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Commentary

The Digital Metaverse: Applications in Artificial Intelligence, Medical Education, and Integrative Health

Abhimanyu S. Ahuja [a], Bryce W. Polascik [b], Divyesh Doddapaneni [c], Eamonn S. Byrnes [d], Jayanth Sridhar [e,*]

[a] Charles E. Schmidt College of Medicine, Florida Atlantic University, Boca Raton, FL, United States of America
[b] Wake Forest University School of Medicine, Winston-Salem, North Carolina, United States of America
[c] Department of Internal Medicine, University of Colorado Anschutz Medical Campus, Aurora, Colorado, United States of America
[d] Department of Internal Medicine, Orlando Regional Medical Center, Orlando, Florida, United States of America
[e] Department of Ophthalmology, Bascom Palmer Eye Institute, University of Miami, Miller School of Medicine, Miami, Florida, United States of America

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1. Introduction

The metaverse is an interconnected virtual 3D environment where people across the world can come together to share social experiences.[1] This environment can leverage immersive technologies such as augmented reality (AR), virtual reality (VR), and artificial intelligence (AI) to offer rich life-like experiences to people all over the world. Blending these technologies can enable seamless social interactions like office meetings, music concerns, e-sports, and more. Particularly, the metaverse and extended reality technologies like AR, VR, and AI have a lot to offer to the healthcare industry by enhancing patient-centric care and medical education.

The metaverse is not a new concept; In the early 2000s, a virtual 3D game called Second Life™ began to explore the concept of immersive virtual 3D experiences.[2] Realizing its potential to connect with different generations and promote public health initiatives, several notable institutions explored how we could leverage 3D environments to improve healthcare literacy. Faculty at Ohio University developed a nutrition game where people could learn about the impact that fast food has on health.[3] In another virtual world, Whyville, a research team released a simulated respiratory virus into the community. As that simulated pandemic was unleashed into the virtual world, the team began promoting public health lessons to the community in the form of frequent washing hands, wearing protective face masks around others, and vaccines which ultimately eradicated the simulated virus.[4] In the past two decades, there have been incredible advancements in computing and refinement in extended reality technologies that could enable a new generation of medical experiences that were previously unimaginable. Not only does the metaverse increase accessibility, but it could also promote collaboration, enhance medical literacy, improve medical education, and promote diversity.

Research related to the applications of the metaverse to health have been sparse, with a PubMed search in July 2022 revealing 51 articles with the keyword 'metaverse' and 10 that referenced medicine. In this paper, we discuss how the fusion of metaverse with extended reality (AR, VR, and AI) can improve healthcare.

2. Artificial intelligence and the metaverse

In the last few years, it has become increasingly clear that AI has a prominent role to play in medicine.[5] For example, it has been

* Corresponding author at: Jayanth Sridhar, Department of Ophthalmology, Bascom Palmer Eye Institute, University of Miami, Miller School of Medicine, 900 NW 17th Street, Miami, FL, 33136.
E-mail addresses: aahuja2016@health.fau.edu (A.S. Ahuja), Jsridhar1@med.miami.edu (J. Sridhar).

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proposed that in the future physicians may be able to perform in-home diabetic retinopathy (DR..) screening using AI powered devices.[6] Such a device would promote health equity by informing patients in rural or access limited settings whether they are exhibiting signs of DR.. and how urgently they need an in-person ophthalmologic evaluation. However, one clear limitation is the performance of AI at the bedside in terms of empathy, high-level conversation, and body language.[5,7] Such limitations may lead to patient distrust and a reluctance to adopt AI-based technologies in direct patient care. By replacing AI-powered chatbots with AI-powered digital avatars in a VR setting, AI may seem less mechanized and unemotional to patients. This in turn may increase patient trust and therefore more widespread acceptance.

Along these lines, AI-based technology in the metaverse can be very useful to patients with various psychiatric conditions. For example, patients with Borderline Personality Disorder (BPD) are a greatly increased of committing suicide.[8] Such people commit suicide because they feel hopeless, anxious, and impulsive.[8] An AI-based chatbot that serves as a virtual assistant or virtual friend could provide a trusted "someone" they can be with all the time to help reduce these sometimes-intense feelings.[8] These virtual assistants can be programmed to provide responses derived from dialectical behavioral therapy (DBT). In fact, some people with BPD who had previously attempted suicide stated they were triggered by confusing thoughts but felt too ashamed to ask someone for help, so they proceeded to try to kill themselves.[8] Others said they felt increasingly empty and had no one they could confide in.[8] A virtual assistant could provide these patients with an outlet to confide in at moment's notice at all hours of the day.[8] However, patients often feel relief with the empathy shown by a fellow human even in things like body language cues and such non-verbal communication is not easily replicated by AI. If we move such applications to the metaverse with the presence of virtual characters and avatars, such limitations could be theoretically overcome.

3. Metaverse and medical education

Extended reality technology demonstrates the potential to profoundly impact the future of medical education. The growing portfolio of use cases for this technology can be applied throughout each stage of the medical training process. Exploration and discussion of these applications is valuable in ensuring the growth and comprehensive capability of our future medical education system.

Applications of extended reality technology could be considered in as early as the first year of medical education, where preclinical coursework focuses on foundational topics such as anatomy, radiology, and more. There is evidence of universities implementing AR and VR technology as supplemental learning tools for medical anatomy, with promising findings.[9,10] The use of these tools has also been increasingly examined for the purpose of radiology education.[11,12] One review investigating the use of virtual reality for radiology and anatomy teaching found that VR was effective for increasing anatomy knowledge after assessing the academic performance of participants.[12] With the development of these many programs still being in their relative infancy, there is exciting potential for the integration of extended reality technology to supplement the traditional preclinical medical curricula.

The continued growth of metaverse-compatible technologies has also shown the potential to revolutionize our approach to clinical skills training. The simulation of virtual environments could provide students with unique opportunities to practice history and physical skills, complex clinical cases, and important ethical issues while remaining in a safe, low-stakes environment.[13,14] One 2018 study examining the feasibility of using virtual reality to teach empathy found a positive increase in students' empathy for multiple age-related degenerative diseases after employing the use of virtual immersion training.[14] The use of VR has also been heavily examined in the field of nursing for its utility in successfully teaching clinical skills competency.[15-17] These studies propose a remarkable potential for medical education supplementation that should be investigated further to develop a more comprehensive understanding of its future implications.

While extended reality technology has demonstrated significant potential for both preclinical and clinical education, its greatest impact may be in revolutionizing surgical training. Many different surgical specialties have begun exploring this concept, unearthing favorable utility for a myriad of cutting-edge use cases.[18-20] With the use of extended reality technology, learners can gain hands-on surgical experience in a zero-stakes environment. With the elimination of patient risk, virtually-immersive surgical training can even be accessible by first year medical students. Early adoption of extended reality tools for surgical training may greatly strengthen the foundational surgical knowledge of students before even applying to residency programs, which would strengthen applicant pools and revolutionize the paradigm of traditional medical education. Additional surgical applications pioneered by this technology include the potential for remote observation and assistance during surgery.[21] With at least one person in an operating room, multiple others are able to digitally immerse themselves from a completely remote location.[21] This supports valuable future utilities such as the ability of students to engage in remote, yet immersive, shadowing experiences and for attending surgeons to remotely provide instruction and assistance to younger members who may be performing unfamiliar or especially complex procedures.

The metaverse ecosystem and the collaborative environment it generates may play a unique role in supporting the progression of health equity initiatives by strengthening the diversity of medical specialties. Many medical specialties have historically demonstrated low levels of diversity, and although counteractive efforts have strengthened in recent years, certain specialties continue to linger behind.[22-24] However, extended reality and the metaverse collaborative ecosystem can help improve access to medical education and valuable specialty-related exposure from anywhere in the world, including low-income areas.[25] Educational opportunities accessible through this emerging technology can help future aspiring doctors gain early exposure to various specialties and meet new mentors from anywhere in the world.[25] With these potential impacts in mind, early exposure and training programs surrounding this technology should continue to be explored.

4. Integrative medicine

Integrative medicine combines a variety of therapies and lifestyle changes to treat one's mind in addition to their body.[26] Studies continue to reinforce the value of integrative medicine in quality of life and morbidity outcomes.[27] The metaverse and extended technologies can offer new approaches to integrative medicine which include guided meditation, nutritional advice, yoga sessions and other mind-body therapies.[26] Furthermore, there is emerging evidence that VR and AR can offer anxiety relieving therapies to individuals suffering from PTSD/anxiety.[28] Such technologies can be further amplified by the metaverse with social experiences like virtual yoga and virtual meditations. One example of virtual mindfulness exists within Roblox, a metaverse platform, where users can jump into a relaxing virtual world to learn a variety of yoga techniques and guided meditations.[29] This experience created by Alo Yoga has garnered over 55 million visits internationally and highlights the market for virtual integrative medicine therapies. For some people, virtual mindfulness may be their first exposure to integrative medicine, and a pleasurable experience can be a foot in the door for additional person-to-person contact sessions. In this way, the metaverse can expose individuals to integra-

tive medicine therapies and highlight the positive aspects of these therapies.

5. Drawbacks to the metaverse

There may also be drawbacks to the use of the metaverse in medicine including the cost of implementation, depersonalization of medicine, communication errors, equipment failures, and security vulnerabilities.

It has been documented that individuals may develop "Post VR sadness" or a "VR Hangover" in which immediately following the use of virtual reality devices individuals may experience a transient depressed mood.[30] In one randomized control trial, Virtual Reality gaming was shown to induce higher rates of Depersonalization-derealization disorder (DPDR) than PC gaming.[30] In DPDR individuals have the sensation that they are disconnected from their physical body, and that the world around them is unreal.[31] While this effect was shown following gaming, it is still uncertain if a similar effect would be shown following the use of virtual reality for medical-related purposes. Other side effects include the development of nausea, dizziness, and eye fatigue.[32]

The depersonalization of medicine has become an additional concern when considering the use of extended reality technology in the future of healthcare delivery. Due to the relative infancy of extended reality and metaverse development, it would be difficult to substantially support the notion that there currently exists an equal level efficacy between the digital and physical approaches to interpersonal interaction. Currently, the majority of research concerning the use of extended reality technology targets its utility within medical education; the true implications for its use in interpersonal physician-patient interactions is not fully understood and must be further explored. Furthermore, the decentralized framework of the metaverse and its related technologies fundamentally truncates the likelihood of traditional regulatory measures to remain effective. Nevertheless, novel regulatory proposals which parallel the developmental course of this technology should persist at the forefront of consideration to ensure that the implementation and use of this technology remains congruent with the future ethical standards of medical conduct.

6. Conclusion

The metaverse has a wide range of potential healthcare applications, and when paired with AI, AR, and VR may profoundly improve medical education, medical literacy, promote diversity, and more. Through enhancing telemedicine, the metaverse may expand the reach of healthcare to better serve more patients. While attempts have been made to implement metaverse technology into healthcare in various ways thus far, there is much room for future growth. There may also be potential drawbacks to the use of the metaverse in medicine that should be considered. For patients with psychiatric conditions, there may be increased options for CBT, DBT, and virtual therapy. In terms of medical education, some universities have already begun to implement augmented and virtual reality technology as supplemental learning tools in the curriculum. The adoption of extended reality tools for surgical training may revolutionize the paradigm of traditional medical education. The metaverse may also expand access to educational opportunities to underserved populations to help aspiring doctors gain exposure and meet new mentors. In summary, by increasing the diversity of options available to patients, healthcare providers, and educators more patients may ultimately benefit from the adoption of the metaverse into the medical field.

Conflict of interests

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Abhimanyu S. Ahuja: Conceptualization, Writing – original draft, Writing – review & editing. **Bryce W. Polascik:** Writing – review & editing. **Divyesh Doddapaneni:** Writing – review & editing. **Eamonn S. Byrnes:** Writing – review & editing. **Jayanth Sridhar:** Conceptualization, Writing – review & editing.

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