for use of virtual reality among the pediatric population, it may not be widely received in current practice due to some barriers.

There are a few barriers with implementing virtual reality in the pediatric outpatient setting. Mainly, the cost for using virtual programs may be far more expensive than the current distraction methods like books, toys, and music. Furthermore, the quality of the virtual reality software can directly impact the immersion factor. When it comes to virtual reality gadgets, the more expensive the gadget, the better the quality of programs that they can host. There exist a stark difference in quality from a head set that is priced lower than that of a headset that is more expensive. A quick Amazon.com search shows that the range of virtual reality headsets can start from $20 to $400, not including the additional cost of software to be installed. The $20 headset contain the goggles that use phones as the interface and the $400 Oculus headset uses their built-in computer and audio technology. However, an argument can be made that the amount of toys, books, stickers, candy, and music that the pediatric clinic currently uses can cost more than the cheapest option of virtual reality, especially if customization of such materials were considered. For example, if a pediatric clinic is using toys as a method of distraction, consider the price of an Elsa doll or Paw Patrol action figure and then having to swap those toys out every year with the newest toy trend to keep up with patient satisfaction, and then also consider having to rip those toys away from an already needle traumatized child.

With virtual reality, customization can be inexpensive, and some are free to download. Walsh (2021) lists more than fifty virtual reality games that are free provided the proper headset used. The number of virtual games and programs being output introduces the idea of customization for each child. The possibilities for customization of worlds can counteract the disparity of trends in age gaps between 4-year-old patients and 8-year-old patients.

Customization also introduces a method for autonomy in children, getting them involved with health care at an earlier age.

Another obstacle with implementing virtual reality is that it may be time consuming. For a pediatric patient who has never been exposed to virtual reality, the time it takes to educate "may increase the duration of a typical immunization encounter" (Chad et al., 2018, p. 178). Having to set up each patient with a virtual headset and selecting the program specific to each pediatric patient can be exhaustive when it comes to vaccinating multiple patients a day. It would also be time consuming to disinfect each headset after use. However, Chad et al. 2018 reported that most of their pediatric subjects have already been exposed to some sort of virtual reality device and therefore time wasted on instructions "have been reported at a minimum at most" (p.178). One can argue that even though it may take a considerable amount of time to implement virtual reality to a patient that has never encountered the device, trying to settle down a distraught pediatric patient is also time consuming. Also, it would be safer to the patient and the provider if the patient were calm. With the effects of virtual reality sedation, theoretically, the patient would be immersed in another world. This allows the patient to be less combative and with less fidgeting during needle insertion.

Lastly, an obstacle that should be addressed is the "technological challenges" that people who purchased virtual reality technology "have already encountered" (Gurwin, 2017, p. 1). Because virtual reality is a relatively new technology, there will be a learning curve for staff who choose to use this method for distraction. Customers who have purchased the more expensive option for virtual reality Oculus have experienced "black screens, random disconnects, and various tracking issues" (Gurwin, 2017, p. 1). Staff will need to be able to trouble shoot some of the malfunctions that can arise from using the virtual reality gadgets. To combat this obstacle,

the pediatric outpatient clinic could either utilize an IT department for trouble shooting or teach staff how to troubleshoot common problems. The latter is more recommended for efficiency because the staff can readily fix components without having to wait for technicians to arrive. Teaching the staff how to navigate virtual reality allows them to become subject matter experts thus building confidence when using the equipment.

Virtual reality is a "computer technology that creates an artificial 3-dimensional simulated environment" (Arane et al., 2017, p. 932). Current virtual reality devices comprise of a "head-mounted display and a thick pair of goggles" (Arane et al., 2017, p. 932) with adjustable straps that secure around the head. The goggles can be adjusted for visual acuity and depth to prevent blurring and nausea, the goggles are connected to a cell phone (less expensive version) or a built-in computer screen like in the popular but more expensive Oculus version. This headset has "sensors that track users' head movements, creating the illusion of moving around in the virtual space" (Arane et al., 2017, p. 932). An additional function that the Oculus headset contains is the built-in audio component which can further immerse the user into the virtual world. Immersion into the virtual world is the goal for therapeutic analgesia to capture the cognitive resources to effectively distract the pediatric patient from the immunization procedure. Thus, desensitizing the lived experience, at least in theory.

Theory

The theory behind virtual reality as a tool for reducing pain and anxiety is derived from people's limited attention capacity (Arane et al., 2017). Pain and anxiety can be amplified with attention, displacing that attention with virtual reality can slow the response to pain (Arane et al., 2017). Even though virtual reality cannot completely remove the feeling of pain, it can act "directly and indirectly" on how people perceive pain through "attention, emotion, concentration,

memory, and other senses" (Arane et al., 2017, p. 933). The theories that guide this idea are pain gate theory and capacity theory. The pain gate theory addresses the way people perceive pain through physiologic and neural pathways and the capacity theory focuses on the magnification or minimization of pain through semiconscious efforts of the brain.

Theory I: Pain Gate Theory

When trying to understand the physiology of pain and how people perceive pain, the pain gate theory is well studied and has led to current practice of pain management. Proposed by Melzack & Wall in 1965 the pain gate theory states that pain is felt when nociceptors on the skin sends a signal to the dorsal root ganglion in the spine which then transmits the signal to the brain for evaluation (Ropero-Peláez & Taniguci, 2016). Thereby, the dorsal root ganglion acts as a gate that opens and allows admittance of one stimuli to the brain. According to Ropero-Peláez & Taniguci (2016) another stimuli may be used to mitigate the perception of pain. They found that pain signals were jammed when another competing stimulus like pressure was given at the location where the pain was produced. Nociceptors are the neurons that collect and transmit pain data while mechanoreceptors are the neurons that transmit stimuli of touch, pressure, and sound. Ropero-Peláez & Taniguci (2016) found that nociceptor stimuli are weaker in comparison to mechanoreceptor stimuli because mechanoreceptors have more myelinated sheaths that allow for faster transmission of signal and thus greater impulse firing at the dorsal root ganglion. People inherently demonstrate pain gate theory by applying pressure to the site of a papercut or using cold water on burn sites to reduce the acute pain felt. Pain gate theory has been implemented to explain how pain can be mitigated and managed in multiple practices involving pain management.

Theory II: Capacity Theory

Capacity theory is very relevant to the PICO question as it is the guiding principle in using distraction as a method for pain mitigation. Capacity theory states that the brain can only focus attention to some information and filters out irrelevant stimuli from being processed (Bernie et al. 2014). For example, when reading this information, the reader's focus is on transmitting visual stimuli to the brain, word formation, and interpretation; even when ambient stimuli like temperature, humidity, outdoor noise are being collected by the body, the brain can only focus on a few activities at a time. This theory explains why multitasking is a difficult concept for some people to achieve and may lead to less quality and worse outcomes. But more importantly, this theory explains how distraction can be used to divert attention from pain. According to Hanrahan et al. (2017), distraction is a simple and effective intervention to lessen pain and reduce anxiety for young children undergoing procedures where pain may be involved. Capacity theory recognizes that our attention is filled up by the number of stimuli that is received and interpreted which would support the idea that distraction will be effective to mitigate pain. On the other hand, if the idea of impending pain is more prominent, it causes hyper vigilance to that stimulus causing greater sensation of pain. This is the reason behind why people who have needle fears are advised to look away from the needle. Capacity theory explains how pain can be minimized or increased based on how much attention is focused on the incoming pain stimuli. In capacity theory, attention that is directed away from the pain stimuli may reduce the perception of pain and increase pain tolerance (Luo et al., 2019) Thus, the capacity theory provides the framework for the use of distraction techniques during painful procedures.

Theories Influence on the Advanced Practice of Nursing

The pain gate theory and capacity theory have influenced the way clinicians protect their patients from feeling acute pain. This is very apparent in the pediatric population where

distraction is often used to alleviate distress. The pain gate theory has influenced current pain management therapy to include involving plasticity blockers, plasticity enhancers, and stimulation injections. Pain gate theory has been used to mitigate pain in chronic pain, phantom limb, and labor pains (Squellati, 2017). Capacity theory is the key idea that supports the distraction method for pain control and reinforces the idea of triage. When triaging a group of patients, focus and resources should be allocated to the candidate requiring the most attention. Capacity theory also bolsters the idea that giving attention to one object at a time is better than juggling many objects at once, a value many nurses and practitioners struggle with daily.

Theoretical Framework Analysis

The two theories used as a framework for the MSN project are the pain gate and capacity theory. These two theories were chosen because they explain how pain is transmitted through the body and offer ways to lessen the pain signal. They both may be used to support the idea that distraction is an effective tool to minimize pain. Distraction is in the forefront of psychological intervention that has been extensively studied and supported for needle-related pain and distress in the pediatric population. Other works in distraction have also been researched to provide some benefit in stress and pain management for procedural pain in the pediatric population. Some methods for distraction that have been found to improve outcomes include passive methods like music and television and active methods like playing video games and problem solving. Virtual reality has been recently studied with having mixed results in efficacy and cost benefits. The research in prior virtual reality studies done in 2006 and 2013 used expensive and outdated virtual reality gear that may not have had enough quality to offer proper distraction from the procedure.

Theories Implication to Guide Personal APRN Practice

Mitigating pain and reducing anxiety in the pediatric population during medical procedures may lead to a more pleasant experience for the patient that may increase compliance up to adulthood. Needle procedures are among children's most feared experiences when pertaining to the medical profession (Birnie et al., 2014). This fear may have a lifelong impact that could cause anxiety for future vaccinations, medical procedures, dental procedures, and hesitancy to seek medical care. Taddio & McMurty (2015) suggest that finding ways to mitigate pain and distress is "clinically relevant" and important to convey an excellent "patient-family-centered health care" (p. 196). The contribution to the medical field for continued research in virtual reality could conclude with high efficacy as it uses both passive and active distraction qualities and offers multiple sensory diversions. Contributing to data that distraction is an effective tool to minimize psychological trauma can also be effective in raising awareness that these methods should be utilized in all cases involving pediatric procedural care.

The pain gate theory has increased personal knowledge on overall perception of acute pain. It explains the science of pain perception and offers strategies like applying touch, pressure, heat, ice, or other stimuli that blocks pain receptors. The capacity theory reinforces the importance of sequential attention. The brain can only process a limited number of stimuli that is used to focus attention on one procedure. When dealing with the pediatric population, using distraction to overwhelm their attention capacity can take their focus away from the procedural task at hand to something that is more pleasant (Hanrahan et al., 2017). Taking the focus away from pain may contribute to reduced pain.

The theories presented thus far provide the necessary framework to build on the idea that using virtual reality can help reduce anxiety during vaccinations in the pediatric population. Pain gate theory explains how pain is perceived and processed in our brain. This theory states that the

spine can only collect and transmit a limited number of signals to the brain at one time which allows for competition of different neurological transmissions (Ropero-Peláez & Taniguci, 2016). Providing a stronger impulse can allow blockage of pain impulses thus decreasing the experienced pain (Ropero-Peláez & Taniguci, 2016). Capacity theory explains how some stimuli are ignored and how some stimuli are focused based on an attention limit. Capacity theory provides strategies on how pain can be minimized or amplified based on the amount of attention allotted to any one given circumstance (Birnie et al., 2014). These two theories provides the structural foundation for the idea that distraction can be used as a tool for mitigating pain and anxiety. Utilizing the knowledge gained from this research can lead to better quality care with improved outcomes as it relates to the pediatric population.

The use of virtual reality as a distraction is not limited to immunizations for children. There has been research on their implications with dental procedures and surgical interventions. Atzori et al. (2018) reports virtual reality can act as "analgesia" and there is evidence that it can be an "effective pain distraction technique" when relating to reduction of suffering. According to Althumairi et al. (2021), virtual reality has also been found to be effective in "reducing elderly falls, procedural pain, itching, cerebral palsy patients during painful physical therapy rehabilitation, and for claustrophobic patients during brain scan" (p. 2629). Using Virtual reality as a distraction from pain has huge implications in current medical practice for pain management and can be used to increase compliance of invasive interventions. More study is needed on the long-term effect of reducing pain via virtual reality and study on the best strategies for implementing virtual reality in different medical settings. The implications to best practices and guidelines are supported by the literature review of current studies.

Literature Search

To determine the impact of virtual reality on pediatric pain perception, a literature search was conducted. The search engine used were EBSCO discovery with parameters set to only include articles from Academic Search Premier, Complementary Index, Cumulative Index to Nursing and Allied Health Literature (CINAHL) Complete, and MEDLINE. Filters were applied to include peer reviewed within the Roseman University library and within the past 10 years. The following search term was used “pediatric” AND “virtual reality” AND “pain” which resulted in 1,711 results. Addition of “AND distraction” yielded 223 results, addition of “AND immunization” yielded 57 results. Of the 57 results, an additional search filter for subject on virtual reality yielded 3 primary study results. The primary sources include 4 randomized control studies (Gerceker et al., 2020; Ozsoy & Ulus, 2022; Ustuner & Kuzlu, 2021; Wong et al., 2019); and one cohort study (Sikka et al., 2019). Additional search engine was used, PubMed, with filters applied to include peer reviewed full text in English language and within the past 10 years. The following search term was used “virtual reality” AND “distraction” AND “immunization” which resulted in 4 primary source results, 2 were randomized control trials (De la Cruz Herrera et al., 2022; Ellerton et al., 2020) and 2 cross sectional studies (Althumairi et al., 2021; Chad et al., 2018). A total of nine primary sources to include six random control trials (De la Cruz Herrera et al., 2022; Ellerton et al., 2020; Gerceker et al., 2020; Ozsoy & Ulus, 2022; Ustuner & Kuzlu, 2021; Wong et al., 2019); one cohort study (Sikka et al., 2019); and two cross sectional studies (Althumairi et al., 202; Chad et al., 2018;) are discussed in this literature review.

Due to the sparsity of available literature regarding the use of virtual reality to help decrease pain during pediatric immunization an additional search was completed to get more evidence for this review. Two studies (Althumairi et al., 2021; Chad et al., 2018) have completed analysis regarding pain specifically with immunizations and will therefore be the focus for

conclusive data. Three out of the five studies that focus on pain related to immunizations (De la Cruz Herrera et al., 2022, Ellerton et al., 2020, and Wong et al., 2019) are currently ongoing at the time of this literature review; therefore, only background and methodology can be gleaned from these studies. Due to this limitation in data, evidence was expanded to review how virtual reality is used for painful procedures, not just immunizations.

Definitions

The following definitions are used to clarify the subject matter as they relate to the study and the PICO question.

1. Immunizations- The independent variable that includes administration of vaccination parenterally with a needle causing trauma to skin and tissues.
2. Pain- An adverse stimulus measured by use of six faces that can be gathered by the clinician, guardians, or patient as defined by Wong & Baker (1988).
3. Virtual reality (VR)- Computer technology that encapsules an augmented 3-dimensional environment (Arane et al., 2017).
4. Pediatrics/children- the target population for this study, although this population is defined from birth to 21 years old by the FDA, limitations are implicated for those suitable for VR headsets which include 4-year-old and above.

Literature Review

Analysis of current literature could lead to solidifying and understanding key concepts and themes while comparing or enhancing the results of preceding studies. During the literature review, varying differences allowed for nuances to be highlighted. These nuances include the variability to define the population's age, the methodology and devices used for virtual reality, the tools used to measure pain, and the procedure that would illicit pain to the target patient.

There were also similarities that most of the current studies provided in their methodologies and conclusions. These similarities can be implemented as themes and used for foundation in the proposed study. These themes include the outcome of the studies and similarity in limitations. All the studies under review showed positive alignment of use of virtual reality with pain and are proponents for its use as a distraction tool. The limitations and strengths were also evaluated to address the validity of the studies.

Population Variations

The variability in defining pediatric age range differed from study to study. These variabilities were due to convenience sampling, actively limiting due to age requirements for virtual reality devices, or the limitation of the setting. For example, Althumairi et al. (2021) reports using an age range of 4 years and above as the pediatric population because that was the limitation set by the VR device that they used. Ozsoy & Ulus (2020) used the age range of 7-10 years old because of the availability in the medical unit that they organized the study under. Sil et al. (2014) used ages 6-13 year-olds due to convenience of the sample that registered into their study. Convenience sampling reduces the generalizability of their studies limiting their claims to just the tested population.

Defining a set parameter with age poses a difficulty in comparing studies especially when the population is pediatrics where the behaviors and mentality are drastically different from a 4-year- old to an 18-year-old. However, Althumairi et al. (2021) reported that there was no evidence of a statistically significant effect of age on pain and fear scores which indicates that pain and fear was similar among the different age ranges. The current studies failed to address the differences in programming between the different age groups; how one VR simulator may be appropriate for one age group but may be too sophisticated for another age group. This can be

further investigated with more research into the effectiveness of one VR simulation compared to another between the difference in ages.

Methodology

Along with the VR hardware, all studies differed in type of programming which also effects the VR experience. Chad et al. (2018) used more passive experiences like riding a helicopter, roller coaster, or hot air balloon while Sil et al. (2014) used a more interactive approach with Sonic the Hedgehog adventure. Currently, there is no study available to compare the two methods of virtual reality. However, Gerceker et al., (2020) ~~study, they~~ compared two different environments: one that was moving and exciting (roller coaster) and one that was more relaxing and musical (ocean rift). They found that there was no statistical evidence that one form of virtual reality was superior to the other and both methods were effective in reducing pain, fear, and anxiety when compared to the control.

Cross sectional analysis was used as a method by the current studies specific to immunizations (Althumairi et al., 2021; Chad et al., 2018). However, they both reported limitation to their study due to not having a control population. The other studies that gathered information on pain (Gerceker et al., 2020; Ozsoy & Ulus, 2022; Ustuner & Kuzlu, 2021) were randomized control studies which were able to show effectiveness of VR intervention when compared to the control group. Consequently, the three proposed studies pending results (De la Cruz Herrera et al., 2022, Ellerton et al., 2020, and Wong et al., 2019) are randomized controlled studies which may help in providing reliable data that VR use is an effective method to reducing pain.

The devices used from study to study were also markedly different. Most of the devices used the same concept of a VR headset with an attachable mobile device (Chad et al., 2018;

Gerceker, et al. 2020; Ozsoy & Ulus, 2020; Sikka et al. 2019; Ustuner & Kuzlu, 2021). These devices were more cost effective than the devices used by Althumairi et al. (2021) who used Future Sight All-in-one Virtual Reality and Sil et al. (2014) who used a VR helmet with built-in audio 5DT HMD 800-26 3D VR system. The differences in devices may constitute a difference in immersive quality. Subpar VR quality may result in nausea, dizziness, or other adverse outcomes. For example, Gerceker et al. (2020) notes that one of their limitations were some participants removing VR equipment during the trial which caused them to be removed from the study, they used Samsung Gear Oculus with a Samsung Galaxy S5 Note. It remains a challenge to have optimal VR equipment that is universal for all pediatric ages but thus far, the majority of the studies used an optical headset that has a separate component for insertion of a mobile device. This is promising as it shows that virtual headsets can easily adapt to whatever modern mobile device is currently the most optimal thus allowing flexibility when it comes to cost of equipment.

Tools to Measure Pain

The tools that were used to measure pain could be adopted to the proposed study as they were similar in most of the current literature. Pain was evaluated using the Wong-Baker FACES scale with the exception of Ustuner & Kuzlu (2021) who used Hick's et al. (2001) Faces Pain Scale-Revised (FPS-R) and measured the duration of children's crying. Using the Wong-Baker FACES scale is appropriate when dealing with the pediatric population as they can be provided by the participant, the parents, or the researcher (Wong & Baker, 1988). FPS-R can be considered as they are similar, however, Wong-Baker FACES scale is used in more than half of the studies and is reported easier to interpret. Ustuner & Kuzlu (2021) used duration of crying to measure pain with findings of the experimental group averaging 8.43s (± 12.42 s) compared to

the control group averaging 33.65s (± 24.02 s). Although this method for measuring pain showed statistical evidence that the VR group's pain was reduced compared to the control group with no intervention, having to measure children's crying required more effort and room for errors in recording for the clinician as evidenced by the greater degree of standard deviations. Also, some children vary in the expression for pain when regarding to tears, age would play a factor in this type of measurement (Ustuner & Kuzlu, 2021).

During review of the articles, it was found that three of the control studies (De la Cruz Herrera et al., 2022, Ellerton et al., 2020, and Wong et al., 2019) are still in trial and thus have not produced a conclusion. However, their methodologies have been noted, they all use similar measurement tools (Wong Baker FACES). These upcoming studies are used to support that the topic is modern, relevant, and that more research is needed to support claims that virtual reality is an effective vehicle for distraction and can reduce pain and anxiety which could easily be implemented to current standard practice.

Althumairi et al. (2022) reported that "older children tend to express their feelings better than younger children" and found that children "responded well with facial expressions" (p. 2632). Using a validated scale like Wong-Baker FACES would improve the strength of future studies. In summation, Wong-Baker FACES is easier to implement and is a more reliable method to measuring pain that can be gathered by the clinician, parent, or the pediatric patient. It is more often utilized by previous studies with measurable outcomes and could be implemented in future studies to strengthen their validity.

Types of procedures

The procedures to illicit the pain stimuli for the target population predominantly differed with each study. Chad et al. (2018) studied how VR improved pain during immunizations

whereas, Gerceker et al. (2020) and Ustuner & Kulu (2021) studied focused on improving pain during venipunctures. Ozsoy & Ulus (2022) measured pain with dressing changes for hospitalized pediatric subjects. Finally, Sil et al. (2014) used cold pressor pain to measure toleration of pain when the pediatric patient submerged their hands in cold bath water. Regardless of the painful procedure, the reviewed studies offered statistically significant evidence that VR decreases pain. Further study is needed specifically looking at utilizing VR as a distraction technique for decreasing pain during immunization as there is paucity of research.

Outcomes

Five studies of the eight reviewed, (Althumairi et al., 2021; Chad et al., 2018; Gerceker et al., 2020; Sikka et al., 2019; and, Ustuner & Kuzlu, 2021) showed positive statistical evidence for pain reduction when using virtual reality compared to the control (if a control was implemented). Chad et al. (2018) reported a 77% ($p=.52$) decrease in pain score with 94% of children reporting they would like to use virtual reality with all future immunizations. Similarly, Althumairi et al. (2021) reported that the mean pain score was reduced with the intervention group that used virtual reality (1.36, ± 2.067) compared to the control group (6.90, ± 3.471). Sikka et al. (2019) measured pain on the same subjects without the intervention and later with a VR headset and reported a significant ($p< .0001$) decrease in pain (7.16 ± 2.5 to 6.49 ± 2.7). Together, these results help to validate that virtual reality is an effective intervention for pain management and stress reduction that the pediatric population would prefer to continue implementing.

Limitations

The limitations of each research study were similar across the board. They all mentioned that sample size was a limiting factor due to all studies being performed at one site. Having only

one research location reduces the generalizability of a study due to sample size bias as the population of children are localized to the one area that the study is being conducted. Another limitation that most of the studies mentioned was the inability to conduct a blind study. This limitation is expected as the use of the intervention cannot be blinded, the experimental group requires a device to be managed and manipulated. The researcher cannot be blinded due to equipment use, however, Gerceker et al. (2020) included a research group that were blinded to the results of the pre and post tools for measuring pain and anxiety. Adding blindness to the study wherever possible strengthens the evidence of the research.

These limitations could be used as a foundation for further study. For example, to address the sample size limitation, future studies could add more trials in different facilities. The blindness issue could be addressed by blinding the results from the administrator or blinding the parents from the study. Having previous studies that address their limitations is helpful in determining what factors could be improved upon in future studies.

Strengths

Although there are a few limitations, each study provided some strengths that enhance the evidence virtual reality decreases pain. For example, Althumairi et al. (2021); Gerceker et al. (2020); Sikka et al. (2019); and Ozsoy & Ulus (2022) managed to get a large sample size of 90 or more pediatric patients for their study. A larger sample size allows the data to be more generalizable to a population. Another strength for Gerceker et al. (2020) is the randomized parallel control design. Most of the studies used randomized assignment of the patients, this increases blindness of the study and deters bias. Gerceker et al. (2020); Ozsoy & Ulus (2022); and, Ustuner & Kuzlu (2021) used control groups which were used to compare the intervention group and collect data. The outcome of all the studies support each other which collectively

support the idea that virtual reality is an effective distraction device that should be implemented when feasible.

Conclusion

The world of virtual reality is rapidly developing as the demands for its technology and programming increases. With time, virtual reality platforms will become increasingly cheaper to implement allowing broader access in different medical settings. The effects of virtual reality as an analgesic are an alternative approach to pain management and can be implemented in various medical settings. This research proposal's aim is to offer evidence that virtual reality is an effective distraction device that is undeniably supported by peer reviewed studies. Having more studies that support the effectiveness of virtual reality as an inexpensive and noninvasive analgesic may influence the clinician's attitude to incorporate its use into clinical practice.

Currently, there are programs in the world of virtual reality that can transport the pediatric patient into a world of whimsy, roller coasters, flying simulations, etc. with the capability for further expansion. The customization of worlds can allow the pediatric patient more autonomy in their care and can make going to get vaccinations a more pleasurable experience not only for the patient but for staff and guardian as well. Associating medical visits with positive experiences can impact the pediatric population in a plethora of ways. The implications include increase in cooperation, better adherence to vaccination schedules, better behavior outcomes, and a more positive interaction between patient, staff, and guardian. Overall, implementation of virtual reality can have an overwhelmingly positive impact on the experience of receiving immunizations. Virtual reality is an underutilized form of distraction that should be implemented in clinical practice to improve the pediatric experience.

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