Immersive medical virtual reality: still a novelty or already a necessity?

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Virtual reality (VR) technologies have been explored for medical applications for over half a century. With major tech companies such as Meta (formerly Facebook), HTC and Microsoft investing heavily in the development of VR technologies, significant advancements have recently been made in hardware (eg, standalone headsets), ease of use (eg, gesture tracking) and equipment cost. These advancements have spurred research in the medical field, with over 2070 VR-related articles indexed in PubMed alone in 2022, and the number of VR articles more than tripling in the last 6 years. Recently, the US Food and Drug Administration (FDA) also approved the first VR-based therapy for chronic back pain.1

Whether the technology has reached a tipping point for its use in medicine is debatable, but it seems timely to provide a brief overview of the current state of immersive VR in neurology and related fields. In this editorial, we will discuss the characteristics of VR that make it a potentially transformative tool in healthcare, review some of the most mature VR solutions for medical use and highlight barriers to implementation that must be addressed before the technology can be widely adopted in healthcare. This editorial will focus solely on immersive VR technology and will not delve into the applications and use cases of augmented or mixed reality.

Characteristics of VR
VR is a technology that allows users to interact with and experience a simulated environment.2 The technology typically involves the use of a headset or other device that displays a 3D computer-generated environment, as well as sounds and haptic feedback, and input devices to create a fully interactive immersive experience. The immersion establishes a sense of presence—a user’s subjective feeling that they are actually present in the virtual environment. This subjective sense of presence is modulated by the employed technology3 and is enhanced by the use of head tracking and other technologies that allow the user to move around within the virtual environment. Medical VR applications take advantage of the technology’s ability to elicit emotional responses, convey spatial information and provide a sense of presence in a simulated environment. Typically, the applications use engaging VR experiences while providing a safe and controlled environment for failsafe practice, learning, distraction, relaxing or treatment.4

Examples of More Mature VR Solutions for Medical Use
The range of trialled medical VR applications is vast and their maturity varies widely, with some still being in the proof-of-concept stage and others having been evaluated in high-quality randomised control studies (RCTs). Some of the strongest evidence for the effectiveness of medical VR is in the areas of mental health interventions, pain management and medical training.

Mental health interventions
VR has been shown to be an effective treatment for various psychological conditions, including phobias,6 post-traumatic stress disorder (PTSD)7 and anxiety disorders. For example, a single-blind RCT in 346 patients with psychosis found significant reductions in agoraphobic avoidance and distress in the VR plus usual care group compared with the usual care group.8 Patients with severe avoidance at baseline demonstrated large VR treatment effects even at the 6-month follow-up.8 A meta-review of 11 meta-analyses on VR therapies for psychiatric disorders found medium-to-large effects for anxiety-related disorders when compared with inactive controls. However, no meaningful differences were found when VR was compared with standard evidence-based interventions.9 The lack of statistically significant differences necessitates further research and research into the best use cases for each intervention.

Pain management
VR is effective as an intervention to control acute pain during medical procedures.10 11 For example, a randomised, crossover study reported a 39% reduction in opioid medication when using VR during painful medical procedures compared with the non-VR condition.12 While less researched than VR interventions for acute pain,13 there are also promising results for chronic pain management.14 This includes an at-home VR intervention for chronic lower back pain, which produced clinically meaningful symptom reduction in pain intensity and pain-related interference.15 While these findings are encouraging, more rigorous high-quality RCT studies are needed16 and unanswered questions about the optimal frequency and dosage of interventions, as well as the durability of any treatment effects remain.

Medical training
There is evidence that VR can be an effective tool for medical training,16 in addition to its use with patients. For example, VR simulations can improve surgical skills, especially in comparison to non-VR traditional training.17 A meta-analysis of 15 RCT studies using VR to teach anatomy found moderately improved anatomy test scores compared with other teaching approaches.18 There is also emerging evidence that VR simulations are useful for non-technical skills, such as training empathy,19 that are essential for providing high-quality patient care.

BARRIERS TO IMPLEMENTATION
The accumulated evidence for the effectiveness of at least some medical VR applications will aid in the removal of roadblocks to their implementation. Some of the most significant barriers to broader adoption of medical VR in hospitals, which are not necessarily mutually exclusive, include:
Content

Current medical VR knowledge is primarily based on the evaluation of research prototypes. The heterogeneity of the VR systems (eg, display type, method and amount of interaction) and the content (eg, how the tasks and activities are introduced, presented and measured) impact outcomes. The lack of generalisation, combined with a lack of standardisation, makes demonstrating evidence for specific VR applications time-consuming and costly. As a result, there are currently very few readily available commercial VR applications to choose from that have proven their effectiveness.

Data use and regulatory barriers

Uncertainty around regulations related to data collection, storage, ownership and use are considerable barriers to use of VR. There may be regulatory obstacles to implementing VR technology in hospitals, such as obtaining approval from relevant governing bodies before using the technology. In the USA, for example, the FDA regulates medical devices, including VR technology used in a medical setting. Hospitals may also be required to follow other medical technology-related regulations, such as those governing patient privacy and data security. The parent companies of two leading VR headset manufacturers (Meta and ByteDance) operate social media platforms that collect large amounts of personal data for advertising and other purposes. Good solutions must be found to ensure that the collected data is not misused or disclosed without the individual’s consent. These regulatory requirements can increase the cost and complexity of implementing VR in hospitals, potentially impeding immediate widespread adoption.

Proof of cost-effectiveness

The cost-effectiveness of VR technology in hospitals has not yet been well established. One study found that VR therapy for pain management saved US$5.39 per patient, compared with usual care, due to lower opioid use and hospital length of stay.20 A randomised clinical trial in senior orthopaedic surgery patients found that not only was VR training superior to technical video training for the acquisition of procedural knowledge and decision-making, but it was also 34.1 times more cost-effective than the control group training.21 A return on investment analysis for a US$300 000 VR delivery (including staff, equipment, software and consumables) revealed a loss of US$38 and cost savings of US$6.79, with 5000 and 20 000 hospital admissions, respectively.20 The analysis, done with the assumption of a 19.3% eligibility and acceptance rate for VR pain interventions, nicely demonstrates the importance of scale.

Competency development

Lack of training and familiarity is a major barrier to the adoption of VR technology. Technological competence, knowledge of the safe use of VR (eg, monitoring for cybersickness, infection control, mitigating the risk of physical hazards such as falls) and the selection of appropriate VR content for a specific patient are required. Many healthcare professionals will lack the necessary skills to use VR effectively. The issue of competency development is amplified by the rapid pace of hardware and VR application developments, with new versions being introduced constantly and headsets becoming outdated within years. The rapidly evolving medical VR field poses significant challenges for developing and sustaining staff competency. A lack of competency undermines not only the acceptability to use the technology, but also impedes buy-in from all stakeholders, including clinicians, senior administrators and IT professionals.

CONCLUSIONS

Advances in VR technology and the accumulating evidence for the effectiveness of VR for some medical applications in the last decade are promising. They provide critical stepping stones towards the wider adoption of medical VR. Further evidence demonstrated in high-quality trials,10–13 linking applications to theoretical frameworks,14 shedding light on mediating outcome factors (eg, content, dosage, frequency, patient characteristics), improving ease of use, and evidence for VR’s cost-effectiveness are required for broader acceptance and medical VR uptake.

The high level of academic research activity, combined with massive investments from established companies such as Meta, and the rise of numerous start-up companies in the field provide an ecosystem that has the potential to drive the growth and adoption of medical VR. However, moving from development and pilot evaluation activities to commercially available and evidence-based VR applications will take time and a widespread use in the medical field is still years away. While VR is undeniably a promising technology, it still has a long way to go before becoming a necessity and to live up to its potential to transform healthcare.

REFERENCES


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