Extended Reality (XR) Technologies in Mental Health Assessment and Treatment

Keywords- Extended Reality (XR), Virtual Reality (VR), Digital Mental Health, Cognitive Behavioral Therapy (CBT), Exposure Therapy, Health Disparities, Immersive Technology.

Abbreviations:

- AFib – Atrial Fibrillation
- AR – Augmented Reality
- CBT – Cognitive Behavioral Therapy
- DALYs – Disability-Adjusted Life Years
- DBT – Dialectical Behavior Therapy
- DSM-5 – Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
- EEG – Electroencephalogram
- ERP – Event-Related Potential
- FDA – Food and Drug Administration
- fMRI – Functional Magnetic Resonance Imaging
- GAD-7 – Generalized Anxiety Disorder 7-item Scale
- GBD – Global Burden of Disease
- HIPAA – Health Insurance Portability and Accountability Act
- IPT – Interpersonal Therapy
- MCI – Mild Cognitive Impairment
- MRI – Magnetic Resonance Imaging
- MR – Mixed Reality

- OCD – Obsessive-Compulsive Disorder
- PET – Positron Emission Tomography
- PHI – Protected Health Information
- PHQ-9 – Patient Health Questionnaire-9
- PFA – Pulsed Field Ablation
- PTSD – Post-Traumatic Stress Disorder
- RFA – Radiofrequency Ablation
- SDI – Socio-Demographic Index
- VR – Virtual Reality
- VRFCAT – Virtual Reality Functional Capacity Assessment Tool
- VRET – Virtual Reality Exposure Therapy
- XR – Extended Reality

Abstract

Mental health disorders are a growing global crisis, contributing significantly to disability and economic burden. While traditional diagnostics and therapies have advanced, access remains limited—especially for marginalized populations. Extended Reality (XR) technologies, including virtual (VR), augmented (AR), and mixed reality (MR), offer promising solutions to these challenges. XR can enhance diagnosis of conditions like depression, anxiety, PTSD, and phobias through immersive simulations that safely elicit behavioral and physiological responses. Therapeutically, XR improves exposure therapy and CBT by delivering engaging, personalized interventions. It also supports self-directed treatments for remote or underserved areas. However, adoption is hindered by issues such as cybersickness, high costs, ethical concerns, and data privacy risks. Regulatory frameworks and further research are needed to ensure safe, equitable implementation. With careful development, XR has the potential to bridge critical gaps in mental health care by offering accessible, tailored solutions across diverse populations.

Introduction:

Mental health disorders have continued to escalate and are increasingly recognized as one of the leading causes of disability and a global public health burden. According to the Global Burden of Disease (GBD) Study 2021, incident cases of mental disorders accounted for more than 444 million, resulting in 155 million Disability-Adjusted Life Years (DALYs) globally ; indicating a 15–17% increase in age-standardized incidence and DALY rates since 1990. The highest DALY incidents occur in affluent countries such as the United States, Australia, and Greenland, which point to the unequal mental burden in more developed settings (1). Major depressive disorder is the most commonly diagnosed psychiatric disorder in the United States. The data from the All of Us Research Program revealed that among over 214,000 participants, 22.1% had been diagnosed with mood disorder, and more than half of those individuals presented with two or more co-occurring psychiatric conditions (2). Approximately 21 million U.S. adults (8.3%) experienced at least one major depressive episode in 2021 (3). These findings are further supported by the global data presented from the GBD 2019 report, which identified 12 major mental disorders as significant contributors to years lived with disability, mainly in high-income countries (4). These conditions affect psychological well-being, leading to a domino effect that significantly impairs the management of physical health, disrupts lifestyle behaviors, and ultimately exacerbates chronic illnesses (5).

There are observable differences by gender and sexual orientation. (6) reports that women are at a higher risk for mood and anxiety disorders, while men are more likely to be affected by substance use disorders and psychosis. Sexual and gender minorities, such as gender-diverse sexual minority individuals, have a much higher risk of all psychiatric disorders. Sexual minority individuals, as reported by (2), experienced higher probabilities for all psychiatric diagnoses, ranging from 1.27 for anxiety disorders to 1.85 for personality disorders. A qualitative meta-analysis of American-based studies also indicated that gender-diverse sexual minority individuals report higher rates of depressive symptoms, suicidal ideation, and post-traumatic stress symptoms compared to their heterosexual counterparts, with disparities being substantial in transgender individuals and gender-diverse sexual minority individuals of color (7). Disparities in racial and ethnic representation further contribute to poor health outcomes, leading to a pronounced prevalence of mental illness burden. Two studies indicated that, though non-Hispanic White individuals have the highest reported prevalence of mental disorders, African Americans, Hispanic/Latino, Indigenous, and multiracial populations often face significant barriers to diagnosis and treatment, resulting in poorer health outcomes (8). (9) discovered that among the African American boys aged 5–1,1 suicide rates were nearly double those of their white peers, black and multiracial youths had a higher susceptibility to being diagnosed with schizophrenia. A cross-sectional analysis of national survey data found that African-American and Hispanic women were significantly less likely to receive mental health treatment despite reporting depressive symptoms that were comparable to or more severe than those presented in white women, illustrating systemic diagnostic disparities (10). Depression rates have doubled in

African-American adults from 9% to 21%, and there has been a 3.5-fold increase in the rate of anxiety, from 6% to 32%, in Hispanic/Latino adults (6,8). Depressive disorders have shown the most significant global increase over the past three decades (11). The most significant increase was observed among females and in high-SDI nations, particularly after the onset of the COVID-19 pandemic. Emerging data also suggest that adolescents and young adults in affluent countries are facing a rising burden of depression and anxiety, with major depressive disorder becoming increasingly prevalent among this demographic (12).

Socioeconomic status consistently remains the primary determinant in predicting mental health outcomes. Diverse cultures indicate that marginalized populations, including immigrants and minority groups, continue to face pressure to assimilate, resulting in amplified disproportionate socioeconomic inequalities (13–15). These population groups, with lower incomes and challenges in employment and education, are most likely to experience psychiatric disorders due to inadequate access to proper mental health services (16). Discrimination is intertwined both structurally and interpersonally, thereby increasing the risk of adverse outcomes. (6) observed that 63% of U.S. adults report experiencing discrimination daily. These exposures are strongly associated with high rates of anxiety and depression, particularly among women, racial/ethnic minorities, sexual and gender minorities, and individuals with disabilities (17). COVID-19 further exacerbated mental health vulnerability in front-line workers and students. The economic burden of untreated mental illness continues to grow in the United States; a recent analysis estimated the cost at $282 billion annually, fueled by decreased productivity, healthcare expenses, and income reductions (18). Together, depression and anxiety have been estimated to cost the world $1 trillion in lost productivity annually. At the same time, (19) reports that 12 billion workdays are lost annually directly due to these mental conditions. Further studies report that mental health disparities will cost an additional $478 billion by 2024 and up to $14 trillion by the year 2040 if unaddressed (20). Significant gaps remain in the mental health service delivery landscape, despite the increased prevalence of mental illness in the U.S. Approximately half of U.S. children with treatable psychiatric disorders are unable to access care from mental health professionals (8,9). These gaps stem from a shortage of providers, insurance limitations, high out-of-pocket costs, and language and cultural barriers. Limited digital literacy and stigma surrounding mental health also continue to restrict access. The unequal distribution among vulnerable groups and the substantial financial burden underscores the need for scalable, innovative solutions.

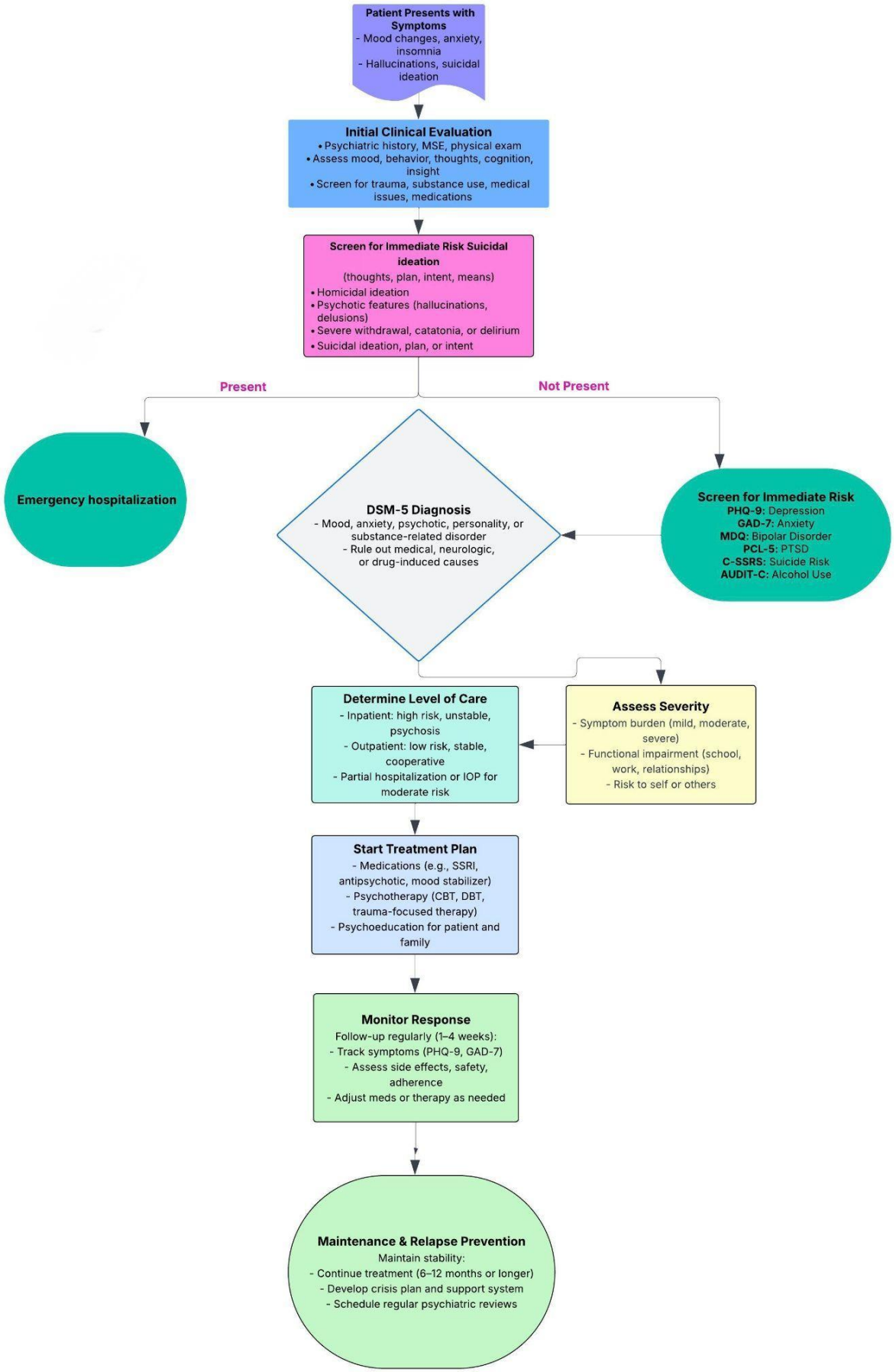
Modern mental health treatment relies on proven diagnostic and treatment modalities.

Diagnostic procedures most commonly include clinical interviews, formal assessment using the DSM-5 criteria, self-report questionnaires, and standardized screening measures like the PHQ-9 and the GAD-7 (21). Treatment is most commonly a combination of pharmacotherapy in the form of antidepressants or antipsychotics and evidence-based psychotherapy such as cognitive

behavioral therapy (CBT), dialectical behavior therapy (DBT), and interpersonal therapy (IPT) (22). These have been traditional methods, which are currently still the norm in clinical psychiatry but depend heavily on direct access to experienced practitioners and health facilities, which might be limited in rural or underserved regions (23).

This study examines the emerging application of extended reality (XR) technologies to drive innovation in mental health assessment and care, particularly as a means to address existing disparities and meet the evolving needs of diverse groups.

Algorithm for Diagnosis & Treatment of Mental Health Disorders (13 - 21)


Patient Presents with Symptoms
- Mood changes, anxiety, insomnia
- Hallucinations, suicidal ideation
Initial Clinical Evaluation
• Psychiatric history, MSE, physical exam
• Assess mood, behavior, thoughts, cognition, insight
• Screen for trauma, substance use, medical issues, medications
Screen for Immediate Risk Suicidal ideation
(thoughts, plan, intent, means)
• Homicidal ideation
• Psychotic features (hallucinations, delusions)
• Severe withdrawal, catatonia, or delirium
• Suicidal ideation, plan, or intent
Present
Not Present
Emergency hospitalization
DSM-5 Diagnosis
- Mood, anxiety, psychotic, personality, or substance-related disorder
- Rule out medical, neurologic, or drug-induced causes
Screen for Immediate Risk
PHQ-9: Depression
GAD-7: Anxiety
MDQ: Bipolar Disorder
PCL-5: PTSD
C-SSRS: Suicide Risk
AUDIT-C: Alcohol Use
Determine Level of Care
- Inpatient: high risk, unstable, psychosis
- Outpatient: low risk, stable, cooperative
- Partial hospitalization or IOP for moderate risk
Assess Severity
- Symptom burden (mild, moderate, severe)
- Functional impairment (school, work, relationships)
- Risk to self or others
Start Treatment Plan
- Medications (e.g., SSRI, antipsychotic, mood stabilizer)
- Psychotherapy (CBT, DBT, trauma-focused therapy)
- Psychoeducation for patient and family
Monitor Response
Follow-up regularly (1–4 weeks):
- Track symptoms (PHQ-9, GAD-7)
- Assess side effects, safety, adherence
- Adjust meds or therapy as needed
Maintenance & Relapse Prevention
Maintain stability:
- Continue treatment (6–12 months or longer)
- Develop crisis plan and support system
- Schedule regular psychiatric reviews

2. Extended Reality in Mental Health Assessment

2.1 Diagnostic Applications

Psychiatric diagnostic tools, such as clinical interviews, surveys, questionnaires, observations, and neuropsychological testing, often rely heavily on a patient's current mental state and memory, which can limit their accuracy and diagnostic comprehensiveness (24). XR addresses this gap by providing a more holistic view of a patient's mental health diagnosis.

XR is increasingly used as both a diagnostic and therapeutic tool for mental health conditions such as anxiety disorders, post-traumatic stress disorder (PTSD), and phobias. It enables the simulation of symptom-triggering environments, allowing patients to confront their disorders in a safe and controlled setting, thereby enhancing diagnostic precision. Among XR modalities, virtual reality (VR) has shown particular promise in assessing and treating depressive and anxiety symptoms. Studies have demonstrated that VR as a therapeutic mechanism can reduce social anxiety and promote higher self-efficacy, with sustained benefits observed up to three months after exposure. Additionally, VR therapies have shown effectiveness in managing psychotic disorders, particularly when patients undergo continuous exposure (25). Like anxiety, depression is often associated with impaired focus and attention. VR technologies can replicate real-world environments—such as classrooms or grocery stores—allowing clinicians to observe attention-related behaviors (26). These immersive simulations enable the monitoring of eye movements and reaction times, contributing to a more holistic and accurate psychiatric diagnosis. Advances within virtual technology have allowed the ability to emulate phobia stimuli; therefore, allowing people to overcome phobias through exposure therapy (27). Overall, XR-based interventions significantly improve mental health symptoms and contribute to positive long-term outcomes.

2.2 Functional and Cognitive Assessments

The Virtual Reality Functional Capacity Assessment Tool (VRFCAT) is a computerized system that assists in measuring cognitive functioning, assessing a patient's abilities in daily tasks. Similar to VR technologies, the VRFCAT emulates various tasks, such as shopping, handling money, utilizing transportation, and preparing meals. Such stimuli are culturally universal, ensuring environmental validity and reliability (28). The VRFCAT has also shown that it is age sensitive; older participants tend to take longer to complete tasks and make more errors through the simulations in the VRFCAT (29). Some older participants may struggle with the use of technology, so it is pertinent to consider age and find participants that are comfortable with using computerized systems.

The VRFCAT has been reported by administrators that it is not only simple to use, but also requires only about thirty minutes to use and evaluate (30). Thus far, VRFCAT has primarily been used to study schizophrenia, Parkinson’s disease, Huntington’s disease, and Alzheimer's disease, so further studies need to be conducted on other mental health disorders, such as anxiety,

depression, and PTSD.

2.3 Physiological and Behavioral Monitoring

In order to assess mental health risks, the brain's structure and function can be studied. Various technologies such as PET, MRI, fMRI, and electroencephalogram (EEG) can be used as diagnostic tools for cognitive functioning and potential mental health risks (31). EEG, a wireless portable device that records brain electrical activity, is more commonly used due to its low cost, real-time capabilities, and adaptable nature of the device among children. EEGs are velocity based and are able to measure specific activity events that occur in the cortex called event-related potential (ERP) (32). XR headsets incorporate these non-invasive optical eye-tracking capabilities, EEGs, to further assess mental disorders and observe cognitive functions, such as attention, memory, and emotional processing.

Resting-state EEG has specifically been shown to be an essential biomarker for mild cognitive impairment (MCI); low efficiency in theta and alpha bands are correlated to MCI. Due to this low efficiency, theta and alpha power placed on the frontal electrode sites are shown to act as an intervention for developing impairment (33). EEG is not only an imperative diagnostic and assessment tool, but also vital for interventional purposes. A deeper understanding of a mental health diagnosis and corresponding treatment can be made by analyzing different eye movements and other physiological signals.

3. XR in Therapeutic Interventions

3.1 Exposure Therapy

Virtual Reality Exposure Therapy (VRET) is a new method of treating anxiety disorders such as phobias and PTSD. It is an established method in which the patient is exposed to a virtual simulated environment, thus enabling them to confront and overcome their fear safely and incrementally (34). This new treatment is highly effective, with meta-analysis suggesting that it is equivalent to comparative exposure therapy in reducing symptoms of anxiety. In treating PTSD, VRET has also been shown to reduce re-experiencing symptoms to a greater extent and to improve patient function. A randomized trial by (35) among veterans showed that VRET resulted in greater symptom reduction compared to treatment-as-usual, especially in refractory patients who failed with regular therapy. XR platforms' immersive and simulation capabilities offer more subtle and progressive exposure, facilitating higher patient compliance and engagement.

3.2 Cognitive Behavioral Therapy (CBT) Enhancements

Extended reality (XR) is increasingly being integrated into Cognitive Behavioral Therapy (CBT), enabling therapists to incorporate interactive and immersive environments within established

therapeutic frameworks. XR supports core CBT components, including exposure therapy, cognitive restructuring, and behavioral activation, through personalized and engaging formats tailored to each patient's clinical needs (36). In a pilot trial, (37) found that patients with psychosis who received VR-enhanced CBT experienced notable reductions in delusional thinking and avoidance behaviors, highlighting the therapeutic value of this approach. As clinical research in this area progresses, ongoing studies are examining the long-term effectiveness of XR-based CBT interventions for conditions such as social anxiety disorder, obsessive-compulsive disorder (OCD), and depression. One notable advantage of XR is its ability to maintain high levels of user engagement, which may be especially beneficial for younger individuals who are comfortable with digital platforms (38). The integration of interactive elements into therapy can enhance patient participation, support adherence to treatment plans, and promote sustained clinical improvement.

3.3 Self-Guided and Remote Therapies

XR technologies offer the potential for creating self-directed therapy products that can be completed by patients individually at home. Such instruments are beneficial where there are few opportunities for seeing therapists. For instance, XRHealth provides remote VR therapy kits to patients in underserved communities in states such as Texas, Florida, Arkansas, Michigan, and Virginia, offering cognitive, pain, and anxiety therapies entirely at home (39). When accessing specialty clinics required travelling over 70 miles, stroke survivors in rural Arkansas have used VR rehabilitation programs (40). Self-directed XR treatment, using robotic CBT programs and attentional control VR programs, has been observed to improve mood and anxiety symptomatology (41). For example, (22) reported in their research that participants who underwent self-directed VR treatment for anxiety experienced statistically significant improvement in symptoms following several treatment sessions, and favorable outcomes were sustained at the 3-month follow-up. These findings suggest the promise of XR in democratizing mental health care and making equity in services possible.

3.4 Special Populations

XR technologies, including Virtual Reality (VR) and Augmented Reality (AR), are continually evolving to meet the distinct needs of various populations. For younger populations who resonate with digital elements, XR offers an engaging platform that corresponds with their digital skills, enhancing the therapeutic adherence and minimizing stigma (27). Conversely, XR environments for older adults are being created with user-friendly interfaces and content that addresses concerns such as social isolation and cognitive decline (42). XR offers environments that help compensate for sensory, motor, and cognitive impairments (43). Furthermore, culturally responsive XR modules are being developed to incorporate a range of sociocultural values, thereby enhancing the relevance and efficacy of XR therapies for diverse demographic populations (44). These

innovations demonstrate the potential of XR to enhance accessibility and inclusivity in mental health care.

4. Technological Considerations

4.1 Hardware and Software Requirements

Technological advancements have introduced a wide range of devices for use in extended reality (XR), each requiring specific components to function effectively. A functional virtual environment typically requires systems that track the user's head and eye movements, as well as a visual display—such as a PC, smartphone, or tablet—to render the user's perspective (45). Most VR and mixed reality (MR) applications rely on head-mounted displays, which project immersive content onto a designated screen or display. Several companies have developed XR-compatible devices across different platforms. For instance, the Meta Quest 3S, introduced in 2023, is a relatively affordable headset that starts at $270, supporting both augmented reality (AR) and virtual reality (VR) (46). It is noted for its clear visuals and compact design. Other manufacturers, including Google, Samsung, and Valve, have also developed similar XR systems (47). In contrast, the Magic Leap 2, released in 2022, is a high-end AR headset priced above $4,000. Its cost reflects advanced features such as enhanced visual clarity, a wider field of view, and more accurate tracking of hand and eye movements (46). Research indicates that participants often prefer VR-based diagnostic and therapeutic approaches over traditional methods. XR platforms also offer a cost-effective alternative to conventional assessment tools, potentially increasing access to. Given these advantages, there is a strong rationale for integrating XR technologies into mental health services. Expanding education and training within the healthcare sector will be essential to increase the scalability and responsible implementation of XR in clinical practice.

4.2 User Experience and Accessibility

Modern technology offers several advantages in mental health care, but concerns persist regarding prolonged use. One such issue is "cybersickness," a condition characterized by symptoms such as headaches, eye strain, blurred vision, and nausea that occur during or after immersion (48). Additionally, the weight and fit of head-mounted displays may pose difficulties, especially for individuals undergoing diagnostic evaluations or therapeutic interventions (49). Nevertheless, continuous innovation in device design is helping to address these challenges, with newer models incorporating features aimed at reducing the risk and severity of cybersickness.

4.3 Data Security and Privacy

As the number of devices and knowledge grow in the technological landscape, the risk of privacy invasion also increases. Devices and browsers are highly vulnerable to virtual hijacking.

Attackers can hack into people's sensitive information, posing a risk of identity theft. Attackers can potentially exploit a device's GPS, leaking Personal Health Information (PHI) and violating the Health Insurance Portability and Accountability Act (HIPAA) (47). Robust safeguards must be tested before XR is fully integrated within healthcare. Proper data encryption must be implemented to prevent unauthorized access to data. Since most of this technology is wireless, specific wireless encryption is vital. Fortunately, many of these encryption software programs are already standard within healthcare (50). While many of these programs are already standard to maintain confidentiality, all other compliance regulations regarding safety and technology must be followed.

5. Ethical and Regulatory Aspects

Despite the growth of XR-based mental health interventions, several ethical considerations must be taken into account. Patient autonomy remains a fundamental concern, as individuals must be empowered to make informed decisions regarding their care. Ethical challenges emerge when patients present with altered mental states that impair their ability to provide valid consent. The studies have shown that many patients with schizophrenia who are experiencing psychosis may not possess the mental capacity required to consent to technologically mediated interventions (51)**.** Recognizing cultural differences in healthcare is essential when obtaining consent for XR-based mental health interventions. Studies have shown that immigrants at risk for psychosis are less likely to fully understand their rights regarding clinical trials and related interventions, often due to differing cultural norms and expectations (51). Patients mustn't be pressured into participation due to limited knowledge or cultural misunderstandings. Therefore, researchers and clinicians must acknowledge and address these cultural differences by clearly communicating relevant information before initiating any intervention. In cases where the patient is unable to provide informed consent and decision-making responsibility falls to family members, it is equally essential that families are thoroughly informed about the nature of the intervention, its potential benefits, and associated risks. In addition to encryption programs to prevent HIPAA violations, other regulatory frameworks govern XR applications within healthcare. The Food and Drug Administration (FDA) efficiently regulates VR and AR devices as medical devices and other healthcare applications, ensuring safety and effectiveness (52). XR device usage must also comply with accessibility laws within the Americans with Disabilities Act, promoting inclusivity amongst all. Governance of technology must address all socioeconomic disparities. To prevent inequities, proper justice should be in place so that all members of society benefit from technological advancements. On a more personal level, many patients emphasize that integrity is a key component when using XR in healthcare. Patients want their healthcare system to be transparent about prices and privacy policies (53).

6. Challenges and Future Directions

As XR adoption in healthcare is emerging, several obstacles must still be overcome. XR usage can be limited due to technological malfunctions, tracking issues, overheating, frequent updates, memory storage constraints, and security risks (47). The success of XR interventions within the mental health field is highly dependent upon sustained patient participation. If patients start dropping out due to technological fatigue, it can disrupt their therapy. Although attitudes are gradually improving, stigma surrounding mental health treatment persists. Individuals are often less willing to report mental health concerns compared to physical health issues. However, the widespread adoption of digital technologies presents an opportunity to increase access to care and help normalize the use of mental health services. To effectively address this stigma, it is crucial to promote a positive image of the mental health profession and increase awareness about the expanding availability of effective treatments (19). Mental health literacy remains low in many populations, highlighting the need for public education efforts that emphasize the seriousness of mental health conditions and the importance of seeking care.

Additionally, it is essential to counteract misconceptions that may lead individuals to underestimate or overlook the need for treatment. Since the COVID-19 pandemic, the demand for in-person therapy has declined significantly, and more people are now open to remote or anonymous forms of care, which may reduce barriers to seeking help (54). While XR is widely focused on the visual aspect for diagnosing and treating mental health, there are potential new advances to be capitalized on, such as the gustatory and olfactory experiences (54). Aside from mental health, XR can also be used for further clinical issues, such as motion sickness, strain, and stress. Investing now for mental health will not only help the mental health patients, but all sorts of patients that may suffer from other acute or chronic illnesses (55). Funding for XR technologies is imperative for many fields in healthcare.

Conclusion

Extended Reality (XR) technologies represent a revolutionary front in mental health assessment and treatment, with new solutions to help mitigate the global burden of psychiatric disorders. In this review, we have summarized the potential of XR in enhancing diagnostic accuracy through immersive simulations, augmenting the effectiveness of established therapeutic interventions such as exposure therapy and cognitive behavioral therapy (CBT), and improving access through self-guided and remote applications. Studies demonstrate that XR possesses the ability to aid in the diagnosis and treatment of conditions such as anxiety, depression, PTSD, and phobias while transcending traditional obstacles such as stigma, provider shortages, and socioeconomic disparities. Despite its promise, it's not without challenges, such as technological limitations (e.g., cybersickness, hardware costs), ethical concerns (e.g., patient autonomy, cultural sensitivity), and data privacy vulnerabilities (e.g., HIPAA violations). Regulatory frameworks must evolve to ensure the safe and equitable implementation of these measures. Future research should focus on maximizing XR usage across various populations, integrating multisensory experiences, implementing data encryption, and securing sustainable funding to enhance scalability.XR technologies hold vast potential to revolutionize mental health care by making interventions more

precise, engaging, and accessible. As technology advances, it will be essential for collaboration among clinicians, researchers, policymakers, and technologists to unlock the full potential of XR technologies in addressing global mental health issues.

Data Availability: As this is a review article, no new data was generated and is therefore not available.

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