Extended Reality in Patient Care and Pharmacy Practice: A Viewpoint

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Abstract

The evolution of technology has given practitioners and educators more tools to better treat, manage, and educate both patients and future pharmacists. The objective of this viewpoint publication is to describe the current use of extended reality (XR) in pharmacy and propose ways in which pharmacy practice and education may benefit from incorporation of this technology. While these tools have been used for decades by many other professions, pharmacy is starting to adopt XR in professional and educational practice. XR (virtual reality, mixed reality, and augmented reality) is being used in various aspects of pharmacy care and education, such as pain management, diabetes self-care, cross-checking of prescriptions, treatments for addiction, and (in limited ways) patient and pharmacy education. There is great potential for further integration of XR into pharmacy practice and pharmacy education to ultimately improve patient care and education as well as pharmacy education.

Introduction

Technology has a significant impact on patient care, pharmacists, pharmacy students, and educators. Virtual reality (VR), augmented reality (AR), and mixed reality (MR), which are collectively known as "extended reality (XR)," are new technologies that are gaining momentum. VR is best understood as "a computer-generated simulation of the real or imagined environment or world."[(1)] MR and AR are gradations of VR. In contrast to VR, where the entire visual display is a simulation, AR is a computer-generated overlay on the real world. MR is similar to AR in that it is an overlay on the real world, but it also has the added feature of being able to recognize and interact with the real world.

XR has long technological roots, tracing back to 1839 with the creation of stereoscopic photos and viewers.[(2)] This technology is dependent on the brain's ability to process separate two-dimensional images into a single three-dimensional image. XR has continued to evolve over the past 180 years, and we are on the precipice of experiencing complete stand-alone systems that are commonplace. XR allows users to experience a realistic mock environment that would otherwise be cost prohibitive.

XR has been prevalent in aeronautical, military, and medical practice[(2)]; however, implementation in pharmacy has been comparatively slow. With the continual evolution of technology, increase in pharmacist responsibilities and training, and patient demands to be treated holistically, the current status of and the potential applicability of XR in pharmacy practice and education are limited.[(3–5)] Previous publications have explored (to a limited extent) XR's applicability to pharmacy. For example, several studies explored the use of the massive multiplayer online role-playing game (MMORPG) Second Life® for pharmacy education. These studies demonstrated benefits to pharmacy education but were limited to virtual environments on two-dimensional (2-D) computer screens.[(3)(4)(6)]

More recently, the utility of immersive VR in pharmacy education has been reviewed. These articles provided a comprehensive review of the uses of VR for pharmacy education but did not fully explore how XR might impact pharmacy practice. Finally, Fox and Felkey proposed opportunities and challenges for the use of VR in pharmacy. This brief review provided several novel

Table 1. Definitions of Common Terms

Technology	Acronym	Explanation
Virtual Reality	VR	A completely artificial computer-generated 3-D environment.
Augmented Reality	AR	An overlay of computer-generated objects on a display of the real world.
Mixed Reality	MR	Computer-generated objects displayed over a display of the real world, with which they are able to interact.
Extended Reality	XR	Any combination of real and virtual environments
Simulation	-	An imitation of a real-world scenario, system, or process. Does not necessarily involve computers.
Wearables	-	Small wearable computers that provide the user with information such as heart rate and distance traveled.
Massively multiplayer online role-playing game	MMORPG	A type of video game where a large number of players can interact with one another in a virtual world.
Virtual world	-	Any computer-simulated environment. May be 2-D, 2-D representations of 3-D, or fully 3-D environments.

suggestions on how VR might benefit pharmacy practice in the future, but did not provide a review of the literature or a discussion of the potential of other technologies within the XR umbrella.[3–5]

After a review of the peer-reviewed biomedical literature from the 1830s to February 2019, the objective of this manuscript was to build upon previous studies to describe current applications and use of XR in healthcare, with particular emphasis on its use in pharmacy.

XR in Self-Care

XR has potential utility in patient self-care. VR technology may be helpful to motivate patients to make healthier lifestyle choices. Pharmacists could help patients to quit smoking by recommending the use of a program like MindCotine, the first of its kind, which combines "VR and mindfulness-based exposure therapy to train and empower" smokers to quit by gaining self-awareness, learning coping skills, and forming healthier habits by addressing cravings head-on in a 21-day program.[7] The effectiveness of MindCotine specifically is yet to be determined, as there are no published studies. However, virtual reality and smoking cessation studies have indicated the ability to create craving-induced environments in VR and effects on smoking cessation with cue exposure therapy.[8][9]

VR has also been used in alcohol misuse studies. Generally, cue-exposure techniques have unreliable results in alcohol misuse treatments. However, VR seemed to be effective as a personalized alcohol use assessment and treatment tool that ultimately reduced alcohol craving in individuals with a history of alcohol misuse.[10]

Fox and Felkey described how VR could provide patients with services such as counseling on new prescriptions.[5] The authors also mentioned that "wearables (e.g., Fitbit)" and health tracking applications are growing in popularity and could be used to track a patient's behaviors, then uploaded into a VR application. This application could then provide a variety of behavior modifications to the patient's current habits and demonstrate the effects of those modifications on the patient's health.[5] Additional applications that support lifestyle modifications include BehaVR©, Peloton®, and Icaros™.[11–13] Because the integration for biosensor feedback in VR is still limited, current devices do not adapt to physiological responses much beyond heart rate. Newer technology like NeuroSky, which has EEG and ECG applications complete with biometrics, may be a solution for improved patient care.[14] Collectively, VR can be used as a means to encourage healthier lifestyle modifications in patients that may, independently and in concert with traditional methods, complement current self-care options.

AR has been used to help individuals with diabetes self-monitor their diets. In one study, individuals manually retraced their food consumption and received feedback on the carbohydrate intake.[15] AR and MR can be useful to inform not only pharmacists but also healthcare providers about real-time patient and drug information. The University of Sydney recently demonstrated that MR can be used to cross-check prescriptions.[16] Diodati et al. developed a prototype mobile AR application that combines information from medication labels and patient health records to provide healthcare providers with information regarding a patient's self-care.[17] Although there is limited biomedical literature evaluating the combination of AR and MR with other devices for patient self-care, the integration of additional tools such as speech and voice recognition, eye tracking, and motion tracking can further enhance personalized self-care treatment plans because of acquisition of real-time patient biometrics between visits.[18]

For many people, self-care is the only option due to the rising cost of healthcare. Pharmacists are often the first and only point of contact. With XR technology, pharmacists will be better equipped to play pivotal roles in patient advocacy. Some challenges remain to be addressed before XR is fully adopted into patient self-care. Challenges that need to be addressed include access to devices, biometric data collection and storage methods, ensuring data protection, and technological limitations.

Innovative strategies to help patients overcome the anxiety of injections have been investigated. The feasibility and effectiveness of VR in reducing pain, discomfort, and anxiety during procedurally common blood draws were evaluated in a randomized control trial in 10- to 21-year-olds.[19] In this study, it was determined that VR was "feasible, tolerated, and well-liked by patients, caregivers, and phlebotomists alike for routine blood draw." A similar situation of particular importance to pharmacists is providing immunizations. Patients commonly fear receiving immunizations due to the associated pain and discomfort.[20][21] When VR was used as a distraction during immunization for 244 children ages 2–16, a decrease (45–74%) in pain was reported. Having VR as an additional tool to help facilitate immunization efforts while decreasing anxiety, distress, pain, and discomfort can lead to increased patient compliance in timely vaccinations and perhaps even minimize trypanophobia.[19–21]

XR in Pain Management

The utility of XR in pain management has been explored for burns, cancer, hemophilia, sickle cell anemia, and for procedural preparations for MRI, laceration repair, and other surgical operations.[19][21–24] Several studies have used VR as a tool in pain management for both acute and chronic pain.[25][26] In fact, the use of immersive VR for pain control in burn patients has been around for some time. "SnowWorld" is a virtual interactive ice environment that was developed in 2003 to treat burn patients, with the idea that the captivating experience distracts attention away from processing pain signals.[25] Wiederhold et al. studied VR as a distraction technique for chronic pain patients. They found that all participants had lower pain scores while they were in the virtual environment.[26] Jin et al. designed a VR game called Cryoslide as a distraction technique for chronic pain patients.[27] Twenty individuals participated in the study, and the authors found that there was a reduction in pain intensity during the VR game. Participants in the VR group also spent less time thinking about their pain compared to the control group. There is growing evidence demonstrating that immersive VR can reduce pain intensity and unpleasantness.[28][29] Pharmacists with knowledge and awareness of VR as a treatment option can help provide patients with adjunctive and alternative solutions to address pain and provide hope, or fight chronic pain, either as direct providers of XR therapy or by recommending XR as a treatment option to physicians. The role of health insurance and guidelines regarding the integration of XR therapies into practice are yet to be established.

XR for Behavioral Interventions

XR may assist pharmacists in providing behavioral modifications, as it facilitates the creation of complex controlled environments that can be used to research and treat complicated disorders involving behavior and emotions.[30] XR may be particularly useful to study and treat phobias and anxiety. VR experiences can be customized to individual phobias and can even be gamified to improve engagement.[31] A meta-analysis conducted by Morina et al. revealed that patients exposed to virtual simulations of their phobias showed significant improvements compared to control groups.[32] A meta-analysis by Parsons and Rizzo also showed that VR exposure therapy for phobias reduced anxiety symptoms. However, the investigators noted that the study was limited by inconsistent reporting in the literature, and stressed a need for further studies with more consistent reporting.[33]

XR has been proposed to be beneficial in the treatment of post-traumatic stress disorder (PTSD). September 11 disaster workers with PTSD were treated with VR exposure therapy.[34] Therapy involved using head-mounted displays to revisit the event and gradually increase the traumatic exposure under the supervision of a therapist. Patients showed a statistically significant improvement in symptoms compared to a waitlisted control.[34] A meta-analysis of VR interventions for anxiety and depression revealed that outcomes were improved in VR groups compared to controls, but that treatment attrition was not improved.[35]

VR has also been used to study substance use disorders.[36] Hone-Blanchet et al. reviewed the use of VR as a mechanism to expose patients to cues that induce cravings. They propose that by exposure to these visual cues in VR conditions, patients could learn to be less reactive to these stimuli, and thus VR could be beneficial in the treatment of addiction.[36]

XR could be used to encourage positive behavioral changes through patient education. For example, Balsam et al. assessed the effectiveness of a 3-D movie demonstrating the risk of stroke associated with atrial fibrillation.[37] Patients with a history of atrial fibrillation watched the movie, then completed a questionnaire assessing their understanding of the role of atrial fibrillation in stroke. Results showed that watching a 3-D movie in VR improved patient understanding of the consequences of atrial fibrillation. Jimenez et al. found that breast cancer patients reported significantly less anxiety following a virtual reality educational experience typically used to train radiotherapists.[38] Fox and Felkey proposed that VR could help with patient education through virtual demonstrations and teach-back sessions.[5] This could be extrapolated to pharmacy education by allowing students to learn the information being provided to patients, and practice teach-back methods with peers.

As the first healthcare providers often sought out by patients, pharmacists are in a unique position to not only offer referrals to behavior intervention specialists, but also encourage complementing traditional behavior interventions with XR for improved patient outcomes. These interventions could be implemented into the current pharmacy landscape for most pharmacist positions. For example, community pharmacists may offer these services within the community pharmacy setting, and clinical pharmacists who work as a part of a healthcare team can make direct referrals for these therapies to the team.

XR for Pharmacy Student Education

In the health professions, XR is gaining traction as an educational tool. Active learning is becoming increasingly important in pharmacy education.[39] VR may offer a platform to encourage active learning, by providing an immersive and interactive environment. Additionally, Coyne et al. recently demonstrated the utility of VR to teach pharmacy students using team-based learning, a pedagogy that has been shown to develop soft skills such as teamwork, critical thinking, and satisfaction with learning.[4][40] This study also demonstrated that students enjoy learning in VR. In a different study, nursing students demonstrated satisfaction with learning in VR.[41] Improving student satisfaction with learning may improve the intrinsic motivation of students to learn. Further studies are needed to ensure that this satisfaction is not just associated with the novelty of VR.

XR may have some utility across all healthcare disciplines, including pharmacy, for anatomy education. Stepan et al. compared achievement in anatomy quizzes in a control group that studied using traditional materials and an experimental group that studied using VR materials.[42] There was not a significant difference in learning, but students in the experimental group demonstrated better engagement and motivation to learn than the control group. Izard et al. recently developed a tool in VR that is specifically designed to teach students about the anatomy of the human cranium.[43] The human cranium model can be manipulated by students to mimic microsurgery, giving medical students the opportunity to practice these skills before ever interacting with a patient. Medical education has used XR in a variety of settings, most notably for surgical simulations, such as tumor resection.[44][45] In a randomized control trial, VR surgical training was found to improve knowledge and self-confidence in surgical residents.[46] Additionally, a review conducted by Samadbeik et al. found that people who trained in laparoscopic surgery using VR were more accurate and had fewer errors compared to those who trained only using traditional methods.[47]

AR and MR have demonstrated utility in surgery. For example, Moreta-Martinez et al. used AR to generate patient-specific 3-D models that could provide a guide for surgeons to identify the specific location of a tumor.[48] Through the use of optical see-through head-mounted displays, AR may also be useful to aid in the visualization of organ locations and decision making during surgical procedures.[49][50] In dentistry, VR is currently being used to simulate dental surgeryand has been explored as a tool for dental OSCEs.[51][52]

Three-dimensional models also have a place in pharmacy education. An up-close and personal experience of exploring drug interactions using 3-D models demonstrated improved student learning compared to a traditional lecture.[53] Although pharmacy students do not typically learn how to perform surgical procedures, they do need to learn complex skills. For example, XR could be used to teach anatomy and to simulate sterile compounding and physical assessment labs. Similar to dentistry, OSCEs play an important role in pharmacy education. XR may be a useful tool for OSCEs, as it could provide truly standardized patients and reproducible scenarios.

As in all healthcare professions, communication is instrumental to providing optimum patient care and to success in the workplace. Real et al. investigated the communication skills of medical residents following a traditional curriculum and a curriculum involving practice with virtual avatars in VR. They investigated the number of vaccine refusals in patients counseled by the control group and patients counseled by the VR group. There were fewer vaccine refusals in the VR group than the control group, suggesting that practice in VR can positively impact communication skills.[54] A panel discussion of VR as a tool for training healthcare professionals further affirmed the utility of XR to develop better communication and self-awareness skills of healthcare students.[55] However, the panel also identified limitations, namely that more data was needed to support VR training.[55]

The role of XR in communication education can be further extrapolated to interprofessional education. XR can provide student physicians, nurses, and pharmacists an environment to learn together. Collaborative interprofessional learning in XR has many potential benefits, including: 1) causing no actual harm to a patient while having lifelike experiences; 2) cost effectiveness; 3) replaying scenarios in 3-D to learn from past experiences; and 4) allowing students who are not physically located on the same campus to work together in a simulated environment.

Although the future uses of XR in pharmacy education will depend on technological advancements and the availability of appropriate software, we may expect to see XR used in pharmacy education for several reasons. First, XR provides an interactive 3-D environment that, with the appropriate software, could be used to simulate pharmacy experiences outside of the classroom, lab, or practice setting. This could allow students to practice their skills more effectively, without the resource demands of experiential education. Second, XR, and particularly VR, can add a level of immersion and engagement for distance learning students that has previously never been possible. A recent study demonstrated that students preferred team activities in VR to traditional distance-learning environments.[4] With further development, VR may become commonplace for distance learning. Finally, as XR is computer-based, it can be used to generate learning activities that are not possible in the real world. For example, students can already travel into the center of a cell in VR with BodyVR©. XR software development could provide engaging learning experiences capable of providing students with a deeper understanding of difficult concepts.

Challenges Facing XR Implementation

There are several challenges facing the adoption of VR, MR, and AR for healthcare, such as the general acceptance of and access to the technology.[5] Other important challenges include comfort and cost. Head-mounted displays, particularly for VR, are heavy, can generate a lot of heat, and are often connected to a computer with a wire. AR and MR head-mounted displays are currently limited by their technological infancy and are particularly limited in their field of view. If visual quality is low, or if there is a misalignment between visual processing and proprioception, simulator sickness, which includes symptoms such as nausea and dizziness, is possible in VR. Cost may also be a challenge, depending on the quality of the technology required. MR head-mounted displays may cost upward of several thousand dollars. High-level technology continues to be just shy of $1,000; however, the quality of entry-level VR equipment has continued to increase over recent years while the cost has decreased.[4] In fact, until high-quality XR is commonplace, many XR applications can be experienced on inexpensive or everyday devices like smartphones and Google cardboards for just $20 or less.[56]

Summary

Virtual, augmented, and mixed reality have been used in many different professions. The utility of this technology is yet to be fully explored, and whether it has clear applicability in pharmacy practice and pharmacy education remains to be determined. XR has the potential to minimize cost while enhancing educational and training experiences for patients, students, and practitioners. Future applications of virtual, augmented, and mixed reality in pharmacy are underway.

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