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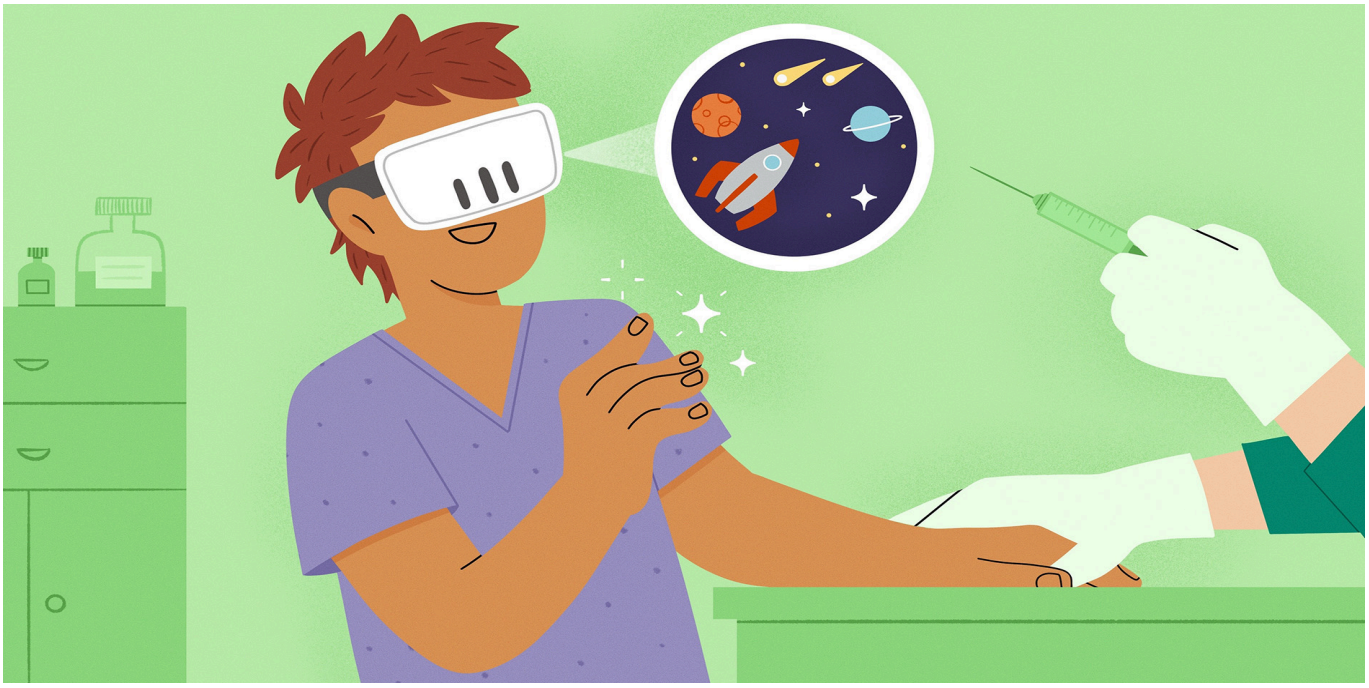
HUMAN HEALTH
Published: 08 August 2024
doi: 10.3389/frym.2024.1376603



VIRTUAL REALITY: A GAME CHANGER FOR CHILDREN'S MEDICAL PROCEDURES

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YOUNG REVIEWERS:

EMILY
AGE: 15

EMMA
AGE: 11

LETICIA
AGE: 15

Going to the hospital can be scary for children, especially when they must go through a painful procedure. Doctors, nurses, and other health professionals may use special distraction techniques to help take children's minds off the pain. There is a cool new way to help distract children from painful procedures. It is called virtual reality (VR). A study was done at a children's hospital that specializes in bone care. The researchers wanted to know if VR was easy to use at the hospital to help the children deal with pain. The study included 44 children who had different kinds of procedures done, like having a needle put in their vein, removing stitches, having blood taken, and more. The researchers concluded that VR can help. VR is fast and easy to use, almost everyone liked it, and it works. To help with pain relief, virtual reality has all the ingredients to be a recipe for success!

WHAT IS VIRTUAL REALITY?

VIRTUAL REALITY

Virtual reality is like stepping into a magical world through special goggles. You can see and interact with things that are not really there, like playing inside a video game.

Virtual reality (VR) is a technology that transports someone to an imaginary world, without the person having to move around. To experience this virtual world, you wear a special headset that looks like a pair of goggles over your eyes. When you put on VR goggles, you feel like you are in a new place, experiencing situations that feel real but are not (Figure 1). In VR, you can do things like play a video game, watch a movie, or go on a virtual adventure. VR makes those activities feel real by replicating our senses. For example, you can move your head around and see the imaginary world in 3D. You can hear things through speakers or earphones. You can touch or interact with objects using game controllers or special gloves. VR is like using your imagination but in a lot more detail, making it feel like you are actually living in this imaginative world.

Figure 1

Virtual reality is a technology that helps people feel like they are in a very detailed imaginary world, where they can move around, explore, play games, or interact with objects (figure credit: [1]).

Figure 1

HOW CAN VIRTUAL REALITY MAKE YOU FEEL LESS PAIN?

When you hear about VR, you probably think of playing your favorite video games in 3D. In hospitals, however, medical professionals use VR to help children with their pain and anxiety during medical procedures, including putting in an IV, dental work, burn treatment, and cancer care [2]. VR has also been shown to help adults with burn pain and routine medical procedures. But how does it work? Your brain has a limited attention capacity—you can only focus on so many things at once. If you are using all your brainpower to focus on the pain, then you are going to feel even more pain! Therefore, a healthcare team can give patients VR during painful medical procedures to compete with pain

for the brain's attention. It is like playing a game of tug of war, where two teams, pain vs. VR, pull on opposite ends of a rope.

Who will win the battle? Well, by immersing you in a captivating and interactive virtual world that feels real, VR pulls the rope away from the pain signals and the pain signals start to lose the tug-of-war battle (Figure 2). The VR experience becomes a powerful distraction that can help you cope with pain, making it feel less intense and overwhelming. Just like a skilled tug-of-war team joining forces and using strategy to win the game, the VR experience can help patients and their healthcare teams work together to manage pain and make medical procedures more bearable.

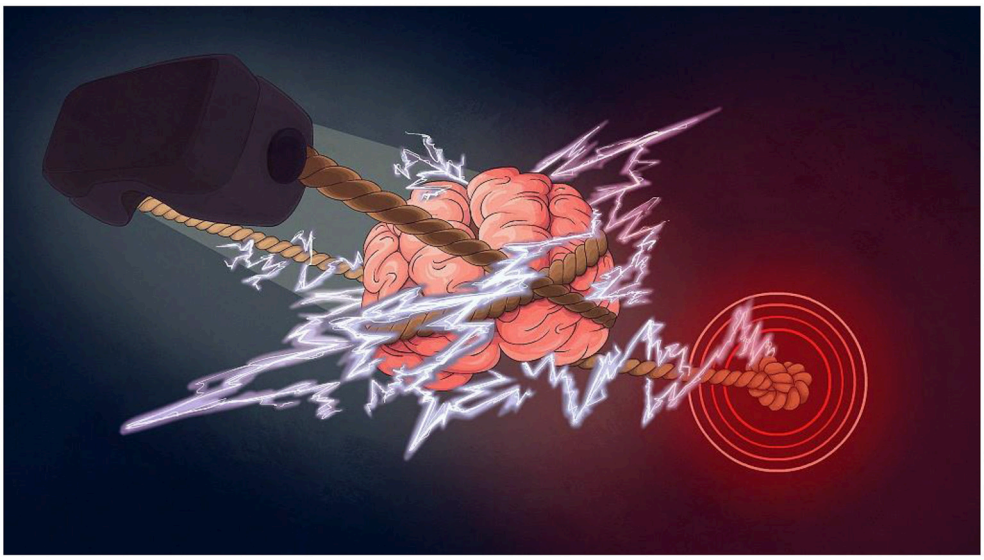


Figure 2

Figure 2

The brain can only pay attention to a certain number of things at the same time, so VR fights with pain for the brain's attention, kind of like a "tug-of-war". The VR experience can pull the brain's attention away from the pain, helping the patient to feel less pain during a medical procedure (figure credit: https://www.mcgill.ca/virtualrealityforchildcare/).

There are many medicines that can be used to reduce pain. Think of the medicines you might take when you are trying to recover from a painful injury, for example. However, these medicines come with side effects, like causing you to have an upset stomach or to feel dizzy [3]. Using distraction techniques like VR does not involve medicines, so these methods can avoid a lot of side effects and extra costs, and they can make a person's experience more enjoyable, leaving them with more positive memories. Studies have demonstrated that VR is still effective even if it is used over repeated physical therapy sessions for burn victims or chronic neck pain treatment [2]. VR can decrease or eliminate the need to give pain medicines to children, while still providing them with good care.

CHRONIC ILLNESS

A health condition that is ongoing and lasts for over 6 months. Some examples include asthma, diabetes, osteogenesis imperfecta, and cancer.

REDUCING PAIN IS IMPORTANT

Children with **chronic illnesses** often go through many medical procedures as part of their long-term treatment. For these children,

it is especially important to give them ways to cope with pain or anxiety during the procedures. A study showed that children with chronic illnesses feel more pain and stress during medical procedures compared to children without chronic illnesses [4, 5]. This is due to a decreased **pain tolerance**. When pain is not properly treated time after time, children form negative memories about the hospital and may not return for their next appointment. Proper pain management can prevent negative memories and create positive ones, encouraging patients to take care of their health and seek help when needed.

PAIN TOLERANCE

How much pain someone can handle before it starts to bother them too much. Just like how some people can handle spicy foods better than others, some people can handle more pain.

THE GOAL OF OUR STUDY

VR was first proven to reduce pain in children receiving treatment for burn wounds [6]. This was an exciting discovery for the scientific community, inspiring other researchers to study if VR could also help children undergoing dental procedures and needle procedures. The results were very positive!

It is very tempting to say that since VR helps with pain, then everyone should and can use it. However, we must investigate other factors that will influence the use of VR in a hospital:

(1) **Feasibility:** What are some barriers that would prevent VR from being used at the hospital? Does VR take too much time?
(2) **Usefulness:** Are healthcare professionals and patients willing to use VR? Can anyone learn how to use VR?
(3) **Tolerability:** Does VR cause side effects or discomfort?
(4) **Helpfulness:** Does VR help? Do patients describe less pain and anxiety with VR?

MUSCULOSKELETAL CONDITIONS

Disorders that affect the muscles, bones, tendons, ligaments, and other body parts that make up the musculoskeletal system.

HOW DID THE STUDY WORK?

We recruited 44 young patients with chronic **musculoskeletal conditions**, who were visiting our hospital with their parents for a medical appointment. The patients' ages ranged from 5–21 years old (VR headsets are not approved for children under 5 years old and are too big for their heads). After getting their agreement to participate in the study, we asked patients about their current pain levels, whether they felt anxious about their procedures, and if they felt like they wanted to try VR. Then, we explained the VR game we would use during their procedure. We used a game called Dreamland®, in which patients are immersed in an imaginary world with purple trolls stealing their balloons and crystals. The patients' job was to catch the objects back by throwing balls and lasers. Does this sound like fun?

Once the patients were comfortable with the game, the healthcare professionals started their medical procedures as usual. We used VR for shots, blood draws, cast removals, and various other medical

procedures (Figure 3). The research team watched carefully during the procedures, noting patients' reactions, how much time using VR took up, and how VR fit in with the workflow of the clinic. Once the procedure was over, we used questionnaires to evaluate whether VR was a convenient tool to reduce pain and anxiety during the medical procedures. We also had quick interviews to understand the patients' and their parents' experiences with VR.

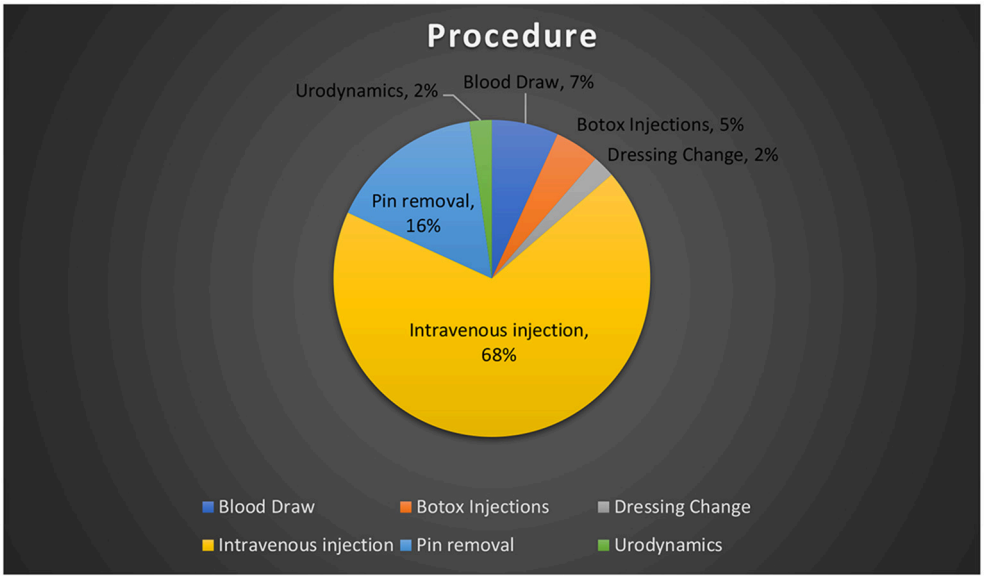


Figure 3

Figure 3

Percentage of VR use for various medical procedures in our hospital. When a surgeon fixes a fracture, they use metal pins to keep the bones in place. When the bone heals, healthcare workers remove the metal pins **(pin removals)**. Although **botox injections** have many different applications such as smoothing wrinkles, they can also be used to relax muscles, helping kids with stiff muscles move more easily. **Changing a dressing** involves replacing an old bandage with a clean one to help the wound heal faster. **Urodynamic testing** helps doctors understand bladder function by showing how your bladder stores and releases pee.

When a surgeon fixes a fracture, for example, they use metal pins that look like small metal sticks to keep the bones in place. Once the bone heals, the surgeon or nurse can go back in and remove the pins! That is what pin removals are. Although botox injections have many different applications such as smoothing wrinkles, the actual mechanism behind it is muscle relaxation. For kids who have stiff or tight muscles due to their illness, botox injections can make it easier for them to move around and relax. Changing a dressing is like putting a new bandage on a cut or scrape. The doctor or nurse gently takes off the old bandage, cleans the area to keep it healthy, and then puts on a fresh, clean bandage to help it heal faster. Urodynamic testing is a special set of tests that help doctors understand how your bladder stores and releases pee. Some of these kids are affected by spinal conditions, which are often associated with bladder/urinary problems as well.

WAS VR FEASIBLE?

In the clinic, the VR game was adapted so that it could be played sitting down and with one hand only, so it was compatible with many medical procedures. For procedures in which the patient was lying down, a pillow was put under the child's head so they could better see the

VR world. For 41 of the 45 procedures (91%), healthcare professionals reported that VR did not interfere at all with their ability to complete the medical procedure.

Two VR systems were tested. The Oculus Rift took an average of 6.5 min to set up compared to the Oculus Quest, which only took 1.3 min to set up. The time difference was super important because clinics can get very busy. Everything needs to stay running smoothly. Most children were well-immersed in the VR game before the procedure started. If they were not immersed in VR for enough time, their brains were not well-distracted. In a clinic that is not too busy, giving the child more time in the game might help even more, but unfortunately, this is not always possible.

When patients are using VR, they can still communicate with their healthcare providers and parents. The nurses could guide the patients through their medical procedures even though the patients were immersed in a VR world. Nurses encouraged the patients to shoot the purple monsters. The children shared their excitement with their parents, who later tried the game themselves. Parents were quite curious!

WAS VR USEFUL IN CLINICS?

All the children and their parents were happy to try VR during their visit. In 6 cases, the children changed their minds because they "preferred seeing the medical procedure to feel more comfortable". Most patients described the VR as easy to use and understand. The parents were satisfied with the VR, too. Parents' only suggestion was to allow their children more time with VR, since that may have made the children feel the pain even less. Most of the patients would recommend VR to a friend.

WAS VR TOLERATED?

Most of the children tolerated VR well. Three of the children said they felt a bit dizzy after putting on the VR headset, but the feeling went away. Some of the participants had a rare condition called osteogenesis imperfecta, in which patients' bones are brittle and more likely to fracture. These patients are often smaller overall, and in two cases the children had to stop using the headset because it was too big for their heads.

WAS VR HELPFUL FOR PAIN AND ANXIETY?

Patients still reported experiencing some pain during the VR experience. However, children and parents agreed that VR helped

distract them through the whole medical procedure (Table 1). One patient said, "I barely paid attention [to the IV insertion] because I was so focused on the game … it [VR] really diverts your attention". The healthcare professionals were impressed with the effectiveness of VR. The patients also reported that VR took away a lot of the stress and helped them deal with their anxiety.

Table 1

What patients thought about the VR intervention. Each item was scored from 0 to 3. For items 1-2: 0 = not at all; 1 = a little bit; 2 = some; 3 = a lot. For items 3-4: 0 = very unlikely; 1 = unlikely; 2 = likely; 3 = very likely. For item 5: 0 = very unhappy; 1 = unhappy; 2 = happy; 3 = very happy.

Patient questionnaire	Average score
1. How much did the virtual reality game distract you during your medical procedure?	2.5
2. How much did the virtual reality game help lower your pain during your medical procedure?	1.7
3. Would you ask to play a virtual reality game for your next medical procedure?	2.6
4. Would you recommend playing a virtual reality game to another patient like you?	2.8
5. How happy were you with playing the virtual reality game during your medical procedure?	2.7

Table 1

VR IS A FUN AND EASY SOLUTION!

We did a study to find out if VR was a useful technology to use at our hospital, which serves children with complex musculoskeletal conditions. The VR game was easy to use and did not affect the workflow in clinics. Patients, parents, and healthcare professionals agreed that VR was successful at helping young patients cope with their medical procedures. There were no side effects from using VR. Future studies should be done to see how VR can be used in other kinds of hospitals and clinics, and for other types of procedures. Additionally, studies should be done to see whether there are any serious limitations of using VR in hospitals and clinics, such as the availability and cost of the technology as well as drawbacks related to training medical staff or technical issues. Overall, virtual reality shows potential as a valuable tool for improving the patient experience and may be viable as a pain intervention to reduce unnecessary medications for children.

ACKNOWLEDGMENTS

We received funding from Réseau de Recherche en Santé Buccodentaire et Osseuse and Fonds de Recherche du Québec—Santé.

ORIGINAL SOURCE ARTICLE

Addab, S., Hamdy, R., May, S. L., Thorstad, K., and Tsimicalis, A. (2022). The use of virtual reality during medical procedures in a pediatric

orthopedic setting: a mixed-methods pilot feasibility study. *Paediatr. Neonatal Pain* 1–15. doi: 10.1002/pne2.12078

REFERENCES

1. Reed, D. 2022. "Escaping your pain and anxiety using virtual reality", in *The Dream Machine*, ed. C. Amarante (Victoria, BC: Tellwell Publishing), 100.
2. Gold, J. I., Belmont, K. A., and Thomas, D. A. 2007. The neurobiology of virtual reality pain attenuation. *Cyberpsychol. Behav.* 10:536–44. doi: 10.1089/cpb.2007.9993
3. Mallari, B., Spaeth, E. K., Goh, H., and Boyd, B. S. 2019. Virtual reality as an analgesic for acute and chronic pain in adults: a systematic review and meta-analysis. *J. Pain Res.* 12:2053–85. doi: 10.2147/jpr.s200498
4. Eccleston, C., Fisher, E., Cooper, T. E., Grégoire, M. C., Heathcote, L. C., Krane, E., et al. 2019. Pharmacological interventions for chronic pain in children: an overview of systematic reviews. *Pain* 160:1698–707. doi: 10.1097/j.pain.0000000000001609
5. Bisogni, S., Dini, C., Olivini, N., Ciofi, D., Giusti, F., Caprilli, S., et al. 2014. Perception of venipuncture pain in children suffering from chronic diseases. *BMC Res. Not.* 7:735. doi: 10.1186/1756-0500-7-735
6. Hoffman, H. G., Doctor, J. N., Patterson, D. R., Carrougher, G. J., and Furness 3rd, T. A. 2000. Virtual reality as an adjunctive pain control during burn wound care in adolescent patients. *Pain* 85:305–9. doi: 10.1016/s0304-3959(99)00275-4

SUBMITTED: 25 January 2024; **ACCEPTED:** 22 July 2024;
PUBLISHED ONLINE: 08 August 2024.

EDITOR: Sagar Chittori, St. Jude Children's Research Hospital, United States

SCIENCE MENTORS: Paulina Buffle and Daniel Czyz

CITATION: Mounsef PJ, Addab S, Hamdy R, Le May S, Thorstad K and Tsimicalis A (2024) Virtual Reality: A Game Changer for Children's Medical Procedures. Front. Young Minds 12:1376603. doi: 10.3389/frym.2024.1376603

CONFLICT OF INTEREST: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

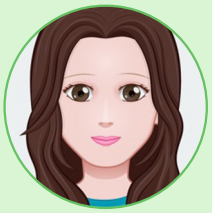
YOUNG REVIEWERS

EMILY, AGE: 15

My name is Emily. I am 15 years old. I enjoy family trips to the beach, fishing, and canoeing. At school my favorite subjects are mathematics and science. I spend my spare time working out at the gym.

EMMA, AGE: 11

My name is Emma. I am a sixth grader. I love to read and I love doing experiments in my spare time. I enjoy going to the beach and exploring nature. Fun fact about me is that I collect rocks and I have over 200 unique rocks in my collection. Whenever I have extra time I sketch movie characters.



LETICIA, AGE: 15

I am 15 years old and live in England. I love learning about science and the human body and want to become a doctor. My hobbies include playing the piano, horse riding, and playing tennis.

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Sofia holds a master's in science from McGill University with a focus on clinical innovations. Her thesis study, which was conducted at the Shriners Hospitals for Children®-Canada under the supervision of Dr. Reggie Hamdy and Dr. Argerie Tsimicalis, explored the feasibility of virtual reality as a distraction tool to help patients cope with painful and anxiety-inducing medical procedures. Sofia graduated from her masters in 2021, and since then has been working at the Shriners Hospitals for Children-Canada as a clinical research coordinator.

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Dr. Hamdy joined the Shriners Hospitals for Children-Canada in 1994 and was appointed chief of staff (September 2010–2020), head of the Division of Pediatric Orthopedics at McGill University (2011–2021) and program director of the Orthopedic Residency Program (2007–2013). He is currently a professor of surgery at McGill University, surgical director of the Osteogenesis Imperfecta Program, director of the Limb Reconstruction Unit at the Shriners Hospital for

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Dr. Sylvie Le May is an active researcher at both CHU Ste-Justine's Pediatric Research Center and TransMedTech Institute in Montreal. She is also a professor at the Faculty of Nursing and at the Faculty of Dental Medicine at the University of Montreal. Her main research interests are related to procedural pain management in children, using innovative technologies, such as virtual reality, particularly in the emergency department, burns, neonatal, dermatology, dental medicine, and orthopedic care units, as well as in radiology (medical imagery).

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Dr. Tsimicalis is an associate professor at the Ingram School of Nursing, and program director, global oncology, in the Gerald Bronfman Department of Oncology, Faculty of Medicine and Health Sciences, McGill University. She holds hospital scientific appointments in clinical research at Shriners Hospitals for Children-Canada and in the Injury Repair Recovery Program at the Montreal University Health Center Research Institute. Dr. Tsimicalis is the recipient of a Junior 2 Research Scholar from the Fonds de recherche du Québec-Santé. Her program of research includes the creation and evaluation of cost-effective, child- and family-friendly innovative health services, arts-based resources, and policies.