International Journal of Multidisciplinary Research and Growth Evaluation.

Exploring the Impact of Generative AI and Virtual Reality on Mental Health: Opportunities, Challenges, and Implications for Well-being

Mantaka Rowshon [1*], Ananna Mosaddeque [2], Tamim Ahmed [3], Umma Twaha [4]
[1, 2, 4] University of North Alabama, USA
[3] University of Toronto, Canada

* Corresponding Author: **Mantaka Rowshon**

Article Info

ISSN (online): 2582-7138
Volume: 06
Issue: 02
March-April 2025
Received: 19-01-2025
Accepted: 23-02-2025
Page No: 103-115

Abstract
By providing cutting-edge therapeutic interventions, improving accessibility, and creating immersive healing experiences, generative artificial intelligence (AI) and virtual reality (VR) are transforming mental health care. This study investigates how these new technologies affect mental health, looking at how they might enhance wellbeing while resolving ethical issues and inherent difficulties. By offering individualized interventions, cognitive behavioral therapy (CBT), and real-time emotional support, generative AI-powered chatbots and virtual assistants lower obstacles to mental health care. By establishing safe, immersive settings that promote gradual desensitization, virtual reality exposure therapy has shown promise in the treatment of phobias, anxiety disorders, and post-traumatic stress disorder (PTSD). Notwithstanding these benefits, issues with algorithmic bias, data privacy, and an excessive dependence on technology pose serious problems. To guarantee patient safety, the ethical ramifications of AI-generated mental health advice—specifically, its accuracy and dependability—need thorough confirmation. Guidelines for ethical use are necessary because VR's immersive nature can also result in dissociation, addiction, or unexpected psychological impacts. To ensure fair access and efficacy, technologists, psychologists, and legislators must work together to create standardized guidelines for integrating AI and VR into clinical practice. The implications of AI-driven mental health interventions for marginalized groups—who frequently face inequities in access to conventional care—are also examined in this research. Generative AI models' versatility makes it possible to create therapeutic applications that are inclusive of all languages and cultures, filling in gaps in mental health care around the globe. To solve issues with AI bias, false information, and responsibility in automated mental health solutions, legislative and ethical frameworks must change. The use of AI and VR in self-guided therapy, crisis intervention, and preventive care is growing as these technologies continue to transform the field of mental health. Research on these technologies' long-term effects on social connections, human emotional intelligence, and psychological resilience is still lacking, despite the fact that they have the potential to improve patient participation and lessen the workload for mental health practitioners. To optimize the advantages of generative AI and VR for mental health, this study emphasizes the need to strike a balance between technology innovation and human-centric ethical issues.

DOI: https://doi.org/10.54660/.IJMRGE.2022.3.1.784-796

Keywords: : Generative AI, Virtual Reality, Mental Health, Digital Therapeutics, AI Ethics, VR Therapy, Psychological Well-being, AI Bias, Mental Health Technology, Digital Mental Health

1. Introduction

Millions of people are impacted by mental health illnesses, which are becoming a major global concern and a major strain on healthcare systems everywhere. According to the World Health Organization, depression is the primary cause of disability worldwide, underscoring the pressing need for efficient mental health treatments (Prescott, 2022). The need for easily accessible mental health treatments has increased due to the increased frequency of conditions including anxiety, depression, and post-traumatic stress disorder (PTSD), which have been made worse by crises like the COVID-19 pandemic (Rauschenberg *et al.*,

2021). The stigma attached to seeking help, high prices, and limited availability of traditional mental health treatments have prompted research into alternative strategies that use technology to improve access to mental health care. (Greer *et al*., 2019; Scott *et al*., 2022).

The way people look for and get help has changed as a result of the advent of digital mental health solutions. Artificial intelligence-driven tools, telemedicine platforms, and mobile applications have become popular because they offer scalable and affordable interventions (Javed *et al*., 2021, Sagar *et al*., 2020). Studies reveal that digital mental health interventions can successfully treat conditions including depression and anxiety, especially in young people and college students (Lattie *et al*., 2019;, Harith *et al*., 2022). For populations who could encounter obstacles to conventional therapy, these technologies are essential since they not only provide instant support but also make it easier for people to continue using mental health resources (Kemp *et al*., 2021; Bell *et al*., 2022). While virtual reality (VR) offers immersive environments for exposure therapy and cognitive behavioral interventions, generative AI uses machine learning and natural language processing to enable real-time conversations and personalized therapeutic interventions (Freeman *et al*., 2016;, Torous *et al*., 2021). For marginalized groups with limited access to traditional therapy, such innovations hold great promise (Naslund *et al*., 2019; Wies *et al*., 2021).

However, there are advantages and disadvantages to incorporating VR and generative AI into mental health treatment. Even though AI-powered chatbots can offer instant psychological help, there are serious issues with algorithmic bias, data privacy, and the morality of automated mental health guidance (Woerner *et al*., 2022). In a similar vein, VR therapy has demonstrated efficacy in treating PTSD and anxiety; however, certain hazards like addiction, dissociation, and financial constraints need for cautious consideration (Jeayareka *et al*., 2020). It is crucial to evaluate these technologies' effectiveness as they develop and set up legal frameworks to guarantee their responsible application (Wies *et al*., 2021). The continuous discussion about digital mental health tools highlights the necessity of a well-rounded strategy that takes into account both the advantages and disadvantages of these tools in improving mental health (LaMonica *et al*., 2019; Leung *et al*., 2021).

Examining the advantages, drawbacks, and moral implications of generative AI and virtual reality in mental health treatment is the goal of this research. This study looks into the advantages and disadvantages of these technologies in an effort to shed light on how they affect mental health and guide future plans for successfully incorporating them into mental health treatments (Santomauro *et al*., 2021; Wainberg *et al*., 2017).

2. Methodology

The methodology for this systematic review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure a structured and transparent approach to identifying, selecting, and analyzing relevant literature. The review aims to explore the impact of generative artificial intelligence (AI) and virtual reality (VR) on mental health, including the opportunities, challenges, and implications for well-being.

A systematic search was conducted across multiple databases, including PubMed, Scopus, IEEE Xplore, Web of Science, and Google Scholar. The search strategy was developed using a combination of controlled vocabulary (e.g., MeSH terms) and free-text keywords related to generative AI, virtual reality, mental health, psychological interventions, and digital well-being. Boolean operators (AND, OR) were applied to refine the search results and retrieve relevant peer-reviewed journal articles, conference proceedings, and systematic reviews published in English.

The inclusion criteria for this review consisted of (1) studies published between 2016 and 2024 that examined the role of generative AI and VR in mental health, (2) research that assessed psychological outcomes and interventions involving AI-driven or VR-based applications, and (3) articles that discussed challenges, ethical considerations, and practical implications of these technologies in the context of mental health. Studies were excluded if they (1) did not specifically focus on mental health outcomes, (2) lacked empirical data or were non-peer-reviewed reports, or (3) were duplicate records.

All retrieved articles were screened using a two-stage process. First, titles and abstracts were reviewed independently by two researchers to remove irrelevant studies. Second, full-text articles were assessed based on the inclusion and exclusion criteria. Any discrepancies were resolved through consensus discussions or by consulting a third reviewer. Data extraction was performed using a structured form that included study characteristics (authors, year, country, study design), population details, AI or VR intervention description, key findings, and conclusions. The extracted data were synthesized through a thematic analysis approach, identifying key trends, benefits, and challenges associated with generative AI and VR in mental health applications.

Quality assessment of the included studies was conducted using the Mixed Methods Appraisal Tool (MMAT) to evaluate methodological rigor. Studies were rated based on criteria such as research design appropriateness, bias risk, data collection methods, and relevance to the research objectives. The final selection of studies was synthesized to identify common themes, such as the effectiveness of AI-driven mental health chatbots, VR-based therapeutic interventions for anxiety and PTSD, and ethical concerns in AI-generated therapy models. The results were analyzed in relation to current technological advancements, user acceptability, and potential policy implications.

A PRISMA flowchart illustrating the selection process, including the number of articles identified, screened, excluded, and included in the final review, is presented below. The PRISMA flowchart shown in figure 1 visually represents the systematic review process, illustrating the number of records identified, screened, excluded, and included in the final analysis.

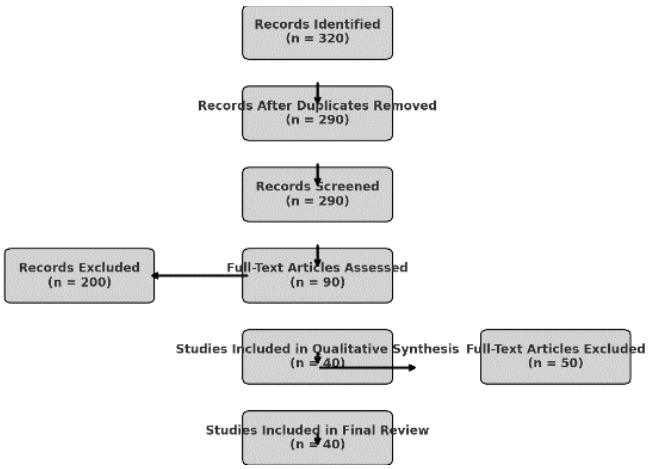

Fig 1: PRISMA Flow chart of the study methodology

2.1 Generative AI in mental health

With its cutting-edge solutions that improve accessibility, cost, and personalization, generative artificial intelligence (AI) has drastically changed the field of mental health treatment. Generative AI facilitates cognitive behavioral therapy (CBT), helps diagnose mental health illnesses early, and offers therapeutic assistance using chatbots, virtual assistants, and sophisticated machine learning algorithms. These developments raise ethical and privacy issues that need to be properly handled, but they also provide new chances to enhance psychological well-being (Patel, 2014, Sleeman, *et al*., 2019).

The creation of chatbots and virtual assistants with AI capabilities that offer real-time psychological help is one of the most well-known uses of generative AI in mental health. By simulating human-like discussions, these AI-powered tools provide users with an open, accepting environment in which to communicate their feelings (Patel *et al*., 2019; Søvold *et al*., 2021). AI-powered chatbots offer instant support at any time, in contrast to traditional therapy, which frequently necessitates scheduled appointments and financial commitment. This makes them especially helpful for people who might not have access to mental health professionals (Rehm & Shield, 2019, Vigo, Thornicroft & Atun, 2016). As AI-powered companions for mental health, apps like Woebot, Wysa, and Replika have become increasingly popular. For instance, Woebot helps people deal with stress, anxiety, and depression by using cognitive behavioral therapy techniques and natural language processing (NLP). While Replika offers an AI companion that helps users have meaningful discussions to fight loneliness and emotional discomfort, Wysa uses AI-powered discourse to give users coping mechanisms, mood tracking, and mindfulness exercises (Akbar *et al*., 2022, Regona *et al*., 2022). These resources act as early interventions that close the communication gap between people in need of psychological support and mental health care providers.

In addition to supplying prompt assistance, AI-powered chatbots and virtual assistants support mental health services by providing affordable options. Particularly in low-income or rural areas, mental health resources are frequently scarce and traditional therapy sessions can be costly (Das *et al*., 2022, Holzinger *et al*., 2022). Platforms driven by AI lessen the cost of therapy, enabling people to get mental health care without having to make a substantial financial commitment. Furthermore, by removing the stigma attached to seeking professional assistance, these chatbots encourage people who might be reluctant to talk to a real therapist about their problems to participate in self-guided therapies (Trenfield *et al*., 2022, Yu *et al*., 2022). People from communities where mental health issues are still highly stigmatized and younger populations especially benefit from this accessibility feature. Cognitive behavioral treatment (CBT) and customized therapies are two more important areas where generative AI is transforming mental health care. Algorithms driven by AI can examine user reactions, actions, and feelings to create individualized treatment plans. AI-driven solutions allow for dynamic and flexible treatment programs that change according to an individual's mental health status, in contrast to conventional one-size-fits-all methods (Pan & Zhang, 2021, Sahoo & Lo, 2022). AI can tailor interventions by offering guided mindfulness exercises, certain coping mechanisms, or structured therapeutic approaches to successfully manage stress and anxiety by gathering and evaluating user data.

Predictive analytics for the early identification of mental health issues also heavily relies on AI. AI systems can identify indicators of mental health decline before symptoms worsen by analyzing patterns in user voice, language, and behavior using machine learning models. To detect indications of sadness, anxiety, or suicidal thoughts, for example, AI systems can analyze variations in text messages, social media activity, and vocal tone (Bohr & Memarzadeh, 2020, Kulkarni, 2022). By enabling early intervention, such predictive capacities lower the likelihood of serious mental health crises. Predictive techniques driven by AI are especially helpful in efforts to prevent suicide since early warning systems can enable caregivers or mental health experts to intervene promptly. AI-driven technologies support proactive mental health management as opposed to reactive treatment by using behavioral analysis to identify possible mental health problems. According to Dawoodbhoy *et al*. (2021), Figure 2 illustrates the broad potential applications of AI in healthcare.

Fig 2: General possibilities for AI in healthcare (Dawoodbhoy, *et al*., 2021)

Even with these encouraging developments, there are still privacy and ethical issues that need to be resolved when generative AI is used in mental health treatment. Algorithmic bias and fairness in AI-generated mental health interventions are among the main issues. When AI models are trained on large datasets, they may reinforce or perpetuate biases in the datasets (Patrício *et al*., 2020; Senbekov *et al*., 2020). For example, AI chatbots that have been primarily trained on Western-centric psychological frameworks might not be able to respond to people from different backgrounds in a way that is sensitive to their cultural differences. Furthermore, biases in AI models related to gender, race, and socioeconomic status may result in differences in the standard of mental health care provided to certain demographic groups. To address these biases and guarantee inclusivity and fair access to quality mental health care, AI training datasets must be continuously evaluated and diversified (Santosh & Gaur, 2022, Xu, *et al*., 2021).

Significant obstacles also exist in data security and confidentiality for AI-powered mental health applications. Concerns regarding data privacy and protection are raised by the collection and processing of sensitive user data by AI chatbots and virtual assistants. Users must be guaranteed that the information they provide to AI systems about their mental health issues will be kept private and safe. However, user privacy may be threatened by hacking risks, data breaches, and unauthorized access to private mental health information (Bhutoria, 2022, Pataranutaporn, *et al*., 2021). The ownership and accessibility of the data gathered by AI mental health applications are other issues that come up. Strict data protection measures must be enforced by regulatory frameworks, guaranteeing that AI-powered mental health platforms abide by privacy and ethical standards.

The ethical environment of AI in mental health care is further complicated by the dependability and accountability of AI-generated mental health guidance. Chatbots with AI capabilities can offer instant psychological help, but they are not as emotionally intelligent, empathetic, or capable of critical thought as human therapists. Despite their sophistication, AI-generated responses may misinterpret user emotions or offer unsuitable advice (Dwivedi *et al*., 2021, Noble *et al*., 2022). Reliance on AI-driven solutions in the absence of human supervision may lead to suggestions that are insufficient or even detrimental in situations involving serious mental health emergencies. AI systems should be used as supplemental tools rather than as a substitute for qualified mental health care practitioners in order to ensure the accuracy and dependability of AI mental health applications, which calls for constant human supervision (Bohr & Memarzadeh, 2020, Mandapuram, *et al*., 2018).

Generative AI will probably play a bigger part in mental health treatment as it develops further, opening up new avenues for therapeutic breakthroughs. Applications for AI-driven mental health have enormous potential to enhance mental health, particularly in places with limited access to conventional therapy (Alanazi, Abdullah & Qureshi, 2017, Javaid, *et al*., 2022). The limitations of AI-generated interventions, data security threats, and ethical dilemmas must all be carefully taken into account. In order to make AI a safe, dependable, and inclusive tool for mental health assistance, the future of AI in mental health depends on finding a balance between ethical responsibility and technological progress. In order to shape the future of AI-driven mental health care and create solutions that optimize benefits while protecting users from potential harms, cooperation between AI developers, mental health practitioners, politicians, and ethicists is crucial (Cho *et al*., 2019, Su *et al*., 2020).

2.2 Virtual reality in mental health treatment

With its creative solutions that improve the accessibility, cost, and personalization of therapeutic support, generative artificial intelligence (AI) has become a game-changer in the field of mental health care. Woebot, Wysa, and Replika are examples of AI-powered chatbots and virtual assistants that demonstrate this shift by providing real-time psychological support (Battineni *et al*., 2021; Thieme, Belgrave & Doherty, 2020). These tools make mental health support more accessible than traditional therapy, which frequently involves scheduled appointments and financial commitments, by using natural language processing (NLP) and cognitive behavioral therapy (CBT) techniques to create a nonjudgmental space for users to express their emotions (Graham *et al*., 2019; Abd-Alrazaq *et al*., 2022). AI-driven support's instantaneity is especially helpful for people who might not have access to mental health specialists, like those living in remote locations or those who are stigmatized for asking for assistance (Chui *et al*., 2018; Johnsen, 2017).

Furthermore, it is impossible to exaggerate the affordability of AI-powered mental health treatments. Many people, especially those living in low-income regions, may not be able to afford traditional therapy (Abd-Alrazaq *et al*., 2022). AI systems lessen this financial strain, enabling users to carry out self-directed actions at minimal expense. Since AI technologies can promote involvement with mental health care without the fear of judgment, this feature is especially important for younger populations and people from communities where mental health issues are severely stigmatized (Graham *et al*., 2019; Fiske *et al*., 2019). These AI systems' capacity to offer prompt, stigma-free assistance is a major advancement in the accessibility of mental health services.

Through tailored interventions, generative AI is transforming cognitive behavioral therapy (CBT) and offering instant assistance. AI systems are able to evaluate user data, such as reactions and emotional states, in order to customize treatment plans to meet the needs of each patient. In stark contrast to conventional, one-size-fits-all approaches, this dynamic approach enables treatment plans to change according to an individual's mental health progress (Abd-Alrazaq *et al*., 2022; Giri *et al*., 2022). AI can increase the efficacy of therapeutic interventions and improve user outcomes by recommending particular coping strategies and mindfulness exercises (Danieli *et al*., 2021). Siddals, Torous, and Coxon (2024) introduced overarching ideas that may be drilled down and explored online. Figure 3 displays the Mindmeister-created diagram.

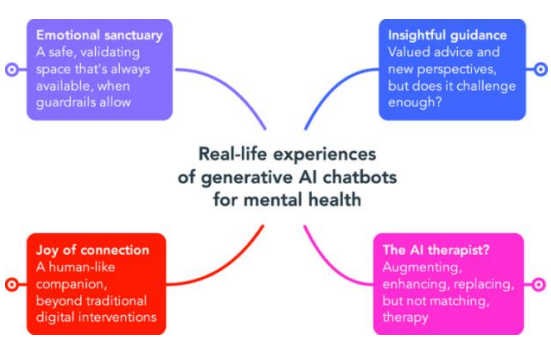

Fig 3: Overarching themes, available online to explore and drill-down. Diagram created with Mindmeister (Siddals, Torous & Coxon, 2024)

Additionally, AI's contribution to predictive analytics is essential for the early identification of mental health issues. To detect early indicators of mental health decline, including anxiety or depression, machine learning models can examine vocal tone, language usage, and behavioral patterns (Ćosić *et al*., 2021; Ameer *et al*., 2022). This capacity is especially helpful in preventing suicide because prompt action can drastically lower the likelihood of serious mental health emergencies (Abd-Alrazaq *et al*., 2022; Ćosić *et al*., 2021). AI solutions can assist prevent the worsening of symptoms and enhance psychological well-being by facilitating proactive management of mental health.

However, there are some difficulties in using generative AI into mental health treatment, especially when it comes to privacy and ethical concerns. Algorithmic bias, which might result from the datasets used to train AI systems, is a major worry. AI interventions may not offer culturally responsive support if these datasets are not representative of various communities, which could exacerbate already-existing gaps in mental health care (Graham *et al*., 2019; Shatte, Hutchinson & Teague, 2019). To guarantee that AI systems are inclusive and egalitarian, training datasets must be continuously evaluated and diversified (Fiske *et al*., 2019; Sebergsen *et al*., 2016).

Confidentiality and data security present serious difficulties as well. Concerns regarding data privacy and protection arise since AI applications in mental health frequently call for the gathering and processing of private user data (Fiske *et al*., 2019; Sebergsen *et al*., 2016). In order to implement stringent data protection procedures, legislative frameworks must be established and users must be reassured that their information is secure (Ahmed *et al*., 2020, Srividya, Mohanavalli & Bhalaji, 2018). Furthermore, because AI systems lack the emotional intelligence and empathy of human therapists, the dependability and accountability of AI-generated mental health recommendations are crucial. To avoid such harm, continual human monitoring is required to ensure the accuracy of AI replies (Shreve, Khanani & Haddad, 2022, Xu, *et al*., 2021).

In conclusion, generative AI has enormous potential to revolutionize mental health treatment by increasing accessibility, affordability, and customisation; but, the ethical and privacy issues surrounding its application must be addressed. In order to develop solutions that optimize advantages while protecting users from potential risks, AI developers, mental health professionals, legislators, and ethicists must work together (Gómez-González & Gómez Gutiérrez, 2020, Kulkarni, 2022).

2.3 Integration of AI and VR in mental health care

The use of virtual reality (VR) and artificial intelligence (AI) in mental health care represents a revolutionary development in the identification, management, and treatment of psychiatric diseases. This collaboration makes it possible for mental health practitioners to use immersive virtual reality experiences in conjunction with AI-driven analytics, enabling more individualized and successful therapy interventions (Trenfield *et al*., 2022, Wasmann *et al*., 2021).

A more adaptive approach to mental health care is made possible by research showing that AI improves VR functionality by evaluating user interactions, emotions, and physiological responses in real-time (Miloff *et al*., 2019; Miloff *et al*., 2020). In the end, this integration improves patient outcomes and promotes a more effective mental health care system by establishing an ecosystem where AI-generated insights optimize VR-based treatments (Aditya, 2022, Xu, *et al*., 2021).

The ability to create individualized, adaptable mental health interventions is the main benefit of integrating AI and VR. In order to determine a user's emotional state, AI-driven analytics can evaluate real-time data including speech tone, facial expressions, and physiological signals like heart rate and eye movement (Bibri, 2022, Martin, *et al*., 2022). For instance, AI can dynamically adapt the VR experience by changing the level of exposure or adding relaxing components like guided breathing exercises if a user shows indicators of distress during an anxiety VR exposure therapy session (Miloff *et al*., 2019; Miloff *et al*., 2020). This feature improves VR therapy's efficacy by guaranteeing that interventions are suitably matched to the patient's emotional reactions, avoiding overpowering or passive encounters. (Susskind & Susskind, 2022, Zhou & Camba, 2021).

AI-powered VR therapy and virtual counseling represent significant advancements in digital mental health care. Traditional therapy models typically rely on human therapists; however, AI-driven virtual therapists and VR-based counseling programs are emerging as viable alternatives (Rudd, 2022; Miloff *et al*., 2020). These virtual counselors can engage users in real-time, delivering therapeutic interventions based on established psychological frameworks, including Cognitive Behavioral Therapy (CBT) and Acceptance and Commitment Therapy (ACT) (Rudd, 2022; Miloff *et al*., 2020). By integrating these frameworks into immersive VR environments, users can practice coping strategies, engage in guided mindfulness exercises, and explore their emotions within a controlled setting, thereby enhancing therapeutic engagement and efficacy (McDiarmid & Zhao, 2022, O'Hare, Fairchild & Ali, 2022).

For those with anxiety disorders, phobias, and post-traumatic stress disorder (PTSD), exposure treatment is a particularly promising use of AI-powered VR therapy (Miloff *et al*., 2019; Miloff *et al*., 2020). While VR enables completely immersive and regulated simulations, traditional exposure treatment is exposing patients to their phobias gradually in real-world situations (Dąbrowska *et al*., 2022, Roy, Meena & Lim, 2022). By tailoring these sessions according to the user's psychological reactions, AI-driven analysis allows for exact desensitization and assists patients in safely facing their phobias (Sayers *et al*., 2021, Trenfield *et al*., 2022). In addition to improving treatment efficacy, this customized strategy raises patient comfort and motivation for therapy (Hollis *et al*., 2018; Susskind & Susskind, 2022). Six challenges for using generative AI in digital health Despite the potential of generative AI for many applications in healthcare presented by Templin, *et al*., 2024, is shown in figure 4.

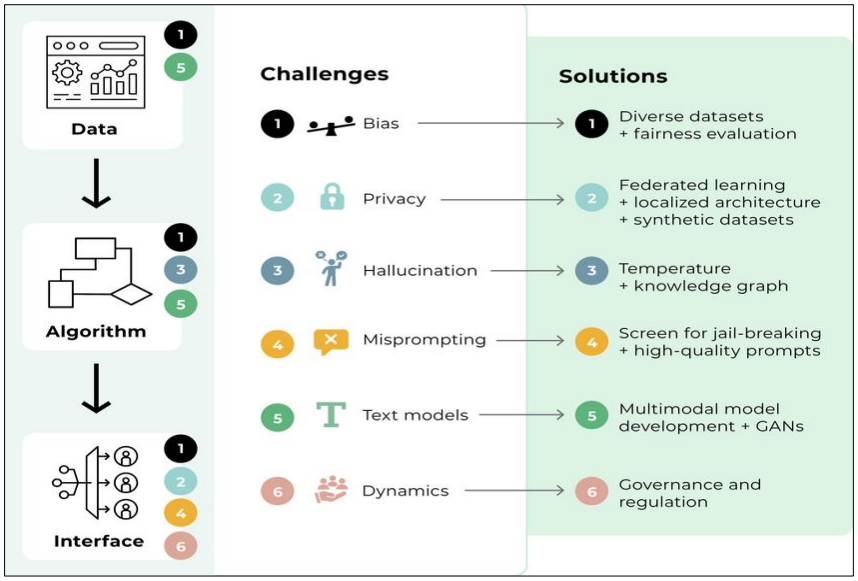

Fig 4: Six challenges for using generative AI in digital health Despite the potential of generative AI for many applications in healthcare (Templin, *et al*., 2024)

Furthermore, people who might encounter obstacles to traditional treatment, such social stigma, financial limitations, or geographic restrictions, can greatly benefit from AI-driven VR counseling (Rudd, 2022; Miloff *et al*., 2020). AI-powered VR counseling lowers obstacles to therapy and increases involvement by offering private, cost-effective, and home-based mental health support (Rudd, 2022; Miloff *et al*., 2020). The legitimacy and efficacy of digital therapy are further strengthened by AI, which guarantees that virtual counselors provide evidence-based therapies (Abdellatif *et al*., 2022, Stein *et al*., 2022).

Beyond therapeutic uses, AI and VR are essential for crisis response and preventive care. According to Rudd (2022) and Miloff *et al*. (2020), mental health illnesses frequently go untreated until they worsen, resulting in significant emotional anguish and higher healthcare expenses. When combined with VR-based mental health programs, AI-driven predictive analytics can spot early indicators of psychological distress, allowing for prompt interventions before things become worse (Rudd, 2022; Miloff *et al*., 2020). AI can, for example, keep an eye on users while they practice mindfulness, identifying minor signs of discomfort and recommending further treatment sessions or self-care activities as necessary (Rudd, 2022; Miloff *et al*., 2020).

VR technologies with AI capabilities offer those going through severe mental health crises instant assistance. Users experiencing panic attacks, suicidal thoughts, or severe emotional distress can receive real-time help from virtual crisis counselors (Rudd, 2022; Miloff *et al*., 2020). These therapies could effectively address critical mental health needs by utilizing immersive grounding techniques and AI-driven conversational bots that offer emotional support (Rudd, 2022; Miloff *et al*., 2020).

Training mental health practitioners will be significantly impacted by the combination of AI and VR. Therapists can hone their diagnostic and intervention abilities by practicing therapies in realistic settings through AI-driven VR simulations (Rudd, 2022; Miloff *et al*., 2020). A more skilled mental health workforce can result from these training programs' ability to give feedback, which can help therapists hone their methods and create more successful treatment plans (Denecke & Baudoin, 2022, Roy, Meena & Lim, 2022). Even though integrating AI with VR has many potential advantages, there are still issues with accessibility and ethical application. To preserve user privacy and guarantee the precision of mental health interventions, AI-driven VR therapy needs to abide by ethical standards (Rudd, 2022). Given the delicate nature of mental health data, concerns over algorithmic bias, data security, and an excessive dependence on AI call for cautious oversight (Rudd, 2022). Furthermore, there are issues with the accessibility and affordability of AI-powered VR solutions because high-quality VR equipment may be too expensive for those with low incomes (Rudd, 2022). To optimize the influence of these treatments on global mental health outcomes, efforts must be made to create affordable solutions and include them into public health programs (Rudd, 2022).

In summary, a paradigm shift in the identification, management, and prevention of mental health diseases is represented by the incorporation of AI and VR in mental health treatment. Immersion VR experiences and AI-driven analytics work together to improve therapeutic interventions and make mental health care more responsive, individualized, and accessible. The potential of AI and VR to transform mental health care and enhance well-being globally is significant, despite ongoing ethical, privacy, and accessibility issues (Krasovsky *et al*., 2020; Van Weelden *et al*., 2021). Future developments in these technologies will further hone their uses, guaranteeing their responsible and fair application that optimizes advantages for people and mental health systems around the globe.

2.4 Implications for public health and policy

By improving accessibility, lowering stigma, and providing scalable solutions for populations that have historically had proper mental health support, the integration of generative AI with virtual reality (VR) in mental health treatment has the potential to have a substantial impact on public health and policy. According to research, AI technology can help manage mental health by anticipating high-cost patients and guaranteeing effective resource distribution, which is especially advantageous for marginalized groups (Shatte *et al*., 2019). Additionally, VR therapy settings can offer immersive experiences that enable people to practice treatment without the limitations of conventional therapy settings, democratizing access to mental health services (Vis *et al*., 2020).

The urgent problem of accessibility in mental health care can

also be addressed by AI and VR technology. AI-powered chatbots and virtual assistants, for example, can provide psychological support 24/7, removing obstacles like lengthy wait times and the stigma attached to asking for assistance (Gamble, 2020). For those living in low-income or rural areas, where mental health treatments are sometimes limited, this is especially important. Mental health care can be made more accessible by incorporating these technologies into public health campaigns, guaranteeing that help reaches a wider audience (Tran *et al*., 2019).

Notwithstanding the encouraging advantages, strong ethical and regulatory frameworks must be established before AI and VR may be widely used in mental health treatment. Accountability, algorithmic bias, and data privacy are critical issues. There are serious concerns regarding the management and security of the vast amounts of user data that AI systems frequently rely on (Czaja & Ceruso, 2022, Miller & Polson, 2019). Important rules for data protection are provided by the General Data Protection Regulation (GDPR) in Europe and the Health Insurance Portability and Accountability Act (HIPAA) in the US, which highlight the necessity of strict measures like data encryption and user consent (Huckvale *et al*., 2019; Kretzschmar *et al*., 2019). Furthermore, algorithmic bias poses a risk, as AI models trained on non-representative data sets may yield culturally insensitive recommendations, underscoring the necessity for continuous evaluation and diversification of training data (Robillard *et al*., 2019).

Another crucial concern with AI-driven mental health interventions is accountability. Liability issues arise when AI-generated counsel has unfavorable results because AI lacks the clinical judgment and emotional intelligence required for complex cases, in contrast to human therapists. To reduce hazards and guarantee patient safety, precise legislative frameworks that specify the obligations of AI developers, platform providers, and healthcare organizations must be established (Carr, 2020). In order to encourage professional consultation when appropriate, these frameworks should also contain disclaimers that advise users of the limitations of AI interventions (Hossain *et al*., 2020).

It is impossible to overestimate the importance of mental health specialists in supervising AI-driven therapy. Hybrid models can improve mental health treatment effectiveness while upholding ethical norms by fusing AI capabilities with human oversight. AI can help therapists, for instance, by evaluating patient data to spot early indicators of mental health decline so that prompt interventions can be made (Reddy *et al*., 2021). Furthermore, physicians can oversee VR treatment sessions and modify therapies in response to real-time patient responses, guaranteeing that AI and VR are used as supplementary tools rather than as a substitute for human therapists (Chowdhury *et al*., 2021).

Although there are many benefits to using AI and VR in mental health care, there are still implementation issues. Policymakers and healthcare professionals continue to have doubts about the effectiveness and dependability of these technologies, which could prevent their widespread use (Taitingfong *et al*., 2020). Additionally, access may be restricted due to the high expenses of VR hardware and AI implementation, especially in low-income areas. Investments in infrastructure development, training, and research are essential to overcoming these obstacles, as are public-private partnerships that can increase the accessibility and cost of these technologies (Strohm *et al*., 2020).

In order to develop morally sound, practical, and easily accessible solutions, legislators, researchers, and clinicians will need to work together to shape the future of AI and VR in mental health care. To control the use of AI and VR in mental health care, proactive regulatory procedures that prioritize accountability, openness, and inclusivity must be put in place (Pradhan *et al*., 2021). To guarantee that doctors are prepared to collaborate with new technologies efficiently, AI literacy should also be incorporated into mental health professional training programs (Murphy *et al*., 2020).

In summary, there are a lot of chances to enhance patient outcomes, accessibility, and efficiency by incorporating AI and VR into mental health treatment. Because these technologies offer scalable and affordable interventions, they help close gaps in mental health care, especially for underprivileged groups. To guarantee that AI and VR complement human-centered care rather than replace it, their effective deployment necessitates the development of ethical and regulatory frameworks that address data privacy, algorithmic bias, and accountability in addition to the crucial supervision of mental health specialists.

2.5 Future directions and research gaps

There are still a lot of unanswered questions despite the fact that the quick development of generative AI and virtual reality (VR) in mental health treatment has created many new opportunities. Examining these technologies' long-term effects on psychological resilience, emotional intelligence, and general well-being is essential as they continue to influence psychological interventions in the future. Although AI and VR have demonstrated promise in treating a range of mental health conditions, the long-term implications of these interventions are not fully understood, according to current literature. For example, research has shown that VR can successfully lessen PTSD and anxiety symptoms in controlled environments, but it's unclear if these advantages will last over time (Freeman *et al*., 2017; Maples-Keller *et al*., 2017; Valmaggia *et al*., 2016).

Furthermore, to maximize the use of AI and VR in mental health, interdisciplinary research is essential. For these technologies to be developed and used in ways that are both ethically and scientifically sound, it is imperative that insights from psychology, neuroscience, and ethics be integrated. One important element in the effective use of VR technologies in the treatment of severe mental diseases, for instance, has been identified as the cooperation between researchers and doctors (Ose *et al*., 2019). The effectiveness and safety of AI-driven mental health applications that are based on psychological theories and clinical best practices can be improved with the aid of this multidisciplinary approach (Guan *et al*., 2021; Jerdan *et al*., 2018).

The creation of increasingly sophisticated AI and VR mental health applications is one of the most exciting areas for further study. The effectiveness of current AI-driven mental health technologies, like chatbots, in offering sympathetic assistance is limited since they frequently struggle with linguistic and emotional nuances (Rajagopal *et al*., 2021). These technologies may become more useful in therapeutic contexts as a result of future developments in natural language processing (NLP), which could improve their comprehension and reaction to emotional cues (Rajagopal *et al*., 2021). The incorporation of haptic feedback has the potential to improve user engagement and therapeutic effects by making VR therapy more immersive and adaptable (Halldorsson *et al*., 2021).

Another crucial issue that needs further research is the long-term effects of AI and VR on emotional intelligence and psychological resilience. Although short-term research has demonstrated that these technologies can reduce stress and anxiety symptoms, longitudinal studies investigating whether

extended use results in long-term gains in resilience and emotional regulation are scarce (Yan-qin *et al*., 2022; Valmaggia *et al*., 2016). Research that evaluates the harmony between the development of internal coping mechanisms and technology help is necessary, as concerns have been expressed that reliance on AI-driven treatments mays impede the development of self-regulation techniques (Best *et al*., 2021).

Furthermore, there is a lot of room for investigation into how VR might improve emotional intelligence via simulating social interactions. However, little is known about how frequent exposure to virtual worlds affects empathy and social skills in the actual world (Jerdan *et al*., 2018). To ascertain whether VR-based therapies might promote or hinder emotional intelligence over time, longitudinal research is required, especially in populations with autism spectrum disorders or social anxiety (Zeng *et al*., 2018; Rus-Calafell *et al*., 2017).

Additionally, interdisciplinary cooperation will be essential in creating legal frameworks and ethical standards for the application of AI and VR in mental health treatment. Addressing concerns like algorithmic bias, data privacy, and the responsibility of AI-driven interventions is crucial as these technologies proliferate (Guan *et al*., 2021; Jerdan *et al*., 2020). In order to reduce potential hazards to users and guarantee fair access to mental health care, criteria for the responsible and safe use of these tools should be established (Yeung *et al*., 2021; Ball *et al*., 2021).

In conclusion, even if AI and VR have a lot of potential to revolutionize mental health treatment, there are still a lot of unsolved issues. In order to maximize digital mental health interventions, future research should concentrate on developing interdisciplinary collaboration, investigating the long-term impacts of VR therapy, and improving the sophistication of AI-driven mental health applications (Czaja & Ceruso, 2022, Miller & Polson, 2019). As long as ethical considerations and a dedication to accessibility and equity in mental health care lead their development, AI and VR have the potential to become effective tools for enhancing psychological resilience, emotional intelligence, and general mental well-being by filling in these study gaps.

3. Conclusion

Innovative approaches that improve accessibility, personalization, and efficacy in treating psychological diseases have been brought about by the merging of generative AI and virtual reality (VR) in mental health treatment. Artificial intelligence (AI)-driven chatbots, virtual assistants, and predictive analytics have proven to be effective in guiding cognitive behavioral treatment (CBT), detecting mental health issues early, and offering instant emotional support. In a similar vein, virtual reality has shown promise as a tool for immersive mental health interventions, stress reduction, and exposure therapy. The potential of mental health care has increased as a result of these developments, especially in terms of reaching marginalized groups and removing obstacles like expense, stigma, and geographic restrictions. But even while AI and VR have the potential to revolutionize mental health treatment, their broad use presents serious ethical, legal, and therapeutic issues that need to be properly handled.

One of the main conclusions of this investigation is that while AI and VR technologies have previously unheard-of potential to enhance mental health treatment, they also carry inherent hazards. Clinical dependability, algorithmic fairness, and data privacy must all be carefully considered when developing AI-driven mental health solutions. While the collection and storage of sensitive user data raises significant security and confidentiality problems, algorithmic biases in AI models may result in differences in mental health support across various demographic groups.

In a similar vein, although VR-based therapy has demonstrated promise in the treatment of phobias, anxiety, and PTSD, it is important to consider the risks of addiction, dissociation, and cyber sickness. The ethical issues surrounding the application of AI and VR in mental health care are strongly related to their efficacy, requiring clear regulatory frameworks and professional supervision. In order to guarantee that AI and VR improve mental health outcomes without endangering patient safety, it is imperative to strike a balance between technological innovation and ethical responsibility. Built-in safeguards that put user well-being first, like real-time monitoring for distress signals, explicit instructions for human intervention, and the option for users to opt out of AI-generated recommendations when needed, should be incorporated into AI-driven mental health solutions. Diverse and representative training datasets are also necessary for ethical AI development in order to avoid biases that can compromise the impartiality and accuracy of mental health evaluations. In a similar vein, VR-based interventions ought to be thoughtfully crafted to offer therapeutic advantages without relying unduly on virtual worlds, guaranteeing that users preserve robust coping strategies in the actual world.

A number of suggestions need to be taken into account in order to guarantee the responsible integration of AI and VR in mental health treatment. First, developing AI and VR-based mental health applications requires interdisciplinary cooperation. To create evidence-based solutions that follow clinical best practices, psychologists, neuroscientists, ethicists, and technologists must collaborate.

To make sure AI-driven tools enhance conventional therapy rather than completely replace human therapists, mental health experts should be actively involved in the development, testing, and validation of these tools. Regulatory agencies should also set rules for AI-powered mental health apps to go through extensive clinical testing prior to widespread implementation.

Second, to avoid exacerbating already-existing inequalities in mental health care, AI and VR mental health technologies need to be made more widely available and reasonably priced. Public health efforts that incorporate AI and VR technologies into community mental health programs should be funded by governments, academic institutions, and business entities.

In order to make AI-driven mental health interventions more affordable for people who might not otherwise have access to professional therapy, policies should be created to facilitate insurance coverage for these services. In order to ensure that technological breakthroughs benefit varied populations rather than just wealthy ones, research should also concentrate on creating affordable VR hardware and AI platforms that may be used in low-resource contexts.

Lastly, to optimize the advantages of AI and VR in mental health treatment, hybrid human-AI collaboration models has to be highlighted. Although VR therapy programs and AI-powered chatbots for mental health provide scalable solutions, they shouldn't be used as stand-alone substitutes for licensed human therapists. Rather, AI and VR should be used as supplemental tools to improve patient monitoring, support clinical decision-making, and offer prompt assistance when human practitioners are not accessible. While VR-based training programs can help doctors improve their therapy approaches through simulated practice environments,

AI-driven analytics can help mental health practitioners diagnose disorders more correctly. AI and VR can be used efficiently without undermining the value of individualized, compassionate human interactions in treatment if they are incorporated into current mental health care systems in a way that emphasizes human monitoring.
In summary, generative AI and virtual reality offer novel techniques to diagnosis, treatment, and preventive care, thereby bringing about a paradigm change in the field of mental health care. These technologies have the ability to increase patient engagement, close gaps in mental health care, and offer prompt assistance to people in need. However, ethical issues, regulatory monitoring, and a dedication to maintaining the accessibility, efficacy, and inclusivity of mental health care must all serve as guiding principles for their broad acceptance. Policymakers and mental health practitioners should leverage technology to build a more effective and fair mental health care system in the future by encouraging multidisciplinary research, prioritizing hybrid human-AI collaboration, and fostering ethical AI and VR development.

4. Reference

1. Abd-Alrazaq A, Alhuwail D, Schneider J, Toro C, Ahmed A, Alzubaidi M, *et al*. The performance of artificial intelligence-driven technologies in diagnosing mental disorders: an umbrella review. NPJ Digital Medicine. 2022;5(1). doi:10.1038/s41746-022-00631-8
2. Abdellatif H, Al Mushaiqri M, Albalushi H, Al-Zaabi AA, Roychoudhury S, Das S. Teaching, learning and assessing anatomy with artificial intelligence: the road to a better future. International Journal of Environmental Research and Public Health. 2022;19(21):14209.
3. Aditya A. Impact of artificial intelligence on business models and their innovation in the healthcare sector [unpublished]. 2022.
4. Ahmed Z, Mohamed K, Zeeshan S, Dong X. Artificial intelligence with multi-functional machine learning platform development for better healthcare and precision medicine. Database. 2020;2020:baaa010.
5. Akbar MS, Hussain Z, Ikram M, Sheng QZ, Mukhopadhyay S. 6G survey on challenges, requirements, applications, key enabling technologies, use cases, AI integration issues and security aspects [preprint]. arXiv. 2022;arXiv:2206.00868.
6. Alanazi HO, Abdullah AH, Qureshi KN. A critical review for developing accurate and dynamic predictive models using machine learning methods in medicine and health care. Journal of Medical Systems. 2017;41:1-10.
7. Ameer I, Arif M, Sidorov G, Gòmez-Adorno H, Gelbukh A. Mental illness classification on social media texts using deep learning and transfer learning [preprint]. arXiv. 2022;arXiv:2207.01012.
8. Ball C, Huang K, Francis J. Virtual reality adoption during the COVID-19 pandemic: a uses and gratifications perspective. Telematics and Informatics. 2021;65:101728. doi:10.1016/j.tele.2021.101728
9. Battineni G, Sagaro GG, Chinatalapudi N, Amenta F. Applications of machine learning predictive models in the chronic disease diagnosis. Journal of Personalized Medicine. 2020;10(2):21.
10. Bell I, Thompson A, Valentine L, Adams S, Álvarez-Jiménez M, Nicholas J. Ownership, use of, and interest in digital mental health technologies among clinicians and young people across a spectrum of clinical care needs: cross-sectional survey. JMIR Mental Health. 2022;9(5):e30716. doi:10.2196/30716.
11. Best P, Meireles M, Schroeder F, Montgomery L, Maddock A, Davidson G, *et al*. Freely available virtual reality experiences as tools to support mental health therapy: a systematic scoping review and consensus-based interdisciplinary analysis. Journal of Technology in Behavioral Science. 2021;7(1):100-114. doi:10.1007/s41347-021-00214-6.
12. Bhutoria A. Personalized education and artificial intelligence in the United States, China, and India: a systematic review using a human-in-the-loop model. Computers and Education: Artificial Intelligence. 2022;3:100068.
13. Bibri SE. The social shaping of the metaverse as an alternative to the imaginaries of data-driven smart cities: a study in science, technology, and society. Smart Cities. 2022;5(3):832-874.
14. Bohr A, Memarzadeh K. The rise of artificial intelligence in healthcare applications. In: Artificial Intelligence in Healthcare. Academic Press; 2020. p. 25-60.
15. Cho G, Yim J, Choi Y, Ko J, Lee SH. Review of machine learning algorithms for diagnosing mental illness. Psychiatry Investigation. 2019;16(4):262.
16. Chui M, Harryson M, Valley S, Manyika J, Roberts R. Notes from the AI frontier applying AI for social good. 2018.
17. Ćosić K, Popović S, Šarlija M, Kesedžić I, Gambiraža M, Dropuljić B, *et al*. AI-based prediction and prevention of psychological and behavioral changes in ex-COVID-19 patients. Frontiers in Psychology. 2021;12. doi:10.3389/fpsyg.2021.782866.
18. Czaja SJ, Ceruso M. The promise of artificial intelligence in supporting an aging population. Journal of Cognitive Engineering and Decision Making. 2022;16(4):182-193.
19. Dąbrowska J, Almpanopoulou A, Brem A, Chesbrough H, Cucino V, Di Minin A, *et al*. Digital transformation, for better or worse: a critical multi-level research agenda. R&D Management. 2022;52(5):930-954.
20. Danieli M, Ciulli T, Mousavi S, Riccardi G. A conversational artificial intelligence agent for a mental health care app: evaluation study of its participatory design. JMIR Formative Research. 2021;5(12):e30053. doi:10.2196/30053.
21. Das A, Day TW, Kulkarni V, Buchanan A, Cottrell K, John NW, *et al*. Towards intelligent extended reality in stroke rehabilitation: Application of machine learning and artificial intelligence in rehabilitation. In: Augmenting Neurological Disorder Prediction and Rehabilitation Using Artificial Intelligence. Academic Press; 2022. p. 309-329.
22. Dawoodbhoy FM, Delaney J, Cecula P, Yu J, Peacock I, Tan J, *et al*. AI in patient flow: applications of artificial intelligence to improve patient flow in NHS acute mental health inpatient units. Heliyon. 2021;7(5).
23. Denecke K, Baudoin CR. A review of artificial intelligence and robotics in transformed health ecosystems. Frontiers in Medicine. 2022;9:795957.
24. Dwivedi YK, Hughes L, Ismagilova E, Aarts G, Coombs C, Crick T, *et al*. Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and

policy. International Journal of Information Management. 2021;57:101994.
25. Fiske A, Henningsen P, Buyx A. Your robot therapist will see you now: ethical implications of embodied artificial intelligence in psychiatry, psychology, and psychotherapy. Journal of Medical Internet Research. 2019;21(5):e13216. doi:10.2196/13216
26. Freeman D, Bradley J, Antley A, Bourke E, DeWeever N, Evans N, *et al*. Virtual reality in the treatment of persecutory delusions: randomised controlled experimental study testing how to reduce delusional conviction. The British Journal of Psychiatry. 2016;209(1):62-67. https://doi.org/10.1192/bjp.bp.115.176438
27. Freeman D, Reeve S, Robinson A, Ehlers A, Clark D, Spanlang B, *et al*. Virtual reality in the assessment, understanding, and treatment of mental health disorders. Psychological Medicine. 2017;47(14):2393-2400. https://doi.org/10.1017/S003329171700040X
28. Giri S, Farid F, Chowdhury N, Foster J. A feasibility study for applying explainable predictive models for the detection of mental health conditions. Research Square. 2022. https://doi.org/10.21203/rs.3.rs-1755594/v1
29. Gómez-González E, Gómez Gutiérrez E. Artificial Intelligence in Medicine and Healthcare: applications, availability and societal impact. Unpublished Manuscript. 2020.
30. Graham S, Depp C, Lee EE, Nebeker C, Tu X, Kim HC, *et al*. Artificial intelligence for mental health and mental illnesses: an overview. Current Psychiatry Reports. 2019;21(11):1-18.
31. Graham S, Depp C, Lee E, Nebeker C, Tu X, Kim HC, *et al*. Artificial intelligence for mental health and mental illnesses: an overview. Current Psychiatry Reports. 2019;21(11):1094. https://doi.org/10.1007/s11920-019-1094-0
32. Greer B, Robotham D, Simblett S, Curtis H, Griffiths H, Wykes T. Digital exclusion among mental health service users: qualitative investigation. Journal of Medical Internet Research. 2019;21(1):e11696. https://doi.org/10.2196/11696
33. Guan H, Qing-li C, Han S, Zhang B. The influence of "artificial intelligence + human–computer interaction" on teachers' psychological changes in academic management in colleges. Frontiers in Psychology. 2021;12:730345. https://doi.org/10.3389/fpsyg.2021.730345
34. Halldorsson B, Hill C, Waite P, Partridge K, Freeman D, Creswell C. Annual research review: immersive virtual reality and digital applied gaming interventions for the treatment of mental health problems in children and young people: the need for rigorous treatment development and clinical evaluation. Journal of Child Psychology and Psychiatry. 2021;62(5):584-605. https://doi.org/10.1111/jcpp.13400
35. Harith S, Backhaus I, Mohbin N, Ngo H, Khoo S. Effectiveness of digital mental health interventions for university students: an umbrella review. PeerJ. 2022;10:e13111. https://doi.org/10.7717/peerj.13111
36. Hollis C, Sampson S, Simons L, Davies EB, Churchill R, Betton V, *et al*. Identifying research priorities for digital technology in mental health care: results of the James Lind Alliance Priority Setting Partnership. The Lancet Psychiatry. 2018;5(10):845-854.
37. Holzinger A, Saranti A, Angerschmid A, Retzlaff CO, Gronauer A, Pejakovic V, *et al*. Digital transformation in smart farm and forest operations needs human-centered AI: challenges and future directions. Sensors. 2022;22(8):3043.
38. Javaid M, Haleem A, Singh RP, Suman R, Rab S. Significance of machine learning in healthcare: Features, pillars and applications. International Journal of Intelligent Networks. 2022;3:58-73.
39. Javed A, Lee C, Zakaria H, Buenaventura RD, Cetkovich-Bakmas M, Duailibi K, *et al*. Reducing the stigma of mental health disorders with a focus on low- and middle-income countries. Asian Journal of Psychiatry. 2021;58:102601.
40. Jeayareka J, Raman K, Singh L, Jagzape T. Effectiveness of virtual reality therapy on anxiety and symptom distress with chemotherapy among children with cancer. International Journal of Research in Pharmaceutical Sciences. 2020;11(SPL4):3117-3123. https://doi.org/10.26452/ijrps.v11ispl4.4640
41. Jerdan S, Grindle M, Woerden H, Boulos M. Head-mounted virtual reality and mental health: critical review of current research. JMIR Serious Games. 2018;6(3):e14. https://doi.org/10.2196/games.9226
42. Jerdan S, Grindle M, Woerden H, Zubala A. Designing and implementing a VR mental wellbeing experience using digital creative practice. Research Square. 2020. https://doi.org/10.21203/rs.2.22499/v1
43. Johnsen M. The future of Artificial Intelligence in Digital Marketing: The next big technological break. Maria Johnsen. 2017.
44. Kemp J, Chorney J, Kassam I, MacDonald J, MacDonald T, Wozney L, *et al*. Learning about the current state of digital mental health interventions for Canadian youth to inform future decision-making: mixed methods study. Journal of Medical Internet Research. 2021;23(10):e30491. https://doi.org/10.2196/30491
45. Krasovsky T, Lubetzky AV, Archambault PS, Wright WG. Will virtual rehabilitation replace clinicians: a contemporary debate about technological versus human obsolescence. Journal of NeuroEngineering and Rehabilitation. 2020;17:1-8.
46. Kulkarni S. Expert Systems in Behavioral and Mental Healthcare: Applications of AI in Decision-Making and Consultancy. Big Data Analytics and Machine Intelligence in Biomedical and Health Informatics: Concepts, Methodologies, Tools and Applications. 2022;147-186.
47. LaMonica H, Davenport T, Braunstein K, Ottavio A, Piper S, Martin C, *et al*. Technology-enabled person-centered mental health services reform: strategy for implementation science. JMIR Mental Health. 2019;6(9):e14719. https://doi.org/10.2196/14719
48. Lattie E, Adkins E, Winquist N, Stiles-Shields C, Wafford Q, Graham A. Digital mental health interventions for depression, anxiety, and enhancement of psychological well-being among college students: systematic review. Journal of Medical Internet Research. 2019;21(7):e12869. https://doi.org/10.2196/12869
49. Leung C, Pei J, Hudec K, Shams F, Munthali R, Vigo D. The effects of nonclinician guidance on effectiveness and process outcomes in digital mental health interventions: systematic review and meta-analysis

(preprint). JMIR Preprints. 2021. https://doi.org/10.2196/preprints.36004
50. Mandapuram M, Gutlapalli SS, Bodepudi A, Reddy M. Investigating the Prospects of Generative Artificial Intelligence. Asian Journal of Humanity, Art and Literature. 2018;5(2):167-174
51. Maples-Keller J, Bunnell B, Kim S, Rothbaum B. The use of virtual reality technology in the treatment of anxiety and other psychiatric disorders. Harvard Review of Psychiatry. 2017;25(3):103-13. doi:10.1097/hrp.0000000000000138
52. Martin D, Malpica S, Gutierrez D, Masia B, Serrano A. Multimodality in VR: A survey. ACM Computing Surveys (CSUR). 2022;54(10s):1-36.
53. McDiarmid GW, Zhao Y. Learning for uncertainty: Teaching students how to thrive in a rapidly evolving world. Routledge; 2022.
54. Miller E, Polson D. Apps, avatars, and robots: The future of mental healthcare. Issues in Mental Health Nursing. 2019;40(3):208-14.
55. Miloff A, Carlbring P, Hamilton W, Andersson G, Reuterskiöld L, Lindner P. Measuring alliance toward embodied virtual therapists in the era of automated treatments with the virtual therapist alliance scale (VTAS): Development and psychometric evaluation. Journal of Medical Internet Research. 2020;22(3):e16660. doi:10.2196/16660
56. Miloff A, Lindner P, Dafgård P, Deak S, Garke M, Hamilton W, *et al*. Automated virtual reality exposure therapy for spider phobia vs. in-vivo one-session treatment: A randomized non-inferiority trial. Behaviour Research and Therapy. 2019;118:130-40. doi:10.1016/j.brat.2019.04.004
57. Naslund J, Shidhaye R, Patel V. Digital technology for building capacity of nonspecialist health workers for task sharing and scaling up mental health care globally. Harvard Review of Psychiatry. 2019;27(3):181-92. doi:10.1097/hrp.0000000000000217
58. Noble JM, Zamani A, Gharaat M, Merrick D, Maeda N, Foster AL, Zaiane O. Developing, implementing, and evaluating an artificial intelligence–guided mental health resource navigation chatbot for healthcare workers and their families during and following the COVID-19 pandemic: Protocol for a cross-sectional study. JMIR Research Protocols. 2022;11(7):e33717.
59. Hare JJ, Fairchild A, Ali U. Money & Trust in Digital Society: Bitcoin, Nostr, Stablecoins, Digital Objects and Generative AI in B2B Spatial Mixed Reality. arXiv preprint. 2022;arXiv:2207.09460.
60. Ose S, Færevik H, Kaasbøll J, Lindgren M, Thaulow K, Antonsen S, *et al*. Exploring the potential for use of virtual reality technology in the treatment of severe mental illness among adults in Mid-Norway: Collaborative research between clinicians and researchers. JMIR Formative Research. 2019;3(2):e13633. doi:10.2196/13633
61. Pan Y, Zhang L. Roles of artificial intelligence in construction engineering and management: A critical review and future trends. Automation in Construction. 2021;122:103517.
62. Pataranutaporn P, Danry V, Leong J, Punpongsanon P, Novy D, Maes P, *et al*. AI-generated characters for supporting personalized learning and well-being. Nature Machine Intelligence. 2021;3(12):1013-1022.
63. Patel V. Why mental health matters to global health. Transcultural Psychiatry. 2014;51(6):777-789.
64. Patel V, Saxena S, Lund C, Thornicroft G, Baingana F, Bolton P, *et al*. The Lancet Commission on global mental health and sustainable development. The Lancet. 2018;392(10157):1553-1598.
65. Patrício L, Sangiorgi D, Mahr D, Čaić M, Kalantari S, Sundar S. Leveraging service design for healthcare transformation: Toward people-centered, integrated, and technology-enabled healthcare systems. Journal of Service Management. 2020;31(5):889-909.
66. Prescott J. Digital technology to support mental health: A brief introduction to what it is and why it is important? Mental Health and Social Inclusion. 2022;26(2):103-106. https://doi.org/10.1108/mhsi-02-2022-0010
67. Rajagopal A, Nirmala V, Andrew J, Arun M. Novel AI to avert the mental health crisis in COVID-19: Novel application of GPT2 in cognitive behaviour therapy. 2021. https://doi.org/10.21203/rs.3.rs-382748/v1
68. Rauschenberg C, Schick A, Goetzl C, Roehr S, Riedel-Heller S, Koppe G, *et al*. Social isolation, mental health, and use of digital interventions in youth during the COVID-19 pandemic: A nationally representative survey. European Psychiatry. 2021;64(1). https://doi.org/10.1192/j.eurpsy.2021.17
69. Regona M, Yigitcanlar T, Xia B, Li RYM. Opportunities and adoption challenges of AI in the construction industry: A PRISMA review. Journal of Open Innovation: Technology, Market, and Complexity. 2022;8(1):45.
70. Rehm J, Shield KD. Global burden of disease and the impact of mental and addictive disorders. Current Psychiatry Reports. 2019;21:1-7.
71. Roy S, Meena T, Lim SJ. Demystifying supervised learning in healthcare 4.0: A new reality of transforming diagnostic medicine. Diagnostics. 2022;12(10):2549.
72. Rudd I. Leveraging artificial intelligence and robotics to improve mental health. 2022. https://doi.org/10.32370/iaj.2710
73. Rus-Calafell M, Garety P, Sason E, Craig T, Valmaggia L. Virtual reality in the assessment and treatment of psychosis: A systematic review of its utility, acceptability, and effectiveness. Psychological Medicine. 2017;48(3):362-391. https://doi.org/10.1017/s0033291717001945
74. Sagar R, Dandona R, Gururaj G, Dhaliwal RS, Singh A, Ferrari A, *et al*. The burden of mental disorders across the states of India: The Global Burden of Disease Study 1990–2017. The Lancet Psychiatry. 2020;7(2):148-161.
75. Sahoo S, Lo CY. Smart manufacturing powered by recent technological advancements: A review. Journal of Manufacturing Systems. 2022;64:236-250.
76. Santomauro DF, Herrera AMM, Shadid J, Zheng P, Ashbaugh C, Pigott DM, *et al*. Global prevalence and burden of depressive and anxiety disorders in 204 countries and territories in 2020 due to the COVID-19 pandemic. The Lancet. 2021;398(10312):1700-1712.
77. Santosh KC, Gaur L. Artificial intelligence and machine learning in public healthcare: Opportunities and societal impact. Springer Nature. 2022.
78. Sayers D, Sousa-Silva R, Höhn S, Ahmedi L, Allkivi-Metsoja K, Anastasiou D, *et al*. The dawn of the human-machine era: A forecast of new and emerging language technologies. 2021.

79. Scott S, Knott V, Finlay-Jones A, Mancini V. Australian psychologists' experiences with digital mental health: A qualitative investigation. Journal of Technology in Behavioral Science. 2022;8(4):341-351. https://doi.org/10.1007/s41347-022-00271-5
80. Sebergsen K, Norberg A, Talseth A. Confirming mental health care in acute psychiatric wards, as narrated by persons experiencing psychotic illness: An interview study. BMC Nursing. 2016;15(1). https://doi.org/10.1186/s12912-016-0126-x
81. Senbekov M, Saliev T, Bukeyeva Z, Almabayeva A, Zhanaliyeva M, Aitenova N, *et al*. The recent progress and applications of digital technologies in healthcare: A review. International Journal of Telemedicine and Applications. 2020;2020(1):8830200.
82. Shatte AB, Hutchinson DM, Teague SJ. Machine learning in mental health: A scoping review of methods and applications. Psychological Medicine. 2019;49(9):1426-1448.
83. Shreve JT, Khanani SA, Haddad TC. Artificial intelligence in oncology: Current capabilities, future opportunities, and ethical considerations. American Society of Clinical Oncology Educational Book. 2022;42:842-851.
84. Siddals S, Torous J, Coxon A. "It happened to be the perfect thing": Experiences of generative AI chatbots for mental health. npj Mental Health Research. 2024;3(1):48.
85. Sleeman KE, De Brito M, Etkind S, Nkhoma K, Guo P, Higginson IJ, *et al*. The escalating global burden of serious health-related suffering: Projections to 2060 by world regions, age groups, and health conditions. The Lancet Global Health. 2019;7(7):e883-e892.
86. Søvold LE, Naslund JA, Kousoulis AA, Saxena S, Qoronfleh MW, Grobler C, *et al*. Prioritizing the mental health and well-being of healthcare workers: An urgent global public health priority. Frontiers in Public Health. 2021;9:679397.
87. Srividya M, Mohanavalli S, Bhalaji N. Behavioral modeling for mental health using machine learning algorithms. Journal of Medical Systems. 2018;42:1-12.
88. Stein DJ, Shoptaw SJ, Vigo DV, Lund C, Cuijpers P, Bantjes J, *et al*. Psychiatric diagnosis and treatment in the 21st century: Paradigm shifts versus incremental integration. World Psychiatry. 2022;21(3):393-414.
89. Su C, Xu Z, Pathak J, Wang F. Deep learning in mental health outcome research: A scoping review. Translational Psychiatry. 2020;10(1):116.
90. Susskind R, Susskind D. The Future of the Professions: How Technology Will Transform the Work of Human Experts. Oxford University Press; 2022.
91. Templin T, Perez MW, Sylvia S, Leek J, Sinnott-Armstrong N. Addressing six challenges in generative AI for digital health: A scoping review. PLOS Digital Health. 2024;3(5):e0000503.
92. Thieme A, Belgrave D, Doherty G. Machine learning in mental health: A systematic review of the HCI literature to support the development of effective and implementable ML systems. ACM Transactions on Computer-Human Interaction (TOCHI). 2020;27(5):1-53.
93. Torous J, Bucci S, Bell I, Kessing L, Faurholt-Jepsen M, Whelan P, *et al*. The growing field of digital psychiatry: Current evidence and the future of apps, social media, chatbots, and virtual reality. World Psychiatry. 2021;20(3):318-335. https://doi.org/10.1002/wps.20883
94. Trenfield SJ, Awad A, McCoubrey LE, Elbadawi M, Goyanes A, Gaisford S, *et al*. Advancing pharmacy and healthcare with virtual digital technologies. Advanced Drug Delivery Reviews. 2022;182:114098.
95. Valmaggia L, Latif L, Kempton M, Rus-Calafell M. Virtual reality in the psychological treatment for mental health problems: A systematic review of recent evidence. Psychiatry Research. 2016;236:189-195. https://doi.org/10.1016/j.psychres.2016.01.015
96. Van Weelden E, Alimardani M, Wiltshire TJ, Louwerse MM. Advancing the adoption of virtual reality and neurotechnology to improve flight training. 2021 IEEE 2nd International Conference on Human-Machine Systems (ICHMS). IEEE; 2021. p. 1-4.
97. Vigo D, Thornicroft G, Atun R. Estimating the true global burden of mental illness. The Lancet Psychiatry. 2016;3(2):171-178.
98. Wainberg ML, Scorza P, Shultz JM, Helpman L, Mootz JJ, Johnson KA, *et al*. Challenges and opportunities in global mental health: A research-to-practice perspective. Current Psychiatry Reports. 2017;19:1-10.
99. Wasmann JWA, Lanting CP, Huinck WJ, Mylanus EA, van der Laak JW, Govaerts PJ, *et al*. Computational audiology: New approaches to advance hearing healthcare in the digital age. Ear and Hearing. 2021;42(6):1499-1507.
100. Wies B, Landers C, Ienca M. Digital mental health for young people: A scoping review of ethical promises and challenges. Frontiers in Digital Health. 2021;3. https://doi.org/10.3389/fdgth.2021.697072
101. Woerner M, Sams N, Nales C, Gorstein T, Johnson M, Mosser B, *et al*. Generational perspectives on technology's role in mental health care: A survey of adults with lived mental health experience. Frontiers in Digital Health. 2022;4. https://doi.org/10.3389/fdgth.2022.840169
102. Xu L, Sanders L, Li K, Chow JC. Chatbot for healthcare and oncology applications using artificial intelligence and machine learning: Systematic review. JMIR Cancer. 2021;7(4):e27850.
103. Xu L, Sanders L, Li K, Chow JC. Chatbot for healthcare and oncology applications using artificial intelligence and machine learning. JMIR Cancer. 2021;7(4):e27850.
104. Xu L, Sanders L, Li K, Chow JC. Chatbot for healthcare and oncology applications using artificial intelligence and machine learning: Systematic review. JMIR Cancer. 2021;7(4):e27850.
105. Yan-qin Z, Workman A, Russell M, Williamson M, Pan H, Reifels L. The long-term impact of bushfires on the mental health of Australians: A systematic review and meta-analysis. European Journal of Psychotraumatology. 2022;13(1). https://doi.org/10.1080/20008198.2022.2087980
106. Yeung A, Tosevska A, Klager E, Eibensteiner F, Laxar D, Stoyanov J, *et al*. Virtual and augmented reality applications in medicine: Analysis of the scientific literature. Journal of Medical Internet Research. 2021;23(2):e25499. https://doi.org/10.2196/25499
107. Yu J, Alhilal A, Hui P, Tsang DH. 6G mobile-edge empowered metaverse: Requirements, technologies, challenges and research directions. arXiv preprint arXiv:2211.04854. 2022.

108. Zeng N, Pope Z, Lee J, Gao Z. Virtual reality exercise for anxiety and depression: A preliminary review of current research in an emerging field. Journal of Clinical Medicine. 2018;7(3):42. https://doi.org/10.3390/jcm7030042
109. Zhou J, Camba JD. Computer-aided process planning in immersive environments: A critical review. Computers in Industry. 2021;133:103547.