Bringing Virtual Reality to Mainstream Pediatric Care

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Virtual reality (VR) is defined as a sensory-stimulating, computer-generated, artificial environment in which one’s actions determine what happens in the environment. The technology is delivered in non-immersive or immersive formats. Non-immersive VR systems project the virtual environment onto large displays or wall screens while immersive VR systems commonly utilize a head-mounted display, allowing for full immersion and interaction with the virtual environment.

The growing widespread interest and commercialization of VR is reflected in its market growth. The global VR market was valued at $21.83 billion in 2021 with a projected compound annual growth rate of 15.0% from 2022 to 2030. VR will become increasingly accessible and adopted, especially by the younger generation, as its hardware and software continue to advance, reduce cost, and improve in portability. Additionally, research in VR continues to expand. The number of publications on PubMed using “virtual reality” as a descriptor has increased from 131 publications in 2000 to 3335 in 2022. We searched through the PubMed database for VR literature related to VR’s use in pediatric health care and categorized articles into various sections. The subsequent sections of the article delve into VR’s potential use in improving the hospital experience, facilitating education during hospitalizations, providing an alternative to pharmacological therapy for pain management, and enhancing mental health care practices.

**Literature Search**

While various recent systematic reviews have been published discussing specific VR utility, we sought to provide a general overview of VR’s potential use in pediatric health care. An initial search was performed by inputting “virtual reality pediatric interventions” and “virtual reality pediatric illness” into PubMed’s search engine and filtering for systematic reviews published from January 2000 to June 2023. Following a brief analysis of the articles, we selected articles evaluating VR intervention in the general pediatric population rather than specified groups. The themes present in this article were subsequently selected by categorizing prevalent unmet needs in the pediatric population frequently highlighted in the literature as potential areas for VR intervention. The subsequent sections delve into VR’s potential use in improving the overall hospital experience, aiding patient education in the hospital, enhancing pain management, and supporting mental health care.
to pharmacological therapy in pain management, and enhancing mental health care practices.

**Impact of VR on the Hospital Experience**

Hospitals can be anxiety-inducing, particularly for the pediatric population, due to unfamiliar surroundings, interaction with strangers, invasive procedures, limited mobility, and frequent interruptions by staff. VR serves as a promising method for alleviating stressors within the hospital. Nihei et al demonstrated that VR experiences in various virtual environments, including the zoo, an amusement park, aquariums, soccer, skiing, or horseback riding, led to decreased psychological and physiological stress in children. Similarly, Bernaerts et al employed a VR application that facilitated breathing exercises, immersed users in meditative environments, and offered gaming experiences. Utilizing the Revised Faces Pain Scale, Self-Assessment Manikin, and the Visual Analog Scale, the authors demonstrated that VR intervention improved happiness, reduced tension, and decreased anxiety compared to baseline measurements in pediatric patients. These findings collectively underscore the potential of VR as a valuable tool in mitigating hospital-induced stress in pediatric patients.

Another aspect particularly distressing for pediatric patients is comprehending complex medical information related to their condition. VR can improve pediatric health literacy by leveraging customizable digital elements and immersion. A comprehensive meta-analysis conducted by Van der Kruk et al evaluated the use of VR as a patient education tool. They discovered 14 out of 18 studies that demonstrated increased patient understanding, knowledge, or comprehension when VR was employed to aid patient education. Other benefits included reduced anxiety, improved comfort with treatment plans, increased patient engagement and empowerment, improved compliance, and increased satisfaction with the health care system. Currently, Stanford’s Childhood Anxiety Reduction through Innovation and Technology (CHARIOT) team is piloting VR experiences, new tablet-based apps, and interactive bedside projector-based games to aid with explanations.

Furthermore, VR can be customized to provide a sense of familiarity and safety such as enabling interactions with pets or people who are unable to visit and allowing drawings or customization of the room virtually. Moreover, given play is an important part of development, it is imperative to minimize disruptions to a child’s life during hospitalizations. Play therapy is a therapeutic intervention under the guidance of a trained therapist to use play and creative activities during a scheduled time to help nurture children’s social, mental, and emotional development. A systematic review demonstrated that play therapy, which is already often embedded in pediatric departments, has a beneficial impact on the care of hospitalized children. If a patient is physically disabled or isolated in a room, VR play therapy can be utilized during play therapy to enhance their hospital experience.

**Continuing Patient’s Education During Hospitalization**

As mentioned above, hospitalizations significantly disrupt the lives of pediatric patients. This includes school activities. School facilitates multiple domains of development, such as learning academic topics, maintaining social relations with peers, and participating in recreational activities. Therefore, prolonged hospitalizations may result in diminished school performance and hindered social development. A retrospective study demonstrated that increasing the frequency and bed-days of hospitalization was associated with two- to three-fold increased odds of performing below national minimum standards across all domains and grades and that children hospitalized with mental health/behavioral conditions were even more likely to be impacted. For patients with chronic conditions requiring long-term admission or continued treatments, ensuring continuity within their daily lives in their inpatient care has been found to be integral. Currently, teachers in the inpatient setting contribute to stimulating patients’ educational interests and alleviating boredom. However, the lack of teaching aids and social engagement with peers remains an issue.

VR may serve as a potential solution to address educational challenges faced by hospitalized pediatric patients by offering an immersive experience that fosters engagement and learning. Villena-Taramilla et al conducted a meta-analysis of 21 studies focusing on the effects of VR learning in K-6 students. Their findings revealed that immersive VR improved student learning compared to traditional learning techniques, with an effect size of 1.11, regardless of the subject. Likewise, Pellas et al performed a comprehensive review encompassing 46 studies applying VR to education in the K-12 population. Common techniques utilized in the studies were educational games, field trips, role-playing, and simulations. The participants engaging in VR had not only better learning outcomes and more positive perceptions of the experience compared to participants engaging in traditional learning methods but also numerous other benefits, including improved attention, group-work skills, self-regulated learning, and critical-thinking tendencies. These findings suggest that VR holds significant potential in establishing a stimulating learning environment for hospitalized pediatric patients.
Pain Management
The prevalence of chronic pain is a significant health care issue, affecting approximately 20% of adults. Contrary to expectations, a study in Norway revealed the total prevalence of chronic pain among school students was similarly around 21%.19 Chronic pain in pediatric patients can impact multiple facets of their lives, including social interactions, participation in hobbies, sleep patterns, and school attendance.

Compared to adults, children have different emotional and psychological factors affecting their pain perception and comprehension.20 Various methods have been developed to evaluate pain in the pediatric population, including the Wong-Baker Faces Pain Rating Scale (WBFPRS). However, despite these efforts, studies have demonstrated inadequate pain management in children undergoing at least one painful procedure within a 24-hour period due to poor documentation of pain and subsequent poor intervention.21 Suboptimal management of pain leads to negative behavioral and physiological consequences later in life, including opioid use disorder.22,23 A recent meta-analysis reviewing prescription opioid misuse disorder among young adults and adolescents demonstrated prevalences ranging from 0.7% to 16.3%.24 However, even appropriate opioid use during adolescence may predispose individuals to later misuse opioids.25 Given that more than 21000 pediatric patients, aged 10–24 years, have died from opioid overdose-related deaths from 2015–2019, there is an urgent need for alternative or adjunctive methods for pain management.26

Several recent studies have explored VR’s effectiveness either independently or in conjunction with standard care in alleviating pain and anxiety in pediatric patients undergoing procedures. For instance, Chen et al conducted a randomized controlled trial wherein school-age children were assigned to receive intravenous injections with or without immersive virtual environments, such as rollercoasters, space exploration, or travel destinations, to serve as a distraction tool. Participants subsequently expressed their pain and fear using the WBFPRS following the procedure. Participants receiving VR interventions demonstrated significantly lower self-perceived pain and fear scores compared to participants in the control group (3.35 ± 2.38 vs. 4.35 ± 2.95 and 1.32 ± 1.19 vs. 1.78 ± 1.40, respectively).27 Similarly, Knight et al evaluated whether VR improved the physical responses to pain by pediatric patients as assessed by the Face Legs Arms Cry Consolability (FLACC) Scale by providers. Their findings revealed that patients distracted by VR exhibited fewer physical reactions to pain during painful procedures, which included cannulation, wound closure, and foreign body removal.28 VR has also been demonstrated to improve pediatric patients’ experiences undergoing various other procedures, including IV insertions and dressing changes for burn wounds.29,31 More broadly, Matthie et al conducted a systematic review, revealing that VR and other related technologies improved pain-related outcomes immediately and up to 1 month post-treatment in 78% of the 46 studies evaluated.32 These findings underscore VR as an effective and safe adjunct to multimodal pain management.

Mental Health
More than 50% of adult mental disorders emerge in late childhood and adolescence and persist lifelong.33 According to a 2014 study, nearly 10% of pediatric hospitalizations in the United States were related to primary mental health diagnosis. The most frequent and costly primary mental health diagnoses were depression (44.1% of all mental health admissions; $1.33 billion), bipolar disorder (18.1%; $702 million), and psychosis (12.1%; $540 million).34 Despite the need for treatment, individuals may avoid admission due to misconceptions and anxieties about the psychiatric ward experience. VR offers a potential solution by allowing patients to experience an interactive virtual environment based on real psychiatric wards. Lau et al’s study compared VR with conventional text-based methods to conduct an orientation prior to admission to a psychiatric ward. Patients undergoing VR were found to be more engaged in the orientation, scored higher on the content exam, and reported lower levels of anxiety.35

VR also presents a promising avenue to mitigate challenges faced by inpatients already in psychiatric wards. Patients who have undergone long-term treatments grapple with reintegration into daily life due to a lack of therapy provision, engagement in meaningful activities, and social interactions.36,37 One common issue during reintegration is patients becoming overwhelmed by social anxiety and withdrawing from everyday activities. To address this, Brown et al leveraged a VR-based exposure therapy before discharge from inpatient psychiatric wards to immerse patients in various virtual environments, including cafes, streets, and buses. An automated virtual coach identified a patient’s defense mechanisms and advised the patient on addressing them.38 VR provides a way to immerse patients into simulated scenarios they are unable to adequately practice prior to discharge.
VR may also improve mental health in adolescents, especially given COVID-19’s impact. A domestic survey on the psychological impact of the recent COVID-19 pandemic reported that approximately 30% of participants experienced mild to moderate anxiety symptoms and peritraumatic distress, and more than 30% of participants had mild to moderate depressive symptoms.38 VR holds potential in addressing the rising rates of depression. A systematic review by Žilinský and Halamová, encompassing 19 studies and 672 participants in total, demonstrated the potential benefits of VR on enhancing self-compassion and self-protection while reducing self-criticism, which could significantly improve depression management.39

Considering the substantial expenses associated with mental health hospitalization, incorporating VR could offer promising avenues for patients to more effectively acclimate to their mental health challenges and enhance their long-term management strategies into adulthood.

**Important Considerations and Call for Action**

This topic synopsis outlines a variety of VR methods exhibiting potential for use as effective primary and adjunctive methods in health care. Our literature review did not uncover current studies evaluating VR’s integration into health care beyond research settings. Nevertheless, foreseeable limitations could include funding, training, and logistical coordination. Primary health and safety concerns appear to be minimal. Among these concerns, nausea and dizziness were less prevalent than anticipated, owing to advancements in software, which have enhanced visual resolution and refresh rates. Nevertheless, clinicians should exercise discretion in considering the individual’s health benefits and clinical condition and ensure age-appropriate use of VR. Additionally, future VR programs should be designed accordingly and age-labeled appropriately for providers, enabling them to discern the most suitable use based on the child’s developmental stage.

VR presents a remarkable opportunity to revolutionize health care among pediatric patients, who are becoming increasingly familiar and accepting of this technology. Alongside increasing research, improving hardware and software, and its expanding global market, VR has reached a pivotal moment as a therapeutic intervention. Its incorporation into mainstream medical care is not only feasible but also beneficial in mitigating pain and anxiety, enhancing the hospital experience, and empowering patients to take charge of their own health.

**Patient-Friendly Recap**

- Virtual reality (VR) is an innovative technology that transforms our interactions with the digital world.
- VR can help health care providers and patients, especially pediatric patients, who are already familiar with the technology.
- This topic synopsis explores current and future uses of VR in pediatric patient care.
- VR has been shown in pediatric patients to improve the hospital experience, facilitate education during hospitalizations, provide an alternative to medication-based therapy for pain management, and enhance mental health care practices.

**Author Contributions**

Study concept: Kuang, Yang. Manuscript drafting: Kuang, Yang, Truong. Critical revision: Woo. Kuang and Yang contributed equally to the manuscript.

**Conflicts of Interest**

None.

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