Virtual Reality Use in Health Care

Literature Review

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(1) Introduction

VA Immersive, an initiative within the Veterans Health Administration's (VHA) Office of Healthcare Innovation and Learning, is defining a new reality for health care delivery and experience through championing the use of immersive technology across the Department of Veterans Affairs (VA). This sphere of technology, which includes augmented reality (AR) and virtual reality (VR), offers Veterans an engaging, non-pharmaceutical approach to a host of acute and chronic conditions such as pain, anxiety, depression, and post-traumatic stress disorder (PTSD) among others. Virtual environments can also create positive distractions, teach new skills, provide objective assessments, guide rehabilitation, and improve overall health and wellness.

VA Immersive seeks to review existing and in-progress academic studies surrounding VR use in health care settings to understand outcomes, both in terms of clinical application and user-experience for patients and Veterans. For this literature review, VA Immersive identified multiple topics of interest and defined the following questions to answer through analysis of published literature and studies:

Research Questions

- What are the benefits of VR in health care?
- What are the risks and/or barriers of using VR in health care?

Discussion Topics

- VR Use in Health Care
- VR Use for Rehabilitation
- VR Use for Mental Health
- VR Use for Peer Support
- VR Use for Pulmonary Rehabilitation
- VR Use for Clinical Education
- VR Use for Training
- VR Use for Patient Education
- VR Use for Palliative Care

(2) Research Methods

To conduct the literature review, VA Immersive utilized academic studies and data from 2004 to 2023 collected through PubMed, ScienceDirect, and Google Scholar. VA Immersive utilized one hundred and forty-two academic papers and articles in this review.

Key words used to search included

- Virtual Reality in Health Care
- Virtual Reality Rehabilitation
- Virtual Reality Physical Therapy
- "Pulmonary Rehabilitation" AND "Virtual Reality"
- Benefits and Challenges of VR in Training and Education
- Augmented Reality AND "Patient Education"
- Virtual Reality Mental Health
- Virtual Reality Exposure Therapy
- Virtual Reality for Medical Training
- Disadvantages to Virtual Reality Health Care
- "Respiratory Rehabilitation" AND "Virtual Reality"
- "Veterans" AND "COPD
- "Palliative Care" AND "Virtual Reality"
- Virtual Reality for Medical Education
- "Virtual Reality" AND "Peer Support"
- "Virtual Reality" AND "Support Groups"
- Peer Support Search Terms
- Virtual Reality Simulation for Medical Students
- "Virtual Reality" AND "Patient Education"
- Benefits of Virtual Reality Health Care

(3) VR Use in Health Care

VR solutions allow both health care professionals and patients to interact with simulated environments tailored for the use case or patient condition. In 1997, the first documented use case of VR for health care was to treat soldiers with PTSD.[1] While VR in health care is not new, the technology used for treatment has improved and expanded its capabilities over the last 26 years. VR use cases span health care indications including common indications such as anxiety disorders, pain management, rehabilitation, peer support, stroke recovery, and PTSD. Additionally, some health care practitioners are leveraging VR to increase patient treatment capacity and quickly identify, diagnose, teach about, and treat health conditions.[2]

Market research into industry trends shows health care is among the top three industries that will remain leading adopters of VR technology through 2025.[3] The key drivers of the growing VR adoption in health care include:

- Extreme demand for quality health care services
- A need to reduce health care costs
- The increased role of connected devices in health care

3.1 Benefits

Health care systems, clinicians, and staff have implemented VR solutions for a wide range of use cases across patient care and clinician/staff training. As use cases grow, those implementing programs continue to assess benefits related to cost and quality of care. Key benefits of VR currently seen across the health care industry, non-specific to conditions or use cases, by patients and health care systems include the following:

Customization: Virtual environments can be tailored to individual patients, including customizations that may be relevant to the patient's condition, or designing a specific, patient-relevant environment.[4] In some cases, the clinician utilizing the VR experience with the patient may have complete control of the stimuli provided to the patient.

Adaptability: Due to its highly customizable nature, VR may be effectively used for a wide range of needs in a health care setting for patients, clinicians, and staff.[5] Any individual within an organization can use and integrate VR into workflows including patient care, education, behavior change, process enhancement, and more.

Ability to Provide a Safe Environment: VR treatment allows patients to remain in safe conditions under the supervision of clinicians. The experience may be easily discontinued if a patient is uncomfortable or is having a negative experience.[5]

Increased Availability of VR Software and Hardware: Health care systems have an increasing number of options for VR software and hardware, and it is possible to reduce software development costs by using ready-made VR software development kits and game engines.[5]

Declining Cost of VR Hardware: VR hardware is becoming more affordable with time and continued investment and as more companies are developing headsets and related devices and content.[6]

Health Care Training: VR allows health care professionals to engage in immersive simulations, enhancing real-world scenarios with guided experiences. This bridges the gap between conventional classroom learning and hands-on clinical practice. VR simulations enable professionals to hone existing skills and acquire new ones to improve patient consultations and education, enhance preparation via treatment planning and trial runs, asynchronously practice skills, and gain insights into patients' experiences by simulating health care conditions and real-life situations.[7]

Learning Tool: Using VR for training can accelerate learning and be more effective than traditional learning methods. According to a study by PwC, learners completed VR training on average four times faster than classroom training and 1.5 times faster than e-learning, while showing up to 275% more confidence and up to four times more focus. Additionally, VR learners were 3.75 times more emotionally connected to the content than classroom learners and 2.3 times more connected than e-learners. Furthermore, VR learning was estimated to be more cost-effective when delivered at scale.[8] VR simulation serves as a vital tool for fostering greater understanding, empathy, and proficiency among health care professionals.[9]

3.2 Barriers

As with any innovation, barriers exist and should be acknowledged and addressed to determine the best path forward to mitigate risks to Veterans and program success. Overarching barriers of VR use in health care, non-specific to conditions or use cases, to patients and health care systems include:

Reduced Face-to-Face Communications: Exclusively utilizing remote VR experiences with minimal face-to-face communication may reduce the relationship between the clinician and patient. Mitigations include ensuring the patient receives face-to-face (either virtually or in person) contact from the clinician to evaluate the patient and ensure VR and overall health care delivery effectiveness.[10]

Education and Training: Implementing new technology into existing processes creates the need to develop trainings and operating procedures for end users (patients, clinicians, staff, etc.) to ensure that the VR program is effectively deployed and utilized.[9]

User Willingness to Adopt: Some patients and providers may be reluctant to use immersive technologies like VR.[9]

VR Experiences Lacking User-Centered Design: Lack of end user considerations and acceptance may lead to resistance. This may arise from experiences designed based on technology-oriented approaches that are more difficult to learn and use. The end-user should be included in the design and development phases.[9]

Lack of Extensive Evaluation and Use History: When designing, developing, and implementing new modalities and experiences, deriving and synthesizing evidence is foundational. As VR becomes increasingly present in health care, the evidence base must continue to grow. Current evidence is often considered nascent due to lack of robust randomized controlled trials for specific indications or populations.[5]

Side Effects: Some studies indicate simulation sickness, also called cybersickness, is at times a limiting factor for implementation of VR in health care. This is an ongoing area of focus and evaluation in the broader VR community, and ongoing improvements in technology and design are the best approach to increase the usability for the broader populace.[4] Extended participation may lead to undesired physical symptoms such as eye strain, dizziness, and ataxia. Limiting time spent using VR to 20 to 30-minute sessions is a potential mitigating action.

3.3 Veteran Demand/Need

The data below shows the scale of Veteran need for effective immersive technology treatment and education programs. VR, supported by the literature and studies in the sections below, is shown to be an effective solution for providing patients with a near-real life situation or environment to improve the quality of their health care delivery and experience. VR is a powerful tool that can enhance patient experience, increase positive patient outcomes, and further VHA's strategic efforts to connect Veterans to the best and soonest care.

Rehabilitation

In 2019, physical therapists treated over 761,430 unique patients within VA, accounting for approximately 2.8 million total encounters.[11] While there are limited published studies demonstrating reported outcomes for VR rehabilitation (VRR), existing programs have shown effectiveness and patient satisfaction with VRR. VRR is vital in connecting Veterans to needed health care services, as it provides an opportunity for patients to participate in rehabilitation from the comfort of their own environment. For example, a Veteran who has a physical disability may experience many challenges leaving their home to present for their rehabilitation appointment. VR closes this gap in access by providing an option for in-home services. Additionally, a 2021 non-VA pilot study asked participants in a VRR program to rate their experience using the VR Physical therapy module on a scale from 0-10 with 0 being anchored as "I hated it" and 10 being anchored as "I loved it." The average rating was 7.5. Patients rated the acceptability of VR physical therapy as a 3.9 out of 5, the feasibility as a 4.0 out of 5 and the usability as a 67.5 out of 100.[12]

Mental Health

Providing Veterans with access to necessary and appropriate mental health care supports Veterans and enables VA to prevent Veteran suicide. One study, conducted in 2022, suggests over half of Veterans with a mental health diagnosis did not receive mental health care.[13] Reasons for non-utilization of therapy-related services vary; however, studies show that VR-based therapy provides an avenue to close gaps for Veterans not receiving necessary and appropriate services. VR can provide Veterans with customized, immersive experiences to support their mental health. Mental health can be negatively impacted by a variety of stressors, particularly for those transitioning from military to civilian life. Studies have found that a significant number of Veterans, between 44 to 72%, experience high levels of stress during this transition, regardless of whether they have PTSD. This stress has been linked to both treatment-seeking behavior and the subsequent development of mental health issues, including suicidal ideation.[14] As shown in the studies below (Section 5), VR-based exposure therapy (VRET) has been a successful VR model of care delivery for individuals diagnosed with mental health disorders. Integrating VR into a range of treatment plans could be a helpful approach to ensure that other important aspects of Veterans' mental health are not overlooked.

Peer Support

Data shows that approximately half of those who recently left military service may not immediately connect with available resources, benefits, and services. Without support, more complex behavioral health concerns might emerge. In 2020, approximately 5.2 million Veterans experienced a behavioral health condition. Additionally, more than 90% of those experiencing a substance use disorder did not receive treatment.[11] Peer support groups and peer-based group therapy have proven to be effective in providing individuals with a positive environment to engage with other individuals who experience similar chronic illnesses/disorders. Peer support environments provide an opportunity for patients to engage in non-clinical, non-expert conversations to discuss shared experiences for support. The data below suggests that Veterans may be suffering in silence and that barriers to care (including stigma, social anxieties and physical limitations) exist.[15] As shown in the subsequently mentioned studies (Section 6), VR peer support groups provide a setting for participants to have open, honest conversations and self-reports from study participants demonstrate that participants feel present and engaged during VR peer support sessions.

Pulmonary Rehabilitation

Lung diseases and chronic respiratory problems, particularly chronic obstructive pulmonary disease (COPD), are leading causes of death worldwide. [16] In the U.S., COPD is more prevalent among Veterans than the general civilian population largely due to Veterans' increased exposure to hazardous conditions and significantly higher rates of tobacco use.[17] In addition to general risk factors, Veterans living in rural areas—nearly a quarter of the total Veteran population—are at an even higher risk of developing and dying from COPD. Additionally, the aftermath of the COVID-19 pandemic has triggered a rising need for rehabilitation services for 'long COVID' patients, challenging the already strained capacity of existing pulmonary rehabilitation services. Such challenges underscore the pressing need for innovative solutions to health care delivery for this population.[18]

Clinical Education

Medical and clinical education is the foundation for building strong practices among providers and for facilitating quality care delivery. There has been a significant increase in the number of schools utilizing VR simulation for their medical programs to enhance learning and understanding. For example, NYU's course, *Our Living Anatomy*, provides students with the opportunity to engage with virtual and photorealistic scanned cadavers through VR/AR exercises.[19] This allows students to deepen their understanding of the human body while reducing risk to Veterans since they do not need to interact directly with human subjects. VR technology also provides an opportunity to enhance communication and interpersonal skills with Veterans. Often, Veterans suffer with debilitating and chronic conditions that may be hard to understand unless directly experienced. MPathic-VR, a VR education platform, is proving to be effective in helping students gain necessary empathy and communication skills.[20] It allows students to practice communication and experience simulated disease symptoms to deepen empathy among Veterans, which will ultimately enhance quality of care.[20]

Clinical Training

Initial and on-going training for medical providers is vital in ensuring quality care is continuously delivered to our Veterans. VR training provides an opportunity for trainees to engage with content in virtually any setting, at any time, and often at a reduced cost when compared to traditional training methods. Standardization is important when training providers to ensure that care delivery for our Veterans is uniform, consistent, and effective. VR technology creates a standardized learning environment on-demand which is almost near impossible to achieve in traditional training models.[21] Training frequently happens in facilities where situations may be impossible to replicate, or time-constraints may impede learning. Additionally, evidence also supports that VR technology is beneficial to assess and enhance medical providers' competencies as well.[22] On-going training is vital to ensure providers are delivering the latest and best care to our Veterans to ensure their health, safety, and well-being.

Patient Education

Patient education helps improve patient health care outcomes through enhancing patient health literacy, increasing treatment adherence, and reducing stress and anxiety. VR education provides a platform for patients to interact with an immersive environment, as it relates to their illness or treatment, to enhance knowledge and desensitize patients to their treatment plan. Patient education and clear communication from the provider can increase satisfaction, compliance, and result in positive health outcomes.[23] Providers delivering information through VR education increases retention of the information delivered. Additionally, patients who receive effective patient education are more likely to have an increased understanding of medical information and a greater sense of empowerment.[23] Additional research is needed to validate the applicability of VR education for patients; however, pilot studies have shown promising results for the future of VR use in enhancing patient health outcomes and experiences.

Palliative Care

The World Health Organization (WHO) estimates 56.8 million people require palliative care annually and these patients tend to experience very similar symptoms, like pain, fatigue, lack of energy, loss of appetite, and nervousness. [24] The use of VR in adult palliative care is emerging, and studies are showing great promise of its use as a part of a holistic approach. [25] The onset of the COVID pandemic highlighted a need when patients were dying in isolation, and VR was used to facilitate interactions between patients and families. [26] VR interventions are generally intended to reduce depression and anxiety as well as manage pain and other symptoms. There are various methods of use in palliative care, from giving people virtual bike rides [27] to creating a virtual environment of the patient's home. [28]

(4) VR Use for Rehabilitation

VRR is the application of VR programs in which patients practice behaviors while interacting with the simulation of an environment that imitates a physical presence in real or imagined worlds.[29] VRR can be conducted in a clinical setting or at home and encompasses modalities such as physical therapy and pain management. VRR shows promise for patient care because it presents patients with an immersive, engaging approach to accomplish the goal of improvement in performance.[12]

The following sections provide a summary of VR applications in rehabilitation, including a concise overview of the associated advantages and barriers. Included in the review of benefits are the results of a meta-analysis and literature review of VRR, referencing twenty-seven validated studies and 128 publications to aggregate data in order to understand VRR outcomes.

Additionally, eleven distinct clinical trials, analysis of multiple clinical trials, pilot studies, or qualitative analyses are detailed in Table 1 (Appendix A). Upon analysis, eight of these studies demonstrate positive outcomes for patients, highlighting the benefits and improvements associated with VR usage for rehabilitation. Of the two studies focused on provider feedback, both found that providers believed VRR is a positive addition to patient rehabilitation. One study, focused on patients with peripheral, central, or mixed vestibular disorders, revealed no significant differences when comparing VR interventions to traditional treatments. Notably, none of the studies reported negative outcomes, indicating that VR usage does not lead to detrimental effects or a lack of significant improvement for patients. Limitations in the analysis of studies and literature include minimal published studies and small patient sample sizes.

4.1 Benefits of VR Use for Rehabilitation

VR has emerged as a promising tool for addressing patient rehabilitation, offering both unique benefits when compared with traditional rehabilitation programs and potential challenges to implementation and for patients. By providing immersive experiences tailored to patients' specific rehabilitation needs, VR has the potential to enhance rehabilitation use cases. Additionally, the data collection capabilities that VR offers in rehabilitation programs allows for patients' progress to be collected and analyzed by clinicians in real-time and offers objective reporting metrics not previously available through traditional methods.

Increased Engagement: Patients often perceive VR programs as more enjoyable than traditional programs. Through integration of VR into the care pathway, gamification and interactive environments may lead patients to enjoy and engage with their experiences, increasing motivation to complete program.[15]

Improved Patient Outcomes: One study analyzed over 27 validated studies and 128 publications to compare patient outcomes in VRR versus traditional rehabilitation programs. The study concluded that patients in VR programs improved their physical abilities 0.397 standard deviations above comparison groups. Additionally, VRR that focused on gait and strength abilities demonstrated the largest improvement compared to traditional programs; VRR that focused on motor control abilities and balance demonstrated positive results but were marginally more effective than traditional programs; and VRR that focused on balance had similar outcomes to traditional methods.[15]

Increased Accessibility: Between 50% and 70% of patients who would benefit from rehabilitation programs do not receive therapy due to access barriers such as travel, time away from work or caregiver duties, or limited access in rural areas.[30] These barriers are particularly salient for individuals with low socioeconomic status or lack of health insurance. This population is overrepresented among patients with unmet physical therapy needs and who are at highest risk for poor functional and pain-related outcomes. The introduction of VRR for use in-home can reduce access burdens on patients.

Scalability of Remote Programs: For in-home VRR, instruction and safety monitoring can be executed independent of a therapist, providing the opportunity to distribute the same intervention to more patients. In-home VRR allows providers more time and resources to focus on patients with more intensive rehabilitation needs.[12]

Cost Savings for Patients: In-home VRR options for patients presents cost savings opportunities through reducing costs associated with travel and time off work for appointments.[12]

Cost Savings for Providers: High costs associated with supervised in-office rehabilitation programs, including cost of space and staff needed for sessions, can be reduced through the introduction of at-home VRR.[12]

Enhanced Data Collection: VR systems have the capability to collect quantitative data on system utilization/compliance with prescribed rehabilitation protocol, accuracy of performing exercises, and sequential data monitoring of progression toward achieving rehabilitation goals using motion and pressure sensors. Data can be transmitted cumulatively and in real-time to both patients and care providers. As of 2021, objective reporting regarding compliance with prescribed rehabilitation and objective measures of progress in functional improvement are extremely limited.[12]

Data-Driven Decision Making: Data collected through VR platforms can help clinicians evaluate which exercises are most effective in achieving specific goals and define the progress of highly compliant and motivated patients versus less motivated or compliant patients. For patients receiving VRR in-home, remote data collection enables providers to identify which patients derive benefit from or struggle with a remote intervention, prompting referral for tailored, in-person care if indicated.[12]

Standardization of Care: VRR enables clinicians to provide standardized rehabilitation protocols, controlled stimulus presentations and objective clinical progress and performance measures.[31]

Pain Management: VR interventions to educate patients pre- and post- surgery have demonstrated effectiveness in reducing pre-operative anxiety and post-operative overall and sensory pain in patients.[32,33] VR therapy may reduce pain-related anxiety, shorten the time patients think about pain, and alleviate acute and chronic pain. VR introduces a non-pharmacological modality to help patients manage pain.[34]

4.2 Barriers of VR Use for Rehabilitation

Safety Issues: In VR platforms, the completely immersive environment for patients wearing the VR headset to complete rehabilitation sessions does not allow patients to see their real environment, such as furniture, introducing the potential for injury. This disadvantage is primarily associated with in-home or unsupervised use and may be mitigated through non-clinical supervision or the utilization of a less fully immersive modality like augmented reality to allow users more awareness of their physical surroundings.[35]

Perception in VR vs. Real Life: An experience in a VR world vs. real life is slightly different in terms of timing and the motions needed to achieve a goal (e.g., picking up a glass). Distance perception in a VR platform can alter patients' reaction time in VR situations when compared to real world situations.[36]

Cybersickness: Cybersickness is a kind of motion sickness that may be experienced by people in VR environments. It may be characterized by discomfort, fatigue, nausea, and/or disorientation and arises from the discrepancy between a more vigorous motion perceived by vision and hearing and a weaker motion perceived by the vestibular system and proprioception. The frequency and severity of cybersickness depends on the device (head-mounted display (HMD) vs. non-wearable displays), the type of tasks (e.g., walking vs. driving), and the individual themselves.[35]

Computer Vision Syndrome: VR may induce eyestrain-related issues such as eye fatigue and discomfort, dryness and redness, and reduced visual acuity, which falls under computer vision syndrome. These findings are more frequent when using HMDs, but this depends on the given display characteristics and length of time in the experience.[35]

Accurate Cost-Benefit Analysis: Definitive cost-benefit analysis is still missing, and although the cost of VR devices has dropped significantly, the software and hardware management required is still demanding with regard to customizable VR experiences. The comprehensive application of VRR is foreseeable due to the increasing availability of low-cost VR devices and the possibility of personalizing

VR settings and delivering VR in-home; this actively contributes to reducing health care costs and improving rehabilitation outcomes through tailored rehabilitation at a distance.[35]

(5) VR Use for Mental Health

VR has become an important tool for mental health care, particularly in exposure-based therapies that allow patients to safely confront feared situations within a safe and controlled environment. It has proven effective in treating a variety of mental health disorders, including PTSD, schizophrenia, and anxiety disorders.[43] While the methodological quality of studies varies, VR's capacity to recreate real-world environments is harnessed to target exposure therapy mechanisms. Notably, one open clinical trial involving Veterans showed that 80% of treatment completers in a VRET sample experienced significant reductions in PTSD, anxiety and depression symptoms with improvements in their daily lives, which persisted at the three-month follow-up.[44] With the increasing need for PTSD-effective treatment among military members and Veterans, VR-aided therapy can enhance treatment quality and capacity, addressing invisible war wounds and fostering improved societal health and military readiness.[45]

The following provides a comprehensive summary of VR applications in mental health, including a concise overview of the associated advantages and barriers. Additionally, studies featuring 24 distinct clinical trials or therapies are detailed in Table 2 (Appendix B). Upon analysis, 22 of these studies demonstrate positive outcomes, highlighting the benefits and improvements associated with VR usage in mental health treatment. Three neutral studies (including one that also had positive results) reveal no significant differences or mixed results when comparing VR interventions to other treatments. Notably, none of the studies report negative outcomes, indicating that VR usage does not lead to detrimental effects or a lack of significant improvement in mental health treatment.

5.1 Benefits of VR Use for Mental Health

VR has emerged as a promising tool for addressing mental health issues in various populations, including Veterans, offering both unique benefits and potential challenges. By providing immersive and customizable experiences, VR has the potential to streamline, standardize, and revolutionize mental health care for Veterans, while also posing certain risks and limitations to consider for effective implementation.

Cost-Effective: Relative to other evidence-based practices, VR exposure therapy (VRET) can be more cost-effective. By comparison, VRET was 28.6% less expensive than the three-week intensive therapy protocol at University of Central Florida's nonprofit clinical research center and treatment clinic.[43]

Increased Patient Engagement: VR can make therapy more engaging, meaningful, and interactive, which may encourage patients to be more invested in their treatment. Enjoyable methods have substantial appeal over traditional assessments.[46] In a particular study, 93.8% of health care providers reported that VR more effectively facilitated patient progress in treatment when compared to other methods, primarily due to its capacity to enhance patient engagement.[47]

Reduced Stigma: VR therapy can be conducted in private settings, which may help reduce the stigma patients associate with seeking mental health care.[48]

Potential to Reduce Patient Dropout Rates: Leveraging VR experiences for indications such as PTSD may contribute to a reduction in dropout rates. While normal exposure treatment programs average a 28% dropout rate, in one Intensive Outpatient Program (IOP) using VR, the dropout rate was 2%, with a 1% relapse rate at six months post-treatment.[43]

Realistic Simulations for Treatment: VR can be particularly useful in treating phobias, anxiety disorders, and PTSD through gradual and controlled exposure to the source of distress. By creating virtual environments, individuals can engage in visual, auditory, and sometimes tactile cues, leading to emotional experiences that can induce physiological changes consistent with emotional responses observed in real-world scenarios.[46] This advantage is crucial in providing accurate assessments and simulating daily life experiences for patients, allowing patients to work through stressful situations in a controlled environment.[46]

Customization: Programs can be modified to match individual needs, abilities, preferences, and pace, ensuring a more personalized experience.[46] One study showed 87.5% of health care providers believe individualized VR treatment was a major factor in helping patients progress in treatment.[45]

5.2 Barriers of VR Use for Mental Health

Cybersickness: Some patients may experience symptoms like nausea, dizziness, or discomfort while using VR (dry eyes, eye fatigue, headaches, sweating), which could limit its acceptability.[49,50]

Preoccupation and Addiction: Patients may become preoccupied or consumed by the VR environment, similar to internet game addiction. If patients with schizophrenia have impairment on reality testing, they may have delusional thinking in the VR environment.[48]

Limitations in Technology: Current VR technology may not perfectly replicate real-life experiences, which could impact effectiveness or generalizability to real-life situations.[46]

In-depth Training and Practice Prior to Clinical Use: Ensuring the ability to effectively troubleshoot glitches or malfunctions while maintaining competent clinical care is a potential disadvantage.[47] Although a potential disadvantage, one study showed a majority (58.8%) of surveyed health care providers did not find transitioning to VR for clinical treatment difficult, while 36.3% cited cost as the most common barrier.[45]

(6) VR Use for Peer Support

Peer support is a valuable approach that provides individuals with the opportunity to connect with others who have shared experiences. Benefits of peer support and group-based therapeutic interventions include cohesiveness, imitative behavior, interpersonal learning, and validation among peers.[72] Although peer support groups have proven to be effective in providing individuals with an opportunity to give and receive non-clinical, non-professional advice and shared experiences to other individuals with similar afflictions, these formats often yield low return rates among attendees. For example, one study highlighted that roughly 40% of patients with depression do not attend or dropout of group treatment due to reasons such as inaccessibility of the meeting (e.g., time and location) and patients feeling socially anxious in a group setting.[73]

VR has shown to be promising for providing opportunities for peers with shared experiences to connect in a virtual setting while still capturing the feel of in-person support. While research on the efficacy and fidelity of VR support groups continues to grow, preliminary studies highlight use of VR in group therapy settings (both adolescent and adult), chronic condition support groups (e.g., substance use disorder), and related support groups (e.g., alcoholics anonymous and narcotics anonymous). Although gaps exist in research on VR use in peer-support environments, several organizations have incorporated VR-based support groups into their care delivery models. For example, Yale School of Medicine researchers are conducting a pilot study where cancer patients can attend VR support groups and share their experiences in a safe and accessible setting.[74] The following summary highlights the use of VR in peer support as well as an overview on associated advantages and barriers. Additionally, studies featuring six distinct clinical trials or therapies are detailed in Table 3 (Appendix C), and organizations hosting VR support groups are listed in Table 4 (Appendix D).

6.1 Benefits of VR Use for Peer Support

VR is a promising new application to provide individuals with an anonymous and in-person feel alternative for peer support groups. Peer support groups rely on peers with shared experiences but can be intimidating for individuals with social anxieties and may be hard to access. The information below describes the benefits of VR-based peer support groups and how integrating them into care delivery models can greatly benefit patients' health outcomes.

Provides Anonymity: VR-based support groups provide an opportunity for individuals to participate without having to share their actual identity. Avatars in VR platforms are generally customizable, so those operating the avatar can represent themselves however they wish. This provides a level of anonymity and encourages openness and willingness to share experiences.[75]

Facilitates Community Building and Reduces Isolation: One study noted that those who benefit the most from VR group-based therapies are those that struggle to leave their house (either due to physical disabilities or social anxiety), and VR peer support programs create a sense of community while lessening social anxiety, isolation, and loneliness.[13]

Reduces Location Barriers: VR peer support provides an opportunity for individuals to join from various locations, increasing participation, retention, and flexibility with participants schedules. One study found that the use of VR support groups decreases the chances of needing to travel to a group, reducing the risk of physical discomfort, social unease, and risk of infection (as many support groups are held in hospitals).[75] Additionally, VR groups provided an opportunity for individuals in more remote locations or with lack of transportation the opportunity to participate from their respective area.[76]

6.2 Barriers of VR Use for Peer Support

Cost: Some studies indicate the cost of VR support groups may be burdensome or expensive for providers and patients. One study found that the average cost of implementing each group therapy was $13,283, excluding the cost of the actual hardware.[13] The cost of the actual hardware (headset) can be costly as well which can be a financial barrier for those wishing to engage in VR support groups. However, VR is becoming more accessible and VR companies are creating solutions to cut the cost and increase access for VR support groups. For example, Innerworld, a VR platform, offers a peer-to-peer counseling community on a subscription basis that can be paid either yearly or monthly for a total cost of $199 and $30, respectively.[77]

Complexity of Technology: Users of VR require a level of competency when using VR technology to engage in support groups, especially when developing an avatar or navigating the virtual world or rooms. One study highlighted that, despite a thorough orientation course prior to use, users highlighted that a higher level of technology literacy is required to participate in this type of support platform.[76] Additionally, VR support groups require an internet connection/Wi-Fi which may decrease the number of participants within the group. Although the complexity of VR technology may not be inherent to users, this serves as an opportunity to develop training programs for use prior to participants engaging in VR support groups.

Limited Empirical Data: There is a gap in research conducted to measure the efficacy, fidelity, and positive/negative impacts with using VR to engage in various support groups. Although this gap exists, there are several organizations/universities currently conducting VR support groups. For example, the Adolescent and Young Adult (AYA) Oncology Clinic at Yale New Haven Hospital is conducting a pilot study/support group for cancer patients which has been yielding very promising results.[74] Innerworld is also conducting pilot launches of peer-to-peer support groups for individuals to engage with each other in a virtual, non-medical environment free from professional counseling directed at providing an opportunity for peer engagement in a non-judgmental manner.[77] Since launching this platform, Innerworld is in the process of conducting three randomized-control trial studies to highlight additional evidence related to the impact of immersive environments for peer support. Lastly, TRIPP, a VR-based wellness platform, is conducting a study to measure the effects of VR wellness tools with mobile-based recovery support. The study combined mindfulness-based VR experiences with a recovery community and certified peer recovery coaching.[78] This study sheds light on participant experiences and is being used to inform further a phase 2 trial examining the efficacy of this platform, which is currently in the planning stages.[78] Despite promising outlooks on the use of VR, more research highlighting the success and advantages of VR support groups will help support the intervention’s applicability in the field.

Inaccurate Representation in Virtual World: Users tended to opt for avatars that most closely represented their individual selves.[76] If a VR support group platform does not have an avatar that closely represents a patient’s outward appearance, this may cause adverse feelings for the patient and discourage them from participating again. Additionally, therapists were worried that if patients selected an avatar that was not a close representation of themselves, they could risk not treating the actual patient, which could prevent forming trusting relationships in the group.[73]

(7) VR Use for Pulmonary Rehabilitation

Emerging research underscores the potential of leveraging innovative technologies, such as VR, for improving pulmonary rehabilitation (PR) outcomes. Traditional methods, such as in-person sessions and group exercises, often pose barriers to Veterans undergoing treatment such as lack of transport, fatigue, and inconvenience.[86,87] Veterans with mobility or fatigue issues can find attending these sessions challenging. However, VR programs, adaptable to seated or low-intensity exercises, offer an accessible, comfortable, and engaging rehabilitation experience, especially for patients with severe COPD. These VR programs allow Veterans to maintain continuity of care even post-discharge from a medical center, an essential aspect of effective rehabilitation. This remotely supervised approach could not only help enhance compliance with pulmonary rehabilitation, but also serve as a viable alternative to traditional programs, offering a promising solution for both 'long COVID' patients and Veterans struggling with COPD. While promising, the exploration of immersive VR in pulmonary rehabilitation is still limited, and existing studies often suffer from small sample sizes.

The following offers a summary of the benefits and challenges associated with VR usage in pulmonary rehabilitation. Out of the six studies in Table 5 (Appendix E) that specifically involve immersive VR use in PR, each one yields positive results and reports minimal, if any, drawbacks. The benefits of VR in this domain highlight its capacity to provide engaging and effective rehabilitation experiences. However, these insights are based on a very limited volume of research. The challenges primarily revolve around the need for additional studies and the limited availability of content related to immersive virtual reality using head-mounted displays.[87] Overall, the existing evidence does accentuate the positive impact and untapped potential of VR in PR, while also acknowledging the need for further exploration and improvement.

7.1 Benefits of VR Use for Pulmonary Rehabilitation

Improved Patient Motivation and Engagement:[88] VR shows potential in improving patients' motivation and engagement, which can help maintain the benefits of rehabilitation over a longer period. Pulmonary rehabilitation programs often involve long-term, repetitive exercises and behavioral changes. Maintaining motivation and engagement is essential to ensure consistent participation in these programs. Patient motivation and engagement are closely tied to adherence to treatment plans. Patients who are motivated and engaged are more likely to stick to their rehabilitation program, take their medications as prescribed, and follow other recommended lifestyle modifications.

Potential for Improved Exercise Capacity: Patients undergoing PR through VR have reported increased strength, mobility, and flexibility, leading to less breathlessness, quicker recovery times, and enhanced cardiovascular fitness enabling longer walking durations.[89] Another semi-immersive virtual reality study showed a significant improvement in exercise capacity assessed before and after training, comparable to improvements typically seen in standard PR programs. [90] Additionally, patients report greater breath awareness, improved breathing control, and reduced anxiety allowing them to feel more confident in their ability to safely exercise. [91] According to a preprint systematic review, the promising application of incorporating gamification and immersive environments shows significant potential. While the majority of the studies are not fully immersive, VR approaches demonstrated significant benefits in increasing exercise capacity.[92]

Customizable for Patient Needs:[93] Providers may adapt VR systems for pulmonary rehabilitation for specific needs of COPD patients, providing an individualized approach to rehabilitation.

- Adaptive Difficulty Levels - VR systems allow for the customization of exercise difficulty, ensuring that the intensity of the workouts aligns with the individual patient's capacity and progression. This tailored approach ensures the patient's rehabilitation regimen is at an appropriate and safe level, which may help improve their adherence to the program.

- Incorporating Specific Rehab Protocols - VR systems can incorporate standard PR protocols, such as specific physical training exercises or teaching breathing techniques. By simulating these practices in a virtual environment, VR can provide patients with an individualized and interactive means of learning and implementing these protocols, potentially increasing their engagement and understanding.

Remote Rehabilitation:[93] With the need for effective home-based rehabilitation highlighted by the COVID-19 pandemic, VR offers a promising solution that can provide continuity of care without requiring patients to physically go to hospitals or clinical care facilities. PR in VR makes it easier for patients to consistently engage in their exercises, as they can perform them from home on their own schedule, removing barriers like transportation, scheduling conflicts, or feeling too ill to travel.

Real Time Monitoring:[88] VR systems can integrate real-time monitoring of patients' physical performance, using embedded sensors. This can provide immediate feedback and adjustments tailored to each patient's performance, ensuring a more personalized and efficient PR program. Real-time monitoring of patients' physiological data can also provide patients with a sense of security and reassurance, as further noted below.

Remote Supervision Capabilities for Patient Safety: VR use in PR offers remote supervision where patients' physiological data (HR and oxygen levels) are continuously tracked and monitored by health practitioners.[89] This real-time supervision alleviates patients' fears of exacerbation during at-home exercises, resulting in heightened feelings of security, increased confidence and enhanced self-management of their condition. It also helps patients avoid overexerting themselves and contributes to a more effective exercise routine.

Cost-Effective Solution:[89] Compared to previous PR methods, VR could provide a more cost-effective way to deliver PR to a vast majority of COPD patients nationwide.

7.2 Barriers of VR Use for Pulmonary Rehabilitation

Despite the existence of barriers, studies indicate that VR utilization can provide a positive and engaging rehabilitation experience for patients with pulmonary-related issues, carrying potential improvements in their physical capacity.

Lack of studies: Currently, there is a limited body of research, particularly on immersive VR in pulmonary rehabilitation. While emerging studies are encouraging, larger and more robust studies are necessary to validate and build upon these initial findings.

Limited Immersive Content: Much of existing research focuses on non-immersive VR platforms like Wii and Kinect, rather than fully immersive VR experiences.

Discomfort:[86] Depending on the type of VR headset, some patients may find that the weight of the head-mounted-device (HMD) is a source of discomfort, leading to dissatisfaction. Sweating induced by the headset can also be a negative aspect of the VR experience.

Needs for Technological Improvements:[89] Some programs could use technological improvements, including app stability, enhanced graphics (minor), and additional control features like fast-forward and pause buttons.

(8) VR Use for Clinical Education

The use of virtual reality has been gaining popularity among educators over the past few years. Educators use VR-based education due to its ability to engage a larger audience in a more practical and immersive manner. Technology enhances the way we communicate, research, and learn. VR technology provides an opportunity for students to learn in a more practical environment while reinforcing classroom learning. VR technology transforms medical education, as it provides a bridge between information from the classroom to a realistic environment, which is shown to be more effective than traditional methods and safe for students and patients alike.[96]

The following offers a summary of the benefits and challenges associated with VR usage in clinical education. Out of the seven studies in Table 6 (Appendix F) that specifically involve immersive VR use in clinical education, each one yields positive results and reports minimal, if any, drawbacks. The benefits of VR in this domain highlight its capacity to provide engaging and effective clinical experiences for students to apply their knowledge. However, these insights are based on a limited volume of research. The challenges primarily revolve around the need for additional empirical studies and the limited availability of content related to VR technology yielding greater knowledge and skills comprehension compared to traditional methods.[97]

8.1 Benefits of VR Use for Clinical Education

Application of Learning: VR technology allows medical students to apply their learning in the classroom to a virtual environment to enhance understanding and skills. For example, medical students devote time to understanding human physiology as it pertains to medical practice. Textbooks do not allow for hands-on learning and therefore can be limited in what they convey, and the traditional use of cadavers can have many barriers as well. VR allows students a more versatile experience than a cadaver by going from the skin layer, down to the bone and back again.[98] Learners have an opportunity to not only see the individual components of the human body, but also understand how they interact with each other and the relationships between the muscles, nerves and organs.[98] Many schools have begun implementing VR-based anatomy classes. For example, NYU offers a course, *Our Living Anatomy*, which includes photorealistic scanned cadavers and digital atlases, use of NYU's radiology record system, lectures from NYU Langone surgical faculty, three-dimensional printed structures and faculty creation of three-dimensional models and VR/AR exercises.[19]

Observation and Peer Interaction: VR technology can be used to educate both the student using the device and other students in the class. In a study by Muhling et al., while one student actively participated in the VR scenario, classmates watched from the first-person perspective on a monitor and were able to verbally assist in the scenario. While the active participants tended to receive more learning benefit from the experience than the observers, members of both groups reported benefiting from the experience. [99]

Social Skills: VR technology provides an opportunity for students to practice bedside manners and necessary communication skills when interacting with patients. Delivering news, whether good or bad, to patients is a vital skill set that is often not gained in the classroom. VR technology provides an opportunity for students to interact with virtual patients and receive feedback on how their words and body language were translated to deliver better care when in the field. One study, conducted by Kron et al. found that students who learned with MPathic-VR (a VR education platform for communication skills) showed significantly more improvement in their intercultural and interprofessional communication performance, as well as higher composite scores on the OSCE, than computer-based learning-trained students.[20] Additionally, students trained with MPathic-VR reported more positive attitudes, experiences, and valued the immediate feedback and teaching of nonverbal communication skills.[20]

Patient Experience and Empathy: Medical school education places a strong emphasis on understanding the human body, diagnosis, and treatment. However, an important factor in patient care is understanding the patient's experience, which is challenging to teach in a classroom. Patients may experience physical limitations due to their illness that the provider may not be able to empathize with having not experienced it themselves, outside of a textbook. VR technology provides an opportunity for students to understand their patient's experience. For example, Li et al. proposed introducing learners to realistic scenarios while operating under a simulation of having Parkinson's disease and having the learners complete specified tasks under the effects of a tremor.[100] This type of simulation can help medical students gain better perspective on a patient's experience with an illness or disease to enhance care delivery.

Increased Confidence and Self-Efficacy: Use of VR educational programs has also been shown to have a positive impact on the perceived competence of medical students. For example, studies have reported increased confidence in skills, such as performing CT scans, managing diabetic emergencies, treating sepsis patients, and making improvements to stroke management following VR experiences. Increases in self-efficacy have been reported in students who received VR educational programs regarding tracheostomy care skills and oral health care. [101]

8.2 Barriers of VR Use for Clinical Education

Limited Empirical Evidence: While many schools have begun implementing VR technology for education purposes, there still exists a gap in evidence showing the effectiveness of VR education. For example, Loue et al. proposed a novel idea for enhancing empathy among medical students, however, no evidence exists on the effectiveness of this type of simulation.[102] Although VR education is showing promising application in various medical schools, little evidence exists that highlights VR technology as more effective in delivering education when compared to current models. Additional research is needed to better understand if, and to what extent, skills learned in a virtual environment transfer to real-life functional settings and if it is more effective than current models.[97]

Realistic Virtual Patients and Interactions: Despite advancements in technology and AI processing, avatars in VR still lack some common and key human characteristics, such as nonverbal cues. This creates a challenge when training medical students to deliver medical news or enhance empathy. There are many complexities of language processing and facial expressions, which may be best represented by a human patient, rather than virtual.[21] Additionally, high-fidelity simulators (full body automated avatars designed to provide realistic tactile, auditory and visual stimuli) currently exist and facilitate students with learning hands on application.[100] However, these simulations often lack emotional relay during interactions. Further research is needed to understand how students can learn social skills through VR as well.

(9) VR Use for Training

VR-based training is used as an effective and efficient avenue for equipping providers (both aspiring and current) with necessary tools and skills to prepare them for the field. VR technology has transformed medical education by providing students and providers with an avenue to practice their skills in a realistic environment and learn from their first-hand experience. One study conducted by Zhao et al. found that VR improved post-intervention anatomy test scores when compared with other types of teaching methods.[104] Similar to most training, standardization is key to ensure learners receive the same information to equip them for practice. Practical and skill-based training can often yield non-uniformed delivery of information as they rely on the trainer to provide the education based on their skillset and knowledge. VR technology facilitates a standardized learning environment in a cost effective manner that can be delivered on-demand with few necessary resources.[21] In addition to a number of studies highlighting the success of VR training for medical studies and providers to learn and engage with new techniques, evidence also supports that VR technology is beneficial to assess and enhance medical providers competencies as well.[22] Although plenty of studies show VR technology is an effective training method, it is still emerging, and additional research is needed to assess barriers and gaps that may exist.

The following offers a summary of the benefits and challenges associated with VR usage in training. Out of the six studies in Table 7 (Appendix G) that specifically involve immersive VR use in training, each one yields positive results and reports minimal, if any, drawbacks. The benefits of VR in this domain highlight its capacity to provide practical and skill-based training necessary for medical providers. However, these insights are based on a very limited volume of research. The challenges primarily revolve around the need for additional studies highlighting the improved learning and benefits for VR training compared to traditional training methods.

9.1 Benefits of VR Use for Training

Clinical Experience: VR training offers providers the opportunity to experience virtual situations within the clinical context without having to be physically on site at a facility. VR provides an opportunity to customize various scenarios. It can create dangerous or difficult situations that are hard to recreate in real life or occur too infrequently to allow sufficient practice and experience.[109,110]

Safety while practicing and decreased risk to patients: Typical training for providers requires skills practice on actual patients, while VR technology allows providers to train in a near-real environment with no patient involvement. For example, Lin et al. identified that bone surgery, for example, requires a high level of experience and ability to perceive the necessary amount of force. VR training and tactical surgery with feedback can be a safe, repeatable, and cost-effective method comparatively.[111]

Flexibility: Providers and medical students have busy schedules with various responsibilities, and VR technology allows both groups to access a clinical learning environment at any time.[21] VR technology creates an opportunity for learners to pick up a head set and engage with a training in nearly any environment. Allowing flexible training options for providers helps to ensure they are acquiring the necessary skills and knowledge while reducing schedule constraint-related stress.

Resource Utilization: VR technology training requires significantly less resources than traditional training and education models. This relieves facilities of the cost, time, and space burden often associated with training providers in the medical field.

- *Cost Effective:* VR technology can often yield high upfront costs considering the average price of a VR headset, associated software, and laptop. However, one study conducted by Farra et al., found that although the upfront cost associated with VR training is comparatively more than the upfront cost of traditional training modalities, the initial investment of VR training is spread across a significantly higher number of trainees, yielding lower average cost per trainee.[108]
- *Free up physical space:* VR technology training can be engaged with in almost any environment. Medical training requires the learner to be on-site engaging with medical scenarios. Additionally, many medical centers will host training-based days or send providers to other locations to receive training which can place a financial burden and staffing-shortage at the facility. VR Technology eliminates this challenge and allows providers to engage with learning in any space.[21]
- *Free up faculty time:* Traditional training models require a faculty or attending physician to be present while delivering the education. The intended audience can independently operate VR technology. While there are special use cases which may dictate an additional physician or faculty member to be present, the requirement is far less when compared to traditional training models.[21]

Standardization: Standardization is vital to ensure providers are well equipped when faced with medical scenarios in the real world. In real world medical scenarios, practicing providers have to make quick and decisive calls that will either positively or negatively impact their patient. Additionally, medical scenarios vary, on multiple levels, from one patient to the next. Unlike real world medical scenarios, VR training scenarios are repeatable, which allows providers to learn more effectively and make mistakes safely to improve performance.[21]

Data Monitoring and Analysis: VR Technology training also has the potential to capture relevant data for providers engaging with the system. This can be effective when looking at practice skills among providers, encouraging engagement, and identifying performance gaps or barriers among staff to increase patient care and delivery.[21]

9.2 Barriers of VR Use for Training

Real-Time Feedback: Most VR technology headsets engage directly with the laptop they are connected to. This interface often lacks the ability to receive real-time feedback as each training session is individualized. Lack of real-time feedback may negatively impact the learner's experience and ability to gain necessary corrective considerations. Although some devices may lack this feedback loop, institutions who have implemented VR technology for training have been working to reduce the gap. For example, Massachusetts General Hospital has recently implemented the PrecisionOS system which allows the professor to see exactly what the trainee is seeing and doing, giving valuable insight.[112]

Limited Research: Although many studies have shown VR technology is an effective form of education for medical providers, gaps still exist in the evidence. This is still a relatively new model of training which contributes to the spaces in research available. Most evidence highlights VR technology effectiveness in surgical and psychomotor skills (i.e., anatomy and physiology, surgical techniques, virtual worlds, etc.).[105] Although these types of training are necessary for many providers, there is limited information on the use of VR technology for nonsurgical/psychomotor skills which are equally as important in the medical field.

Technology Literacy: Although technology has rapidly developed and become a key component in our society, there still exists a technology literacy gap between older and newer generations. A provider's unfamiliarity with technology can create a challenge when engaging with VR training. Those who are unfamiliar with technology may be reluctant to use VR training, which can negatively impact facility-wide patient care and full adoption of the training.[105]

Accessibility Issues: VR technology has been touted as a means for making training more accessible, but research has not examined how it may exclude certain types of learners, such as those with disabilities that may make VR education ineffective. [110]

(10) VR Use for Patient Education

Health care organizations continuously seek innovative technologies with the goal of encouraging patients to take an active role in managing their health. For example, many health care organizations adopted online portals to provide telecommunication with their providers.[118] Although patients are encouraged to take a more active role in their health, much of the information presented is complex, or delivered in a manner that is difficult for the patient to interpret, leading to poor adherence and health outcomes. There are many barriers that may impact a patient's understanding, including health literacy of the patient, the provider's ability to deliver complex information in a digestible manner, and stress and/or anxiety related to their treatment.[119] Considering barriers to treatment adherence and recent advances in technology, many organizations seek new avenues, such as VR education, to enhance patient care and experience with their providers.

Initial analysis of VR training and education highlights it to be an effective format for training providers. The effectiveness of VR training extends beyond provider training and can be a beneficial tool to facilitate patient education as well. Patient care is highly impacted by provider interaction and health care literacy, adherence, and maintenance. Through VR education, patients can develop valuable tools while enhancing their knowledge of their condition to increase their chances for successful health outcomes.

The following offers a summary of the benefits and challenges associated with VR usage in patient education. Out of the ten studies in Table 8 (Appendix H) that specifically involve immersive VR use in patient education, each one yields positive results and reports minimal, if any, drawbacks. The benefits of VR in this domain highlight its capacity to provide effective health care delivery and education experiences for patients to enhance their knowledge and interactions with providers and care. However, these insights are based on a limited volume of research. The challenges primarily revolve around the need for additional empirical studies and the limited availability of content related to VR technology yielding greater knowledge and comprehension compared to traditional methods.

10.1 Benefits of VR Use for Patient Education

Improved Health Literacy: VR education increases a patient's knowledge relative to their illness or chronic condition. Patients who understand their illness and treatment plan have improved health outcomes as well as a higher rate of treatment adherence. However, medical information is often complex, and patients can be easily confused or misunderstand the information being delivered. For example, one review found that 60% of patients misunderstood the information provided to them concerning their prescribed medication following a consultation.[120] VR has shown to help with cognitive recall and can enhance the patient's understanding when interacting with their provider concerning their treatment plan. In a study of patients with congenital heart disease (CHD) aimed at measuring experiences and perceptions using VR for their transition education, researchers found patients enjoyed using the platform and found it helpful with understanding their heart lesion and surgery.[121] This study highlights how VR can enhance understanding complex medical treatments while still being a positive interaction for the patient.

Treatment Adherence: VR education facilitates an interactive scenario for the patient to immerse themselves in specific to their illness. Additionally, VR interactions improve retention and recall in memory.[122] Research shows that learning through self-driven and interactive activities enhances retention of information.[120] Since VR immerses patients into an interactive environment, it has the potential to enhance deeper understanding of the information being delivered, ultimately increasing the chances for treatment adherence.

Stress and Anxiety Reduction: Patients may experience stress and anxiousness when interacting with their provider or comprehending their illness and treatment plan. One multi-study literature review on patients using VR for education found that 13 of the 18 studies reviewed highlighted that levels of anxiety, distress, and systolic blood pressure significantly decreased in the intervention groups, when compared to the control groups, in both pediatric and adult patients.[120] This reduction could be due to patients having an opportunity to interact with a virtual environment that mimics their reality and increased knowledge concerning their treatment plan, reducing the amount of unknowns. This can help alleviate secondary symptoms of patients who experience psychological distress when interacting with their provider and treatment plan.

10.2 Barriers of VR Use for Patient Education

Limited Research and Application: VR use for patient education within health care is relatively new and evolving. Most research shows promising application for the use of VR to enhance patient experience, however, more evidence-based intervention studies are needed to further understand the benefits and limitations. Given VR use for patient education is novel, additional research could help to expand its implementation in the health care field and enhance patient experience.

Lack of Validation: Of the studies that currently exist researching the applicability of VR/AR use in patient education, most, if not all, collect data for applicability analysis through asking patients to fill out a post-intervention survey. Additionally, these surveys are developed by the investigators themselves and often not validated or assessed within the study population.[120] Further research should be conducted to validate the questionnaires being used, and additional studies should focus less on self-reported data to highlight applicability. For example, future studies could focus on patient treatment plan retention as a measure opposed to self-report interaction data to highlight feasibility and care delivery enhancement. This could help enhance the use of VR/AR for patient education, as well as identify gaps and/or barriers.

(11) VR Use for Palliative Care

Various ways to offer VR are becoming more widespread in palliative care (PC) world-wide. While much of the research consists of survey data and case studies, there are meta-analyses, systematic reviews, and feasibility studies that show VR is a promising tool and popular with patients, families, and staff alike. This emerging evidence base mostly consists of small samples of adult cancer patients and other adult patients with advanced diseases, but there are some samples using adult patients with dementia, children, and adolescents.[128]

The following offers a summary of the benefits and challenges associated with VR usage in palliative care based on the most rigorous studies available at this time. Out of the 9 studies in Table 9 (Appendix I) that specifically involve the use of VR in palliative care, each one yields positive results and reports minimal adverse effects. The benefits of VR in this domain highlight its capacity to provide patients with an escape from pain as well as more positive emotional experiences. However, these insights are based on studies with less rigorous research methods. The challenges primarily revolve around the need for more randomized controlled trials as the trend continues. There are side effects of VR that need to be considered for patients, as well as a need to customize the technology according to patient needs.

11.1 Benefits of VR Use for Palliative Care

Feasibility: In a systematic review, Vasudevan et al. contend that VR in palliative care is feasible due to promising results of patient engagement and satisfaction as well as user willingness to try VR again after their initial use. [25] Burridge et al. mentioned the need for larger scale evaluation of feasibility. [129]

Cost Effectiveness: As mentioned previously, health care systems have an increasing number of options for VR software and hardware, and it is possible to reduce software development costs by using ready-made VR software development kits and game engines.[5] Headsets can be used for multiple people when cleaned appropriately, making them cheaper than relative medical treatments. [130] More studies reviewing cost effectiveness/cost implications need to be conducted. [128,129]

Simulations for Treatment: One study used a large screen TV that simulated a bike path [27] while another used one showing underwater sea exploration ("VR Blue"). [131] Others use avatars to reconstruct self and identity. [132] There are no rigorous studies comparing certain simulation environments, but Austin et al. compared the difference between 2D and 3D technology and found no difference in patient experience.[133]

Customization: Many studies discuss creating a safe space for patients based on different levels of mobility [25] while others are beginning to explore "personalization", meaning they tailor the VR experience to each patient based on a series of responses to an interview. [134] The latter study was a randomized controlled trial where those assigned to the control group were given a VR experience that was the same across participants (except the researchers asked if there were any phobias to avoid) were compared to the test group that received a personalized version of the VR experience. The authors found no significant difference in the two groups' experiences. Finally, some researchers combined the VR experience with a musical soundtrack selected by each patient in conjunction with a music therapist and received positive feedback, although there was not a control group for comparison. [130]

Emotional Well-Being: A meta-analysis of 5 studies found that VR demonstrated statistically significant improvements in depression and psychological well-being. [128] In a study where patients were assigned to a test group because of anxiety or pain (see pain reduction section below), there was a 40% reduction in anxiety in 28 patients. [129]

Facilitates Connection to Family/Reduces Isolation: Palliative cancer patients may require inpatient hospital care for medical reasons. In a systematic, integrative review of VR in palliative care, Carmont and McIlfatrick note that the progression of advanced disease and impending mortality can exacerbate disconnection through the onset of anticipatory grief, at a time when support and connection is arguably most vital. [135,136] Thus, Carmont and McIlfatrick conclude that VR can enhance connection between families, patients, and healthcare professionals.[135] VR can also provide an approximation to the individuals' home environment.[28]

Pain Reduction: Despite current standards of care, pain management in palliative care continues to be a symptom that is the most difficult to control compared to all other symptoms.[24,137] A systematic review of research by Canfield et al. contends that 9 articles found VR to be an effective intervention for reducing pain.[24] In a randomized controlled trial, Groninger et al. assigned participants to receive either a single 10-minute VR session (intervention) or a single 10-minute 2D guided imagery (active control). The authors found significant pain reduction during, immediately after, and one hour after the intervention. Both groups showed a decrease in pain scores, but the VR group showed a greater improvement that was statistically significant and persisted up to 24 hours post intervention. The research suggests that VR seems to be a feasible and effective tool for pain relief as an approach to total pain and symptom therapy.[138]

11.2 Barriers of VR Use for Palliative Care

Side Effects: Reports of headaches, dry eyes, and nausea, like in all environments utilizing VR, are rare but do happen. [137] Austin et al. mentions the relative lack of cybersickness as a support to warrant larger clinical studies.[133]

No Guidelines for Dosage in Literature: There is a large gap in the literature regarding dosage of VR according to a systematic review conducted by Martin et al.[139] Brungardt et al. in a pilot implementation study did discuss dosage in terms of length and frequency of VR sessions, although it was a small sample size. The researchers received feedback from patients that they would prefer to have options choosing their own frequency and length of session based on the time of day, how they are feeling, and the amount of hospital intervention received the day of VR participation.[130]

Uncomfortable/Cumbersome Equipment: Headphones and other equipment can be difficult to maneuver for palliative care patients. Four studies reported difficulties in using virtual reality, including difficulty wearing the headset at a comfortable position, difficulty making mouse movements, involuntary keyboard strokes, difficulties getting used to the button configuration of the remote controller, and not being able to see the image clearly.[128]

Gaps in Research: There are substantial gaps in research on the use of VR in palliative care. There have only been a couple of randomized controlled trials in the past few years, and most of the other research has not evaluated dosage of VR. The majority of studies are conducted from the patient's point of view, and there are few available that have been conducted from the families' and healthcare professionals'.[135] In order to better provide literature to propel the field, further research should determine the extent of VR efficacy among patients, families, and healthcare professionals in such settings.[135] Future research ought to include if and to what extent VR could reduce the necessity of pharmacological pain relief. [137] More research needs to be done to evaluate certain customizable options needed.[135]

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(13) Appendices

13.1 Appendix A

Table 1: Clinical trials and studies focused on VR use for rehabilitation

Author/Date	Subjects	Design	Method	Conclusion
Abbasnia et al., 2023[32]	Adult patients with cholecystitis (gallstones) pre- and post-operation (n=150)	Three-group pretest-posttest randomized clinical trial	The procedure of this randomized clinical trial was administered to three groups of patient education using VR, patient distraction using VR and a control group. The VR interventions in this study were provided in two phases: 1) 2 hours before the laparoscopic cholecystectomy (LC) and 2) 4 hours after receiving the first dose of analgesics after the LC.	VR approaches for patient education and distraction equally decreased pre-operative anxiety and post-operative pain in patients undergoing LC.
Baker et al., 2022[33]	70 studies (n=4105) on acute and chronic pain	Literature Review	Searched online databases PubMed, Web of Science, PsycInfo and CINAHL from 2010 to 2020 and included studies from peer reviewed journals that examined VR interventions for people with pain, (excluding pain-free participants) with a primary outcome measuring pain.	VR treatment groups showed significant improvements in pain, particularly for intensity of pain (72.1%) and quality of pain (75.0%).

Author/Date	Subjects	Design	Method	Conclusion
Brassel et al., 2022[37]	Speech-Language Pathologists (SLPs) (n=14)	Qualitative analysis	SLPs and VR specialists participated in focus groups to discuss participants perspectives related to ideas, barriers, and facilitators for VR implementation to manage cognitive-communication disorders (CCDs) post traumatic brain injury (TBI).	SLPs and VR specialists viewed VR as a positive, exciting tool that has potential for use in patient rehabilitation for CCDs following TBI. Participants viewed VR as a tool to supplement current practice to recreate naturalistic environments with an opportunity for increased practice and complexity to prepare patients for real-world interactions.
Greenhalgh et al., 2021[38]	Health Care providers (n=20)	Pilot study	Deployed a prototype protocol for health care providers to investigate usability of a VRR Instrumental Activities of Daily Living (iADL) protocol at the Air Force Research Laboratory for cognitive rehabilitation for Veterans with a TBI.	Health care providers had some concerns with vertigo-like symptoms from using digital technology, but believed the protocol would improve iADL functioning and was a good addition to pre-existing rehabilitation protocols.

Author/Date	Subjects	Design	Method	Conclusion
Huang et al., 2021[39]	31 randomized controlled trials	Review and meta-analysis of Randomized Control Trails	Randomized controlled trials that reported on VR for pain management were included.	VR groups had lower levels of anxiety, lower pain unpleasantness, lower pulse rate, shorter duration of dressing change, and less time spent thinking about pain. There was no statistical difference in pain tolerance. VR can effectively alleviate acute pain. In terms of chronic low back pain and cancer-related pain, there was no statistical difference between VR therapy and standard therapy.
Rawlins et al., 2021[34]	Veterans experiencing anxiety, acute and chronic pain (n=79)	Prospective, pretest-posttest mixed methods assessment	Patient VR experiences lasted between 10 and 30 minutes utilizing an immersive head-mounted display with multiple, autonomously chosen virtual environments. Qualitative data was collected concurrently to provide context to quantitative measures which included pain scores and stress/anxiety levels.	Results for the cohort demonstrated a statistically significant decrease in pain intensity ($p < 0.001$) with an average 12% decrease in pain levels and an 92% reduction in anxiety for those in concurrent pain.

Author/Date	Subjects	Design	Method	Conclusion
Reilly et al., 2021.[12]	Adult patients with operative fractures of the femur or tibia referred to physical therapy (n=15)	Pilot study	Patients enrolled in the VR physical therapy program and completed a pre- and post-program survey. Patients completed all PT sessions through the VR platform.	After having completed the VR-based PT program, 87% of patients reported that their preferred method of PT would be VR-based in-home PT with supplemental office-based PT, compared with either VR-based or office-based PT alone.
Chuan et al, 2020[40]	18 clinical studies using VR in adult patients for management of acute and chronic pain	Systematic narrative review	Studies investigated virtual reality use: intra-operatively; for labor analgesia; for wound dressing changes; and in multiple chronic pain conditions.	Twelve studies showed reduced pain scores in acute or chronic pain with virtual reality therapy, five studies showed no superiority to control treatment arms, and in one study, the virtual reality exposure group had a worsening of acute pain scores.
Feng et al., 2019[36]	Patients with Parkinson's Disease (PD) (n=28)	Single-blinded, randomized, controlled study	The experimental group (n=14) received VR training, and the control group (n=14) received conventional physical therapy.	The results of this study indicate that 12 weeks of VR rehabilitation resulted in a greater improvement in the balance and gait of individuals with PD when compared to conventional physical therapy.

Author/Date	Subjects	Design	Method	Conclusion
Alahmari et al., 2014 [41]	Patients with peripheral, central, or mixed vestibular disorders (n=38)	Controlled study	The experimental group (n=20) had six treatment sessions with Virtual Reality-Based Therapy, and the control group (n=18) had six treatment sessions with conventional treatment.	Individuals with vestibular disorders demonstrated significant improvements in self-report and performance measures for both interventions at one week and at six months after discharge. There was no difference between groups.
Shema et al., 2014[42]	Patients referred to gait training program for recurrent falls, fear of falling, complaints of gait instability, or recent deterioration of gait (n=60)	Retrospective data analysis	The current retrospective data analysis reviewed the medical records of the first 60 patients attending a gait rehabilitation program at the VR clinic in the Tel Aviv Sourasky Medical Center.	The findings in the current work demonstrate that an innovative VR gait training program can serve as a practical and effective clinical service whose aim is to enhance gait in a variety of patients with gait instability.

13.2 Appendix B

Table 2: Clinical trials and studies focused on VR use for mental health

Author/Date	Subjects	Design	Method	Conclusion
McCullough et al., 2023[51]	VA patients who used VR during outpatient, wide-awake hand surgery (n=22)	Observational	Evaluate an immersive VR program as a nonpharmacologic intervention to reduce anxiety and increase satisfaction in patients undergoing wide-awake, local-only hand surgery and to assess provider experience with the program.	Patients who used VR exhibited lower anxiety scores after the procedure compared with what they exhibited before and had high satisfaction levels with their VR experience. Surgeons who used the system reported that VR improved their ability to teach learners and better focus on the procedure.
Riva, 2022[52]	53 systematic/meta-analysis studies	Literature review	Two recent meta-reviews assessing more than 53 systematic reviews and meta-analyses	VR use in anxiety disorders, pain management, and eating and weight disorders, with long-term effects were proven. There was also proven support for the use of VR in the assessment and treatment of psychosis, addictions, and autism.

Author/Date	Subjects	Design	Method	Conclusion
Rawlins et al., 2021[34]	Veterans experiencing pain and anxiety (n=79)	Case control	VR 10-30 min, immersive headsets, various environments, qualitative context for pain scores and stress/anxiety levels, 79 participants pre/post-VR data	Cohort showed significant pain intensity decrease, 12% avg pain reduction, 92% anxiety reduction in concurrent pain. VR found to be an effective distraction, pleasurable, non-pharmacological options for Veterans.
Reger et al., 2019 [50]	Active-duty soldiers with PTSD (n=108)	Observation al	Randomization to exposure through 1 0 sessions of prolonged exposure or VRE or 5-week minimal attention waitlist	No group differences in average or peak subjective distress during exposure therapy.
Doniger et al., 2018[53]	Middle-aged adults with Alzheimer's disease family history (n=125)	Randomized Controlled Trial	VR cognitive-motor training, 45 min, twice/week for 12 weeks	VR patients demonstrated increased cognitive function.
Flores et al., 2018[54]	Two patients with spinal cord injury with psychiatric symptoms (n=2)	Case report	4 VR DBT sessions for patient 1, 2 VR DBT sessions for patient 2	Reductions in negative emotions for patient 1, mixed results for patient 2
Peskin et al., 2018[55]	Men and women with World Trade Center-related PTSD (n=25)	Randomized Controlled Trial	100 mg D-cycloserine versus placebo augmented VRE sessions for 12 weeks	Temporal relationship between posttraumatic and depressive symptoms during VRE

Author/Date	Subjects	Design	Method	Conclusion
Du Sert et al., 2018[56]	Schizophrenia patients with refractory AVH (n=19)	Randomized Controlled Trial	A 7-week phase-II, randomized, partial cross-over trial	Significant improvements in severity of auditory visual hallucination, depressive symptoms, and quality of life
Pot-Kolder et al., 2018[57]	Patients with a psychotic disorder and paranoid ideation (n=116)	Randomized Controlled Trial	VR-CBT with treatment as usual, 1 hour long, 16 individual sessions versus treatment as usual	Significant reduction in momentary paranoid ideation and anxiety
Gomez et al., 2017[58]	21-year-old Latino male patient with burn injury	Observation al	Immersive VR enhanced DBT mindfulness skills training, 4 sessions for 1 month	Increased positive emotions and decreased negative emotions
Beidel et al., 2018[59]	Veterans and active-duty soldiers with combat-related PTSD (n=92)	Randomized Controlled Trial	VRET plus group treatment versus VRET with psychoeducation control	Decrease on PTSD scale for both group and decrease in social isolation for VRET plus group treatment
Ferrer-Garcia et al., 2017[60]	Patients with bulimia nervosa and binge eating disorder (n=64)	Case control	Two second-level treatment condition: VR- Cue Exposure Therapy or additional CBT	More proportion of achievement abstinence from binge eating or purging episodes
Shiban et al., 2017[61]	29 patients with aviophobia	Randomized Controlled Trial	VRET treatment either with or without diaphragmatic breathing	Higher tendency to effectively overcome the fear of flying in VRET with diaphragmatic breathing
Bouchard et al., 2017[62]	Patients with social anxiety disorder (N = 59)	Randomized Controlled Trial	14 weekly sessions for VRET or in vivo exposure or waiting list	Improvement in both CBT groups, more effective in VRET

Author/Date	Subjects	Design	Method	Conclusion
Reger et al., 2019 [50]	Active-duty soldiers (n=162)	Randomized Controlled Trial	Randomization to 10 sessions of Prolonged exposure, VRET, or a minimal attention waitlist	Significant reductions in PTSD symptoms in Prolonged exposure and VRET groups
Norrholm et al., 2016[63]	Participants met criteria for PTSD (n=50)	Randomized Controlled Trial	6 weeks of VRET combined with d-cycloserine, alprazolam, or placebo	In the d-cycloserine group, elevated startle before VRE T predicted better outcome.
Son et al., 2015[64]	Alcohol dependent subjects (n=12)	Case control study	10 sessions of VRET, consisted of 3 steps: relaxation, presentation of a high-risk situation, and aversive situation	Decreased metabolism in the basal ganglia after VRET (PET shows)
Jahanishoorab et al., 2015[65]	Primiparous parturient women having labor (n=30)	Randomized Controlled Trial	Randomization to VR with standard care group and only standard care group	Decreased pain during the episiotomy repair when use of VR with local anesthesia
Rothbaum et al., 2014[66]	Iraq and Afghanistan war Veterans with PTSD (n=156)	Randomized Controlled Trial	An introductory session and five sessions of VRET augmented with d-cycloserine or alprazolam or placebo	Significantly improved PTSD symptoms from pre- to posttreatment across all conditions
Marco et al., 2013[67]	Participants diagnosed with eating disorders (n=34)	Case control study	15 CBT group sessions and 8 individual psychotherapy sessions with VR	Improved body image and this improvement was maintained at the one-year follow-up.
Diemer et al., 2013[68]	Patients with arachnophobia (n=58)	Randomized Controlled Trial	A single dose of quetiapine XR or placebo prior to a VR	Effect of VR challenge on behavioral avoidance, psychophysiological reaction

Author/Date	Subjects	Design	Method	Conclusion
Mclay et al., 2012[69]	Active-duty service members with PTSD (n=20)	Observational	Open-label, single-group VRET	Reduction in PTSD symptoms, improvement in PTSD, depression, and anxiety
Culbertson et al., 2012[70]	Healthy treatment-seeking cigarette smokers (n=11)	Randomized Controlled Trial	Randomization to CBT plus either smoking-VRET or placebo-VRET	Higher quit rate, smoking fewer cigarettes per day
Park et al., 2011[71]	Inpatients with schizophrenia (n=91)	Randomized Controlled Trial	Compared social skills training using VR role playing to social skills training using traditional role playing, over 10 semiweekly sessions for 5 weeks	Improved more in conversational skills and assertiveness
Mclay et al., 2011[72]	Active-duty military personnel with combat-related PTSD (n=10)	Randomized Controlled Trial	Randomization to VRET or treatment as usual	Higher number of improvements reported more improvement on the CAPS score

13.3 Appendix C

Table 3: Studies focused on VR use for Peer Support

Author/Date	Subjects	Design	Method	Conclusion
Fortuna et al., 2022 [79]	Peer support specialists (n=426)	Observational	This study measured how digital peer support is delivered, by which technologies it is delivered, and how certified digital peer supporters are trained within the United States to inform future delivery of digital peer support by using an online cross-sectional self-report survey. The study included questions regarding the types of peer support training and the delivery methods used within their practices.	Of certified peer specialists trained in CPS, a majority were trained in peer support (98.1%). Peer support specialists deliver services via telephone calls (62.1%), videoconferencing (54.6%), SMS text (42%), smartphone apps (23.2%), and social media (22.2%). Certified peer specialists deliver services through virtual reality (3.8%) and video games (2%). Virtual reality may represent emerging technologies to develop and deliver community-based support.
Dilgul et al., 2021 [73]	10 clinically depressed patients and 10 therapists (n=20)	Observational	The patients and therapists watched a demonstration video of the proposed VR Group Therapy (VRGT) intervention and tested the VR application using a VR headset where patients used an avatar to interact with each other and with their therapist	Positive response: anonymity via avatars favored; recommendations for future VRGT delivery.
Mahapatra, 2021.[75]	Individuals recovering from substance abuse (n=17)	Observational	Participants provided with an Oculus Quest VR headset to join virtual group recovery sessions.	Positive psychological impact and open, honest discourse reported by most participants.

Author/Date	Subjects	Design	Method	Conclusion
Collins-Pisano et al., 2021 [80]	Four focus groups were conducted with peer support (n=59) specialists from 11 US states and three countries	Observational	While telehealth competencies exist for other fields of mental health practice, such as social work, psychiatry, and psychology, limited research has been done to develop and promote digital peer support competencies. The goal of this study is to introduce the coproduction of core competencies that can guide digital peer support.	10 themes were identified: (1) protecting the rights of service users, (2) technical knowledge and skills in the practice of digital peer support, (3) available technologies, (4) equity of access, (5) digital communication skills, (6) performance-based training, (7) self-care, (8) monitoring digital peer support and addressing digital crisis, (9) peer support competencies and (10) health literacy (emerging). The established competencies can potentially act as a guide for training and skill development to be integrated into US state peer support specialist competencies and to enhance competencies endorsed by the Substance Abuse and Mental Health Services Administration (SAMHSA).

Author/Date	Subjects	Design	Method	Conclusion
Marshall et al., 2020 [13]	Two intervention groups were randomized to an immediate condition and two were randomized to a delayed condition. (n=34)	Observational	This study investigated feasibility and indicative effects of intervention and the costs in delivering group social support to people with aphasia via a multi-user, virtual reality platform. It comprised 14 sessions delivered over 6 months and was led by community-based coordinators and volunteers. Effects of intervention were explored using a waitlist randomized controlled design, with outcome measures of wellbeing, communication, social connectedness, and quality of life.	Feasible and cost-effective; larger trial merited with review of treatment content and outcome measures. Feasibility findings showed that the recruitment target was met (N = 34) and 85.3% of participants completed intervention. Costs varied across the four groups ($10,972 - $18,419).
Miller et al., 2019 [81]	Support groups at two sites in one south-eastern state, one urban and one rural (n=27)	Observational	Study assessed the impact of participation in a virtual, pilot-phase 10-week adoptive parent support group on adoptive parent stress and parental competence. Data was collected via a retrospective pre-/post-design and utilized the Parental Stress Scale and Parental Sense of Competency measures to assess variables of interest.	Urban group showed increased competency and decreased stress; rural group showed no significant differences.

Author/Date	Subjects	Design	Method	Conclusion
Fortuna et al., 2019 [82]	Literature published in peer-reviewed scholarly journals within the past 36 months.	Literature Review	This selective review highlights findings and opportunities relevant to digital peer support services.	Digital peer support spans peer-delivered and smartphone-supported interventions, peer-supported asynchronous technology, artificial peer support, informal peer-to-peer support via social media, video games and virtual worlds. Digital peer support is an emerging area of research that shows promise in improving mental health symptoms, medical and psychiatric self-management skill development, social functioning, hope and empowerment. As it advances, peer support specialists will likely have an increasingly important role in the mental health workforce to reach vulnerable populations and communities.
Moustafa et al., 2018 [76]	Participants geographically distributed (n=17)	Observational	Geographically distributed users were provided with Samsung Gear VR headsets to see how social groups could use VR for collaborative activities.	Users felt present and engaged; emotional states similar to face-to-face interactions; avatar representations need improvement.

Author/Date	Subjects	Design	Method	Conclusion
Weiner et al., 2016 [83]	n/a	Literature Review	The virtual reality world of Second Life offers patients the chance to participate via avatars in synchronous health care visits and support groups, as well as explore online resources asynchronously. This paper describes and reviews the development of a Second Life environment that served as a platform for nurse practitioner driven care supplemented by a patient portal as well as the institutional electronic health record.	Viable alternative to face-to-face engagement; requires technology literacy; potential to improve patient involvement in care.

13.4 Appendix D

Table 4: Organizations/Universities Hosting VR Support Groups

NAME	OVERVIEW
Adolescent And Young Adult (AYA) Oncology Clinic at Yale New Haven Hospital [74]	Pilot study looking at the use of VR to engage our AYA patients in support groups led by AYA social workers. The software was designed by Foretell Reality and runs on Oculus Quest headsets. Each support group session is attended by four AYA patients using their headsets from any location with a Wi-Fi or cellular data connection. Upon entering the therapeutically curated virtual space, they find themselves sitting in a circle with other participants and a group moderator. Each session runs 45-60 minutes for a total of six sessions. The pilot is nearing its end with a goal of five separate groups participating, for a total of 20 patients.
XRHealth VR Therapeutic Applications for Support Groups [84]	XRHealth, the leader in extended reality and therapeutic applications, announced the first VR telehealth support groups, where patients with similar ailments can gain support from each other and from doctors associated with the XRHealth telehealth clinics (clinics are now certified in Boston, Connecticut, Florida, Michigan, Washington D.C., Delaware, California, New York, Texas, North Carolina and many others) and are covered by Medicare and most major insurance providers.
LGBTTech/ Innerworld [85]	LGBTTech teamed up with Innerworld to facilitate bi-weekly LGBTQ+ support groups in the Metaverse. This built-for-wellness VR world is an alternative to traditional therapy environments, providing unlimited access to peer support. The group also created a dedicated space in Innerworld for private or LGBT Tech hosted events/communities.

13.5 Appendix E

Table 5: Studies focused on VR use for Pulmonary Rehabilitation

Author/Date	Subjects	Design	Method	Conclusion
Pittara, et al., 2023 [91]	32 papers that focused on VR technologies related to breath and breathing exercise gaming	Literature Review	Compared aspects of each of the studies, including sample, design, objective, intervention, measures used, training, study duration, use of biofeedback sensors and interactive devices, and virtual environments	Of the 32 studies reviewed, 29 had positive outcomes and 3 were neutral. VR was found to be effective in enhancing functional outcomes of pulmonary rehabilitation, increasing breathing body awareness, and improving relaxation techniques.
Rutkowski et al., 2021 [94]	Patients diagnosed as having COPD from the Specialist Hospital in Głuchołazy, Poland (n= 50)	Randomized Controlled Trial	Daily exercise components spanning 15-30 minutes for two weeks. Varied exercises and therapies were employed, including fitness exercises, diaphragm strengthening, exhalation exercises, chest percussion, inhalation therapy, and stationary cycling. The groups differed in relaxation training: one used VR therapy, the other Schultz autogenic training.	Benefits in terms of mood improvement and reduction in anxiety and stress in patients with COPD. VR therapy is more effective than the traditionally used Schultz autogenic training.
Xie et al., 2021 [95]	Stable COPD patients (54 males and 6 females) (n = 60)	Randomized Controlled Trial	Two groups: an experimental group utilizing virtual reality technology combined with pulmonary rehabilitation, and a control group employing conventional rehabilitation. The treatment period lasted for eight weeks.	While VR and telemedicine can aid in COPD management and temporarily enhance exercise capacity, they cannot substitute for direct medical care, particularly during exacerbations. Benefits from pulmonary rehabilitation may diminish over time without sustained guidance and supervision.

Author/Date	Subjects	Design	Method	Conclusion
Jung et al., 2020[93]	COPD patients with grade 3 or above on the MRC breathlessness scale (n = 10)	Pilot Study	Delivery model: supervised VR-based PR Intervention: 20 min physical exercise and education (HD video), led by virtual instructor via a VR headset and probe, and data monitored remotely by clinical staff	Significant improvement in patients' compliance, physical ability, and psychological well-being
Høeg et al., 2021[87]	3 older males, 2 with COPD & 1 with high risk of cardiovascular disease (CVD) (n = 3)	Longitudinal Observational Study	10 – 12 sessions, in alternating high-low intensity cycling sessions, guided by physiotherapists, using VR equipment and heart rate sensors, each session lasting approximately 14.5 minutes	VR as an application for PR is feasible and acceptable, with maintained motivation throughout and no increase in dyspnea, cardiovascular demands, or serious adverse events.
Moorhouse et al., 2019[89]	Elderly patients (aged 63 – 75) COPD graded MRC 4 or 5 and registered at a selected health care center and a hospital in Cumbria, United Kingdom (n = 10)	Non-randomized Trial	Education and rehabilitation 20 minutes per day during 8-week trial using PR in VR program and VR headset Pico Interactive Goblin. Physical rehabilitation exercises led by virtual instructor.	• Improved compliance • Alternative to traditional PR • Enhanced physical ability and psychological well-being • Increased feeling of security • Accessible PR at scale • Cost-Effective Solution

13.6 Appendix F

Table 6: Studies focused on VR use for Clinical Education

Author/Date	Subjects	Design	Method	Conclusion
Zhao et al., 2020[104]	Meta-analysis of 15 randomized controlled trials from 1990-2019 of studies on the performance of VR anatomy education.	Literature Review	15 randomized controlled trials with a teaching outcome measure analysis were included. Two authors separately chose studies, extracted information, and examined the risk of bias. The primary outcome considerations were examination scores of the students and secondary were the degrees of satisfaction of the students.	Outcomes showed that VR improves test scores moderately compared with other approaches. They also found that VR improves post-intervention test score of anatomy compared with other types of teaching methods. The finding confirms that VR is an efficient way to improve the learner's level of anatomy knowledge.
Baniasadi et al., 2020[105]	Analysis of relevant literature on VR use in medical education	Literature review	The review searched Science Direct, Google Scholar, and PubMed databases for relevant papers to determine the challenges associated with the use of VR in the field of medical education and treatment.	The main challenges of developing and using VR with educational and therapeutic objectives include reduced face-to-face communications, education, cost challenges, users' attitudes, and specific challenges such as designing, safety considerations, VR side effects, evaluation, and validation of VR applications.

Author/Date	Subjects	Design	Method	Conclusion
Muhling et al., 2023[99]	227 medical students (97 active participants and 130 observers)	Pilot Study	Evaluated the Simulation-based Training of Emergencies for Physicians using Virtual Reality (STEP-VR) with regards to learning benefit, presence, estimated learning success, motivation, student acceptance, and perceived stress as rated by active participants in the program and student observers	STEP-VR was well accepted by students. Active participants reported being moderately challenged by the scenario, and both active participants and observers reported high estimated learning success. Active participants were more motivated and reported a higher degree of presence than observers.
Kron et al., 2017[20]	421 subjects were assigned to either he VR-based platform (n=210) or a computer-based platform (n=211)	Single-blind, randomized trial	Compared MPathic-VR to computer-based learning. Outcomes measured included communication scores during repeat interactions with MPathic-VR's intercultural and interprofessional scenarios, student attitude surveys and qualitative assessments of their experiences with MPathic-VR or computer-based learning.	MPathic-VR was effective in training advanced communication skills and in enabling knowledge transfer into a more realistic clinical situation.
Dhar et al., 2023 [101]	28 studies that focused on VR-based medical education training and interventions	Literature review	3743 articles were retrieved from PubMed, Embase, Scopus, and Web of Science. After applying inclusion/exclusion criteria, 28 articles were reviewed.	22 of the 28 articles reviewed reported improved clinical outcomes, and 9 of 11 reported that VR enhanced knowledge, skills, attitudes, confidence, self-efficacy, and empathy of medical students following intervention.

Author/Date	Subjects	Design	Method	Conclusion
Bracq et al., 2019[106]	26 studies were reviewed to analyze the use of VR training for non-technical skills	Literature review	PsycInfo and Medline databases were reviewed for articles published through 2017. Of the 1377 publications identified, 80 were assessed for eligibility and 26 were included in the qualitative analysis.	Overall, the use of virtual training for non-technical skills is new in health care education but has increased since 2010. Screen-based VR simulators were found to be the most frequently used systems. The non - technical skills addressed in VR simulation included teamwork, communication, and situation awareness. The majority of studies found in this literature review evaluated the usability and acceptability of VR simulation, and few studies have measured the effects of VR simulation on non-technical skills development. This highlights to need to additional research
Dyer et al., 2018[107]	Analysis of the University of England's Embodied Lab's VR training program, which has trained more than 600 students so far.	Literature review	This paper reviews a recent project at the University of New England that uses virtual reality (VR) technology to teach empathy to medical and other health professions students, specifically in the geriatric field. Users experience age-related conditions such as macular degeneration and high-frequency hearing loss from the patient's perspective.	Results show that VR enhanced students' understanding of age-related health problems and increased their empathy for older adults with vision and hearing loss or Alzheimer's disease.

Author/Date	Subjects	Design	Method	Conclusion
Samadbeik et al., 2018[22]	Analysis of 21 papers to identify the application of VR technology for training medical groups	Literature review	Articles were retrieved through databases such as Pub Med, Scopus, Web of Sciences, Springer, and Google scholar. After applying the entry criteria, 21 papers were selected from a total of 1343.	Results showed that VR improved learning in 17 (74%) studies and a higher accuracy in medical practice by people trained through VR was reported in 20 (87%) studies. Results indicate that the application of VR capabilities plays an important role in improving providers education and performance.
Jiang et al., 2022[108]	114 were reviewed to map existing research on the use of VR in undergraduate medical education to analyze the future need for additional research.	Literature review	Articles were retrieved from MEDLINE (Ovid), Embase (Elsevier), Cochrane Central Register of Controlled Trials (Wiley), and Education Resources Information Centre (Ovid). 114 studies were included from 2010-2020.	Of the 114 articles, 69 (60.5%) reported the use of commercially available surgical VR simulators. Other VR modalities included 3D models and virtual worlds which were mainly used for anatomy education. Most of the VR modalities included were semi-immersive. There is limited evidence on the use of more novel VR modalities, such as mobile VR and virtual dissection tables, as well as the use of VR for nonsurgical and non-psychomotor skills training or in a group setting. The need for further research on applicability is evident.

13.7 Appendix G

Table 7: Studies focused on VR use for Training

Author/Date	Subjects	Design	Method	Conclusion
Van Herzeele et al., 2008[113]	47 subjects, including 27 endovascular physicians and 20 surgical trainees without endovascular experience. procedure.	Non-randomized trial	Surgical trainees were placed in one of two training protocols: group 1 (n = 10) received a 45-minute didactic session followed by expert demonstration of the procedure (VR group) and group 2 (n = 10) was only given a demonstration of an iliac dilation and stent.	Group 1 outcomes were similar to the endovascular physicians. Group 2 performed significantly worse than the physicians in stent/vessel and residual stenosis. Group 1 took longer to perform the procedure with greater use of fluoroscopy than the endovascular physicians. Group 2 performed as quickly as the endovascular physicians but used less fluoroscopy. Training improves the quality of end-product on a VR endovascular simulator and is fundamental prior to assessment of inexperienced subjects.
Wong et al., 2018[114]	30 CPR instructors (doctors and nurses) completed surveys assessing their views	Observational study	Instructors were surveyed on their views towards current CPR education and the use of virtual reality for provider CPR education. Surveys were completed before and after interacting with a CPR virtual reality simulation.	CPR instructors perceived current CPR education as limited due to a lack of resources, practice, motivation, frame of mind, and performance. They perceived fidelity, engagement, resource conservation, and memory enhancement as features of VR ideal for CPR education.

Author/Date	Subjects	Design	Method	Conclusion
Lin et al., 2014[111]	25 participants (16 novices and 9 experienced surgeons) were included in 2 groups to perform the bone-sawing simulation	Nonrandomized trial	Each of the participants completed the same bone-sawing procedure at the predefined maxillary region six times. Sawing operative time, maximal acceleration, and the percentage of the haptic force exceeding the threshold were recorded and analyzed. After six trials, all of the participants scored the simulator for safe force learning, stable hand control, and overall performance.	The results of construct validity showed the two groups significantly reduced their sawing operative times. The curve significantly descended and reached a plateau after the fifth repetition for novices and third repetition for surgeons for maximal acceleration. For safe haptic force, the novices reduced the percentage of the haptic force exceeding the threshold after four trials, but the surgeons did not show a significant difference. The scored results showed that the simulator was more helpful for the novices than for the experienced surgeons.

Author/Date	Subjects	Design	Method	Conclusion
Nagendran et al., 2013[115]	109 surgical trainees from 8 different trials conducted until 2012	Literature review	This study included eight trials covering 109 surgical trainees with limited laparoscopic experience. They searched the Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE, EMBASE and Science Citation Index until 2012. The study included all randomized clinical trials comparing VR training versus other forms of training.	The operating time was significantly shorter in the virtual reality group than in the non-supplementary training group. The operative performance was significantly better in the virtual reality group than the non-supplementary training group using the fixed-effect model. Virtual reality training appears to decrease the operating time and improve the operative performance of surgical trainees with limited laparoscopic experience when compared with no training or with box-trainer training.
Khan et al., 2018[116]	18 trials, consisting of 421 participants and 3817 endoscopic procedures were reviewed	Literature review	Analysis was conducted to determine whether VR training can supplement or replace early conventional endoscopy training in diagnostic esophagogastroduodenoscopy, colonoscopy, and/or sigmoidoscopy for providers with limited or no prior endoscopic experience.	VR training was shown to be beneficial for supplementing early conventional endoscopy training for health professions trainees with limited or no prior endoscopic experience. However, there was insufficient evidence to advise for or against the use of VR training as a replacement. Further research is needed to determine the optimal nature and duration of training.

Author/Date	Subjects	Design	Method	Conclusion
Amer et al., 2017[117]	100 medical students were recruited; the control group (n = 50) were students learning about carpal tunnel release surgery using a video lecture and the study group (n = 50) were students learning the procedure through an app.	Randomized trial	This study utilized the TouchSurgery application, an interactive virtual reality smartphone app that offers a step-by-step tutorial and simulation. The purpose was to compare the efficacy of the app versus traditional teaching modalities. The content covered was identical in both groups but delivered through the different mediums. Outcome measures included comparison of test scores and overall app satisfaction.	Test scores in the study group (89.3%) were significantly higher than the control group (75.6%). Students in the study group rated the overall content validity, quality of graphics, ease of use, and usefulness to surgery preparation as very high (4.8 of 5).
Abbas et al., 2023[110]	34 peer-reviewed articles published between 1998 and 2022 that involved VR training within the field of emergency medicine or surgery	Systematic literature review	A data extraction tool was developed based on the Cochrane Handbook for Systematic Reviews of Literature, and narrative synthesis was performed focusing on study characteristics, description of VR interventions, assessment of evidence quality, outcomes measured through literature, adverse effects including stress and side effects, and cost analysis.	Key educational benefits to using VR in simulation-based emergency skills training include knowledge gain and retention, skill performance in simulation, acceptability, usability, and validity. Evidence is insufficient to demonstrate clear cost effectiveness or direct improvement of patient or institutional outcomes.

13.8 Appendix H

Table 8: Studies focused on VR use for Patient Education

Author/Date	Subjects	Design	Method	Conclusion
Kieu et al., 2023[121]	Patients in the WAtCH transition program and had cardiac lesions contained in the SVH library between the ages 16-19. (n = 22, m = 13, f = 9)	Pilot Study	Pilot study using SVH (VR education content platform). The study disseminated an 8-question survey to participants immediately following their use of the VR platform to measure how enjoyable, useful, and feasible their experience was ranked on a 5-point Likert scale.	Outcomes showed using VR in patient education among the subjects was found to be a good use of time (Average=4.6), helpful in understanding their surgery (4.6) and lesion (4.7) and enjoyable (4.7). The finding confirms that VR is an efficient way to improve a patient's knowledge.
Van Der Linde-Van Den Bor et al., 2021[122]	17 studies published between 2015 and 2020	Literature review	Investigators searched Embase, CINAHL, MEDLINE and PsycInfo databases with the terms 'Virtual Reality' and 'Patient Education' to review VR in patient education in medical somatic treatment.	Patients showed anxiety reduction in some studies and patients found VR education useful. VR education helped to enhance understanding of treatment, improved communication with healthcare professionals, and encouraged treatment compliance. The meta-analysis highlights that VR in patient education is a promising technology.

Author/Date	Subjects	Design	Method	Conclusion
Pandrangi et al., 2019[123]	Patients with a diagnosis of an abdominal aortic aneurysm (AAA) participated between 2017-2018 (n = 19)	Cross-sectional study	A 3D model of an abdominal aortic aneurysm was generated and uploaded into a 3D model. Patients with an AAA wore a Google Cardboard VR headset, with a mobile device displaying the digital 3D AAA image in VR. Patients completed a survey afterward for assessing satisfaction with VR on a 5-point agreement Likert scale.	89% of participants agreed/strongly agreed that they felt better informed after using VR and would like to see VR used more in their health care. Additionally, 84% agreed/strongly agreed that they felt more engaged after using VR. Almost all participants felt comfortable using VR (90%) and enjoyed using the technology (84%). The use of VR in patient education shows promising application to further enhance care delivery.
Van der Kruk et al., 2022[120]	18 studies	Literature Review	The databases searched were Medline, Embase, PsychInfo, the Cochrane library to gather information on literature describing the use of VR as a patient education tool in health care.	72% of studies consisted of pre- and post-questionnaires. Five studies included a control group. Levels of anxiety, distress and systolic blood pressure significantly decreased, and satisfaction and knowledge significantly increased in the intervention group in both pediatric and adult patients. These findings highlight the value of VR in educating and there is indication that patients find VR acceptable.

Author/Date	Subjects	Design	Method	Conclusion
Urlings et al., 2022[23]	10 studies consisting of 788 patients total	Literature Review	Ten studies, including 788 patients, were included and literature showed to be highly heterogeneous. The studied population included patients suffering from a diverse spectrum of chronic diseases.	Results from the studies included indicated that the use of AR had a positive effect on knowledge retention and patient satisfaction. The findings suggested that patients liked the technology and felt comfortable with its use.
Shepherd et al., 2022[119]	12 studies	Literature Review	Investigators conducted a broad search using Ovid MEDLINE, Cochrane Database of Systematic Reviews, Scopus, CINAHL, Web of Science, ProQuest, PROSPERO and Embase. Twelve studies were included, consisting of non-randomized experimental trials, to measure VR use among patients in a perioperative setting.	Of the studies reviewed, a majority highlighted the use of VR in the perioperative setting during consent to show patients a model of anatomy as it related to their procedure. Studies highlighted that both subjective and objective patient understanding improved after interacting with the VR technology.

Author/Date	Subjects	Design	Method	Conclusion
Wang et al., 2022[124]	Patients recruited from a single radon oncology clinic. Patients were over 18 and all planned to receive radiotherapy (n = 43)	Prospective study	The purpose of this study was to determine if this could improve patient understanding of radiotherapy and reduce anxiety. Investigators developed a VR application that allowed patients to view a simulation of themselves receiving radiotherapy. The patient's CT simulation data was converted into a 3D translucent virtual human on a treatment table while radiation beams were delivered.	Patients completed pre- and post-experience questionnaires. 74% of patients indicated they "strongly agree" that the VR session gave them a better understanding of how radiotherapy will be used to treat their cancer. Of the 21 patients who expressed anxiety beforehand, 57% stated that the VR session helped decrease their anxiety. This study found that most patients felt the personalized VR experience was educational and can reduce anxiety.
Jung et al., 2022[125]	Undisclosed	Current-and-Future-State Review	The purpose of this review was to summarize and discuss the current and future state of VR use within the cardiology field, including its benefits, challenges, and different perspectives for providers to consider.	This review summarized that there are many benefits for the use of VR in cardiology, including enhanced understanding of the pathophysiology of their cardiac disease and improved relationship with their provider. Additionally, this review also notes challenges related to VR use for patient education, such as cybersickness, technical issues, and other ethical considerations.

Author/Date	Subjects	Design	Method	Conclusion
Jakl et al., 2020[126]	Patients with a strabismus diagnosis (n = 24)	Pilot project for the development of a prototype AR	Enlightening Patients with Augmented Reality (EPAR) is a patient education AR platform prototype that helps patients with strabismus understand the processes of examinations and eye surgeries through interactive storytelling. Patients engaged with EPAR and were able to adjust the level of information based on their interests.	Investigators conducted post-intervention surveys to measure which interaction prompt was most comfortable and goal-oriented, if the 3D model was beneficial, and whether it was clear to the user on how to interact with the 3D models. Overall, patients found the AR system as a complementary tool for patient education and felt it could lead to a better understanding.
Lee et al., 2022[127]	25 patients	Pilot Study	This study conducted used a prototype of a 360 AR visualization platform (ARVP). Patients were provided with the opportunity to use the 360 ARVP concurrently with the neurosurgeon. All patients completed a post-intervention survey on their experience immediately after use.	All patients (79.2%) strongly agreed and (20.8%) agreed that using the 360 ARVP system helped improve understanding of their medical condition. 95.8% either agreed or strongly agreed that the 360 ARVP helped improve their comfort levels and that they felt included in decisions about their treatment.

13.9 Appendix I

Table 9: Studies focused on VR use for Palliative Care

Author/Date	Subjects	Design	Method	Conclusion
Austin et al., 2022[133]	Palliative care patients 18 years or older with a diagnosis of cancer, presence of cancer-related pain in the past 24 hours and life expectancy of one month or more	Within-subject randomized cross-over feasibility trial	The effects of both 2D and 3D VR interventions on patient symptoms were examined. Acceptability of VR devices was determined using a semi-structured interview that examined usability, presence, cyber sickness, and expectations. Participants completed the Pain Numerical Rating Scale after each intervention, the Edmonton Symptom Assessment Scale at baseline and immediately following each session, the Australian-modified Karnofsky Performance Status at baseline, and the iGroup Presence Questionnaire after each session.	VR in palliative care settings is acceptable and feasible although not without challenges. The results support growing evidence that VR applications provide pain relief for people receiving palliative care. No significant difference was found between 3D and 2D VR in reduction of cancer pain or in reduction of nausea and loss of appetite.
Carmont & McIlfatrick, 2022[135]	16 studies were selected for critical analysis: 9 focused on the patient experience, 1 on the family experience & 6 on the healthcare professional experience	Systematic review	Using pre-defined MeSH search terms to identify eligible studies from five electronic databases (Cochrane Library, CINAHL, OVID Medline, PubMed, and Scopus) between April 2020 and February 2021.	This review identified that VR could support patients, families, and healthcare professionals in palliative care. As a result of the COVID-19 pandemic, the findings could prove particularly significant for facilitating connection.

Author/Date	Subjects	Design	Method	Conclusion
Martin et al., 2022[139]	Eight studies published between 2019 and 2021 were included, representing 138 patients. Participants needed to be defined as "in palliative care" or as "living with a life-limiting illness". Adul ts over age of 18 who requested palliative care consult/in hospital/in hospice. Some staff.	Meta-analysis	This review included palliative care patients engaged in VR interventions using HMDs. The WHO definition of palliative care was used [26]. This definition describes palliative care as an approach that "improves the quality of life of patients and that of their families who are facing challenges associated with life-threatening illness, whether physical, psychological, social or spiritual" [26]. Participants needed to be defined as "in palliative care" or as "living with a life-limiting illness." Peer-reviewed experimental, quasi-experimental, observational, case, and feasibility studies consisting of single or multiple VR sessions were included. Studies also needed to report psychological and/or somatic outcomes. No restrictions on language or year of publication were imposed.	While the reported quantitative psychological and somatic outcomes were ambiguous, the qualitative outcomes were largely positive. Participants were generally satisfied with VR, and most studies reported the VR interventions as usable, feasible, and acceptable.

Author/Date	Subjects	Design	Method	Conclusion
Mo et al., 2022[128]	Eight studies were included, of which five were in the meta-analysis.	Meta-analysis	Inclusion Criteria: Adults (over 18 years of age); palliative participant group (or a synonym of palliative, i.e., 'not curable', 'terminal', 'stage 4'); participants completed at least one virtual reality session; outcome measures reported included at least one of the following: feasibility, acceptability efficacy (through a validated measure) on physical and/or psychological symptoms; Randomized Control Trial (RCT), a non-RCT or a pre-post design; English language	Virtual reality statistically significantly improved pain (p = 0.0363), tiredness (p = 0.0030), drowsiness (p = 0.0051), shortness of breath (p = 0.0284), depression (p = 0.0091) and psychological well-being (p = 0.0201).

Author/Date	Subjects	Design	Method	Conclusion
Moloney et al., 2023[140]	Papers addressing virtual reality in palliative care	Scoping review of literature	Relevant studies were identified and included based on inclusion criteria (adults 18 and older, receiving palliative care, use of VR intervention), data from included studies was charted and summarized.	There is evidence that VR is being used with patients receiving PC in a variety of clinical contexts, and data around VR usability, feasibility and acceptability in patient care contexts appears positive; however, the evidence relating to patient outcomes ensuing from VR use is limited. VR is gathering momentum in PC and potentially is a helpful intervention, but more research is needed to underpin the evidence base supporting its application, particularly in understanding the impact on biopsychosocial patient outcomes and ascertaining the best approach for measuring intervention effectiveness.
Moutogiannis et al., 2023[141]	Patients in hospice and palliative care	Rapid review of VR literature	This rapid review aims to present the current literature on the uses and benefits of VR for palliative care and hospice patients. Through a systematic process, we identified 14 articles published between 2018 and 2023 that used VR as an interventional strategy for symptom management.	Assessments of the intervention were measured before, during, after, and several hours afterward to evaluate benefits and potential adverse effects. Pain was the predominant symptom assessed in the studies. Overall, most of the studies focused on establishing the safety, efficacy, and feasibility of VR using a single-arm interventional method. Future research should implement randomized controlled trials, increase sample size, and expand to pediatric populations.

Author/Date	Subjects	Design	Method	Conclusion
Perna et al., 2021[134]	Adults (18+) in the care of a hospice with advanced disease	Feasibility randomized control trial	Participants were randomly assigned to one of two groups: personalized or non-personalized. Participants completed four 4-minute VR sessions once a week. Participants in the personalized group completed an interview to obtain preferences for the VR session while control group members received randomly selected VR sessions. Feasibility of the recruitment and retention, acceptability of VR sessions, and patient symptoms (Edmonton Symptom Assessment Scale) were examined.	It is feasible and acceptable to recruit people with advanced illness to trial multiple sessions of VR. Personalized VR did not significantly improve symptom scores over non-personalized VR. Repeated VR improved some psychological and physical symptoms, but not statistically significant.
Ridout et al., 2021[142]	Studies that targeted adolescents, ages 10-19	Systematic review of literature	Reviewed studies that used immersive forms of VR delivered through a head-mounted display and took place in inpatient or outpatient settings. Data was extracted from the studies, and a narrative synthesis approach was used due to the small number of studies. Risk of bias was also assessed.	Overall, there was support for the effectiveness of VR in hospitals to reduce pain and anxiety in adolescents, particularly when VR software was highly immersive and specifically designed for therapeutic purposes.

Author/Date	Subjects	Design	Method	Conclusion
Vasudevan et al., 2023[25]	Adults 18 and older receiving palliative care	Scoping review of literature	To understand design trends, gaps, and opportunities for VR in PC, we conducted a scoping review across 4 databases. We found 14 articles that shared the design and use of VR in the PC setting, demonstrating aspects of PC that VR currently supports: symptom management, embedded enrichment, personalized care and decision-making, with the former dominating the field. Dominant design strategies included: active vs. passive engagement in VR, narrative building, and supporting accessibility and mobility. It is notable that participatory approaches were under-utilized. VR currently takes an interventionist approach, focusing on clinical outcomes. We argue that there is a need to change stance towards proactively fostering enrichment as an outcome and present five mechanisms to support person-centered PC using VR.	Virtual Reality (VR) demonstrated efficacy for reducing stress for Palliative Care (PC) persons and distracting from pain. However, VR in clinical settings may do more to foster the holistic approach of PC, creating an enriching experience adjunct to focusing on clinical outcomes or as a distraction from suffering. Current VR experiences have shown great promise in supporting aspects of a holistic model of care in adult palliative care, but more can be done to personalize and better involve the patient in the development and design of the VR experience and remove barriers to creating accessible, comfortable, and safe virtual experiences.