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Exploring Therapeutic Applications of Virtual Reality in Mental Health: A Bibliometric Analysis

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Abstract: This research explores the connection between interventions for mental well-being and Virtual Reality (VR). A bibliometric analysis was conducted to assess the state of the field, comparing mental health applications to understand VR's significance. The study revealed a limited but growing body of literature examining VR's effects on mental health, primarily targeting mood, stress, and anxiety disorders. Various approaches, including immersive VR experiences, were identified, offering unique therapeutic benefits. The comparative investigation across disorders underscored the potential of VR therapy to create synergistic effects when combined with other interventions. Immersive VR experiences were found to offer innovative ways to address emotional regulation and stress management, enhancing traditional therapeutic methods. The applications and techniques developed so far provide significant insights into the transformative role VR could play in mental health care. The findings emphasize the importance of further research to optimize and expand VR interventions for mental well-being. Such advancements could pave the way for more personalized, engaging, and effective mental health solutions, particularly for conditions resistant to conventional therapies. By leveraging VR's immersive and interactive capabilities, mental health practitioners can create interventions that not only alleviate symptoms but also foster long-term psychological resilience. This study highlights the critical need to develop and implement VR-based interventions systematically, ensuring their accessibility and efficacy across diverse populations. By doing so, VR can serve as a cornerstone in the evolution of mental health care, bridging gaps and unlocking new possibilities for well-being.

Index Terms: Virtual Reality, Mental Health, Bibliometric Analysis, Immersive Technology, Therapy, Innovations

1. Introduction

The arrival of cutting-edge innovations has brought about a new era of possibilities in the constantly changing field of healthcare, one that promises better patient outcomes [1], tailored treatment regimens, and improved diagnostics [2]. Virtual reality (VR) is one of these ground-breaking inventions that really stand out as a game-changer since it breaks through conventional limits and redefines the patient care experience [3]. Virtual reality, a technology that was formerly thought to be limited to games and entertainment has developed into a powerful tool that has significant implications for patients, researchers, and healthcare practitioners [4]. Virtual reality (VR) holds great promise to transform medical practices, diagnostics, therapy, and training by submerging users in digitally generated surroundings [5]. This shift, in

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perspective not enhances the quality of care but also opens up exciting opportunities for innovation. Virtual reality (VR) has a range of applications, such as educating patients offering mental health treatments providing therapeutic interventions and simulating virtual procedures. Virtual reality is more than a tool, it is a driving force behind a healthcare revolution that brings about advancements and fosters a patient centered approach, to treatment. Figure 1 provides an illustration of how virtual reality is used in healthcare across domains.

Fig. 1. Applications of Virtual Reality in Healthcare

1.1 Virtual Reality and Mental Health Treatment

Virtual reality (VR) refers to a technology that enables individuals to interact with a computer- generated virtual world. In the field of health treatment, virtual reality is increasingly recognized as an approach [6]. Virtual reality offers a controlled and distinct environment, for interventions. It has been utilized to address health concerns, such as phobias, post-traumatic stress disorder (PTSD) and anxiety disorders among others. By simulating settings, VR based therapies assist patients in confronting and managing their fears within a setting [7]. When combined with the nature of VR experiences exposure therapy has shown results in reducing individual sensitivity to stressors and enhancing traditional therapeutic methods. Moreover, researchers are exploring the potential of VR in development, mindfulness training and relaxation techniques. These applications could have an impact, on the treatment of health issues. Figure 2 illustrates how early symptoms of illnesses can be identified and addressed through reality by providing a calm, engaging and peaceful environment [8].

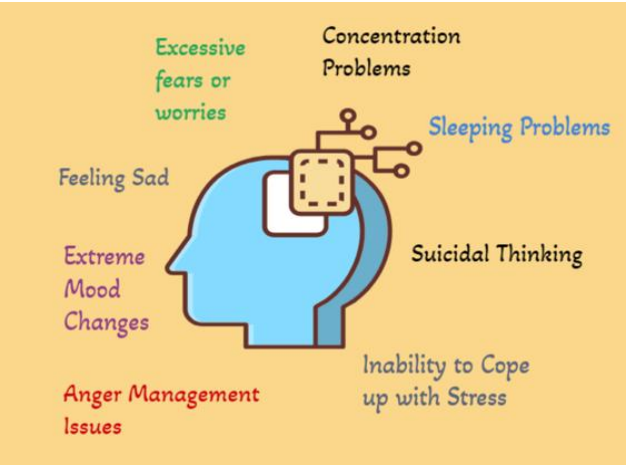

Fig. 2. Symptoms of Mental Illness

1.2 Benefits of using VR in mental health interventions

In the field of health interventions, virtual reality (VR) has shown potential. VR can create realistic environments to address mental health concerns by immersing individuals, in computer-generated worlds [9]. Here are some potential benefits of using VR in health interventions:

i. **Enhanced Exposure Therapies:** With VR, therapists can recreate triggering situations in an environment making exposure therapy more manageable for individuals, with phobias, post-traumatic stress disorder (PTSD) or anxiety related conditions. Gradually exposing individuals to their fears. Traumas helps them desensitize and reduce their symptoms [10].
ii. **Safe and Controlled Setting:** VR provides a controlled space where individuals can navigate scenarios without worrying about real world consequences. This controlled exposure can increase patient's sense of security and safety [11].
iii. **Customization and Personalization:** Virtual Reality (VR) treatments can be tailored to meet the needs and unique challenges of each person. Therapists have the ability to modify the environment, circumstances and difficulty levels according to requirements of each patient [12].
iv. **Remote Accessibility:** VR therapies offer the advantage of being accessible from a distance. This provides convenience and accessibility, for individuals who face limitations or physical impairments that make it difficult for them to receive treatment methods [13].
v. **Participation and Motivation:** The immersive nature of VR has the potential to enhance patients' motivation and engagement during therapy sessions. The interactive experience fosters involvement, ultimately reducing treatment failure rates while maintaining patients' motivation throughout their journey [14].

1.3 Challenges of using VR in mental health interventions

The following are some potential advantages of employing VR in interventions for mental health:

i. **Cost and Easy access:** The cost of VR technology makes it less readily available to some people and medical facilities. Costs, though, are probably going to go down over time as technology develops [15]. The implementation of VR demands specific equipment investments for headsets and motion sensors and compatible computers as well as licensed therapeutic software and continuous maintenance. The specialized equipment makes VR inaccessible to clinics with limited resources and community mental health centers and people from low-income backgrounds. The operational costs increase when clinicians need training to effectively use the technology during the initial adoption phase. Reimbursement poses another challenge. Health insurance providers have not established coverage for VR-based treatments which restricts their practical use in clinical settings. Traditional therapeutic approaches receive standard insurance coverage and need minimal technological infrastructure. The expected reduction in costs due to technological advancement does not address the current economic obstacles that restrict VR intervention scalability and equity. Public funding together with insurance support and affordable VR solutions are necessary to prevent restricted access to well-funded institutions and private practices.
ii. **Ethical Issues:** VR therapies expose participants to simulated uncomfortable scenarios that could create ethical issues regarding upsetting or hurting patients who are already in a vulnerable state [16].
iii. **Technical Problems:** When therapeutic sessions are disrupted by technical errors or malfunctions, patients and therapists may become frustrated or distracted [17].
iv. **Data security and privacy:** VR therapies may gather private information about patients' feelings, reactions, and behaviors. In order to keep patients' trust, it is essential to guarantee the privacy and security of this data [18].
v. **Incorporation with Conventional Therapy:** It can be difficult to incorporate VR therapies with conventional therapeutic modalities. In order to use VR efficiently and effortlessly incorporate it into their current therapeutic practices, therapists need to undergo specialized training [19].
vi. **Evidence of Efficacy:** While preliminary research on VR based therapies is encouraging, further research is required to determine its long-lasting efficiency and evaluate it against conventional therapeutic approaches [20].

1.4 Ethical issues related to using VR in mental health

VR has showed potential in a number of therapeutic applications for mental health, including exposure treatment, training in mindfulness, stress management, and cognitive behavioral therapies. However, there are ethical issues that need to be carefully explored, just like with any technology utilized in healthcare [21].

i. **Privacy concerns:** VR systems frequently need access to user data and information, including sensitive mental health information, behavioral trends, and physiological data. Maintaining patient trust depends on guaranteeing the integrity and anonymity of this data. Unauthorized utilization, security breaches, or improper handling of sensitive information could cause substantial psychological and social harm to people [22].
ii. **Informed Consent:** Patients' informed consent should be obtained before using VR for mental health treatment. People should be informed about the goals of VR therapy, potential hazards, and any data collecting that will occur during the sessions. Patients should have the knowledge necessary to understand what their involvement comprises and the freedom to decide whether to continue with the therapy on their own.
iii. **Adverse impact:** Virtual reality therapy has the potential to have both beneficial and negative impacts. During VR sessions, some people may feel uneasy, anxious, or even have their symptoms worsen. Psychologists as

well as researchers should keep a careful eye on participants throughout sessions and set up procedures to deal with any unfavorable reactions right away. Continual screening and appropriate evaluation help in minimizing harm [23].

iv. **Inclusivity and accessibility:** These are considerations when it comes to VR therapy. Not everyone may have access to this type of treatment due to disabilities, sensory impairments, or economic constraints. To avoid widening the gap in healthcare access, it is crucial that VR therapy is designed with inclusivity in mind [24].

v. **Technology Dependence:** While VR technology can be a tool for health treatment it should not replace face to face therapy or other traditional forms of support. Over reliance on VR technology could inadvertently discourage individuals from seeking the connection and support that comes from interaction. Therefore, it is important to view VR as a complement to established practices than a complete replacement [25].

vi. **Long-term effects:** Effectiveness of VR therapy in treating illnesses is still being studied. It is essential to conduct research to understand how long the treatment effects last whether people become desensitized to virtual reality stimuli over time and how well their skills acquired in environments translate into real life situations [26].

vii. **Standardization and Effectiveness:** With the increasing use of reality, in health interventions ensuring their effectiveness becomes paramount. Standardization measures must be put in place to guarantee that these interventions deliver results consistently. To ensure the integrity of therapy and ethics it is essential to establish standards for VR therapy protocols, therapist training programs and best practices in development [27].

viii. **Connections between Therapist and Patient:** The traditional dynamics, between therapists and patients may undergo changes when incorporating VR into therapy. Therapists must navigate this transformation carefully to integrate technology while maintaining an alliance [28].

ix. **Data Management and Utilization:** The data gathered throughout VR counselling sessions, including psychological data and performance information, may be used for research or distributed with other parties. The ownership of the data, its intended uses, and the level of patient control over those uses should all be made apparent to patients [29].

In a nutshell while virtual reality (VR) has the potential to completely change how mental health treatments are delivered, its use should be constrained by ethical standards. Key factors in maintaining the ethical and successful use of VR include privacy, informed permission, potential negative impacts, inclusion, and continuous study. The research aims to perform a bibliometric analysis which evaluates VR mental health treatment trends and influential publications and research areas. The research aims to identify present gaps in literature and propose future research directions through bibliometric indicators.

2. Related Work

This study investigates the work done by various authors in improving mental health with the help of VR. It also includes the applications developed for meditation and relaxation purpose using VR [30].

2.1 Based on VR applications

Based on the funding amounts authors provided a breakdown of VR applications that have been developed to treat health conditions on a country, by country basis. The compilation includes projects and their sources of funding aiming to provide insights into the landscape of VR interventions [31]. Table 1 provides information on the financing dynamics that influence these advancements making it a valuable resource for researchers, policymakers and practitioners seeking an overview of VR applications, in mental health worldwide [32].

2.2 Based on Mental Health Issues

Recent years have seen unprecedented developments in the understanding and treatment of complex illnesses like schizophrenia, dementia, psychosis, and fibromyalgia due to the convergence of technology and mental health research. Virtual reality (VR) has emerged as an engaging tool that offers a perspective, on understanding different mental health issues [33]. The purpose of this literature review is to explore the applications of reality in gaining a deeper understanding of fibromyalgia, dementia, schizophrenia, and psychosis. In this section we delve into the potential of reality as a platform for both diagnosis and intervention strategies through an examination of relevant research [34]. By immersing individuals in environments, we can gain insights, into the daily experiences faced by those living with these conditions [35]. This section provides descriptions of these health conditions based on the work conducted by various authors.

i. **Schizophrenia:** Patients suffering from Schizophrenia often experience emotional instability, a lowered mood, social withdrawal, and loneliness can result from these factors. VR is used as a simulation tool in exposure therapy for anxiety-related disorders, but defined avatar therapies for schizophrenia's negative symptoms which focuses on interactive VR.

ii. **Dementia:** The mental ability of a person who has dementia has declined from weeks to decades earlier. When someone has dementia, they frequently struggle with memory, but they may also struggle with direction, language, planning, judgement, and attention. Dementia is caused by brain disease or injury. Medical diseases that begin in other places of the body may cause it. A person's ability to think may be impacted, for example, by a blood clot that starts in the heart, travels to the brain, and blocks blood flow to a specific area of the brain. Dementia-causing disorders frequently have brain-based origins. Alzheimer's illness, which affects roughly 7 million individuals in the US, is one of the most prevalent diseases. Alzheimer's disease risk increases with ageing. The brain is most impacted by a number of common age-related illnesses, such as Alzheimer's and stroke, when dementia develops [36].

iii. **Fibromyalgia:** The symptoms of fibromyalgia, a chronic illness, include fatigue, discomfort in specific regions, and generalized musculoskeletal pain. Irritable bowel syndrome, migraines, and mood disorders are among the several illnesses that frequently coexist with this intricate ailment. Although the precise a etiology of fibromyalgia is unknown, a combination of genetic, environmental, and psychological factors is thought to be involved. Table 2 displays the comparison between Schizophrenia, Dementia and Fibromyalgia based on different parameters in context to Virtual Reality [37]. Table 3, describes the comparison of VR studies with traditional studies in terms of mental health [23, 27].

Table 1. Comparison of Applications on the basis of Countries

Application Name	Funding (Million US Dollars)	Area Covered	City/ Country
Oxford VR	4.2	Fear of Heights, Psychosis, Anxiety	Oxford, United Kingdom
Openmind 360	0.14	Mental Health amongst Teenagers	Israel
MindCotine	0.13	To break off the Smoking habit	California
Happinss	0.27	Stress Management amongst employees	California
AppliedVR	Not Disclosed	Anxiety and chronic and acute pain in a hospital environment	California
Rendever	0.04	Depression and isolation among the elders	Massachusetts
Virtue Health	Not Disclosed	Heart Disease, Dementia, Arthritis, Menopause	London
Cognitive Leap Solutions	Not Disclosed	To check attentivity level among children	Pasadena
Psious	1.2	Biofeedback and personal therapy amalgamated with VR	Spain
Limbix	7	Mindfulness, Addiction and Fears	California

Table 2. Comparison between Schizophrenia, Dementia and Fibromyalgia

Parameters	Schizophrenia	Dementia	Fibromyalgia
Nature of Condition	Severe mental disorder characterized by distorted thinking, perception, and emotions.	Progressive decline in cognitive function affecting memory, reasoning, and daily activities.	Chronic pain condition characterized by widespread musculoskeletal pain and fatigue.
Potential VR Applications	Cognitive training, social skills development, exposure therapy.	Cognitive stimulation, reminiscence therapy, virtual reminiscence.	Pain distraction, relaxation, mindfulness, gentle exercise.
Challenges in VR use	Sensory overload, potential exacerbation of symptoms, ethical concerns.	Adaptation to varying cognitive abilities, potential confusion.	Patient comfort, potential exacerbation of symptoms, adaptability to physical limitations.
Evidence and Research	Growing research, positive outcomes in some areas, ongoing exploration.	Expanding research, positive impact on well-being and mood.	Limited evidence, positive impact on pain perception in some cases.
User Engagement	Varied response due to symptom severity, willingness to engage.	Potential for positive engagement, depending on cognitive abilities.	Moderate engagement, depending on symptom fluctuations.
Adaptability to VR Technology	Potential challenges due to paranoia, hallucinations, or negative symptoms.	Variable adaptability depending on the stage and type of dementia.	Generally adaptable, depending on individual comfort and physical limitations.
Diagnostic Tools	Structured Clinical Interviews for DSM-5 (SCID)	Mini-Mental State Examination (MMSE), Clinical Dementia Rating (CDR)	Widespread Pain Index (WPI), Symptom Severity (SS) Scale
Cognitive assessment	MATRICS Consensus Cognitive Battery (MCCB), Brief Assessment of Cognition in Schizophrenia (BACS)	Montreal Cognitive Assessment (MoCA), Addenbrooke's Cognitive Examination (ACE)	Fibromyalgia Impact Questionnaire (FIQ), Revised Fibromyalgia Impact Questionnaire (FIQR)
Symptom Severity Scales	Positive and Negative Syndrome Scale (PANSS), Scale for the Assessment of Negative Symptoms (SANS)	Neuropsychiatric Inventory (NPI), Behavioral Pathology in Alzheimer's Disease (BEHAVE-AD)	Visual Analog Scale (VAS) for pain, Patient Global Impression of Change (PGIC)
Psychosocial Functioning	Global Assessment of Functioning (GAF), Personal and Social Performance (PSP) Scale	Functional Assessment Staging (FAST), Activities of Daily Living (ADL)	Fibromyalgia Impact Questionnaire (FIQ), Health Assessment Questionnaire (HAQ)
Virtual Reality Tools	Virtual Reality Cognitive Training, VR-based Social Skills Training	VR Cognitive Stimulation, Virtual Reality Reminiscence	VR Relaxation Environments, Virtual Reality Distraction Therapy
Pain Assessment	McGill Pain Questionnaire, Brief Pain Inventory (BPI)	Pain Assessment in Advanced Dementia (PAINAD), Abbey Pain Scale	Widespread Pain Index (WPI), Pain Catastrophizing Scale (PCS)

Table 3. Comparison of VR studies with traditional studies

Aspect	Virtual Reality (VR) Studies	Traditional Studies
Immersion	High sensory immersion (visual, auditory, sometimes haptic)	Low to moderate immersion, often limited to verbal or written interaction
Ecological Validity	High; simulates real-world environments and scenarios	Often lower; based on hypothetical or controlled lab tasks
Control over Variables	High; researchers can manipulate environments precisely	Moderate to high; control varies by design (lab vs. real-world)
Engagement and Motivation	Typically high due to interactive and novel experience	Variable; can be lower in passive formats (e.g., talk therapy, surveys)
Measurement Capabilities	Can include real-time behavioral and physiological tracking (e.g., eye-tracking, HR)	Often limited to self-report, observation, or clinical assessments
Therapeutic Exposure	Safe, controlled exposure to triggers (e.g., phobias, PTSD)	Often relies on imagination or real-life exposure
Accessibility and Cost	High initial cost; limited accessibility in low-resource settings	Generally more accessible and cost-effective
Personalization	High; environments can be tailored to individual needs	Varies; depends on therapist's flexibility
Replicability	High; scenarios can be exactly reproduced across participants	May vary due to therapist or environmental differences
Training and Expertise	Requires technical training and VR setup expertise	Requires clinical training, less technology-focused
Ethical Considerations	Risks of cybersickness, dissociation, or overexposure	Fewer technology-related risks, but still ethical challenges in exposure
Evidence Based	Emerging, promising but still under development	Extensive and well-established

2.3 Usage of Mobile Multimedia, Technology, and Mobile VR in Mental Well-being

There have been exciting developments in mobile multimedia and VR that could really help with mental well-being. Mobile devices that use multimedia content like sounds, visuals, and interactive features make it easier for people to access mental health support tailored just for them. Apps that use these technologies can help with things like reducing stress, managing anxiety, and aiding cognitive recovery, and more and more studies are backing up how effective they can be. Mobile VR has caught people's attention because it offers experiences that really help with relaxation, mindfulness, and managing emotions. By creating environments that support deep focus and meditation, VR apps have been shown to ease symptoms of anxiety and depression. These tools are becoming more popular for mental health care, giving users a sense of being present that other methods might not provide. The combination of mobile technology and VR is broadening the availability of mental health support, creating solutions that can reach people all around the world. Table 4 provides a clear overview of how these technologies are applied in mental health, along with their impact and examples of existing applications [41, 42].

Table 4. Applications of Mobile Multimedia, Technology, and Mobile VR in Mental Well-being

Technology	Application	Impact on Mental Well-being	Examples
Mobile Multimedia	Stress and Anxiety Management	Provides guided relaxation, mindfulness exercises, and emotional regulation techniques through audio and visual content.	Headspace, Calm, Moodfit
Mobile Technology	Cognitive Behavioral Therapy (CBT) and Support	Offers on-demand therapy tools, tracks emotional health, and provides support for behavior modification.	Woebot, Youper, MindShift
Mobile VR	Immersive Meditation and Relaxation	Reduces stress and anxiety by immersing users in calming, virtual environments, promoting mindfulness and relaxation.	Oculus Relax, Tranquil VR, VR Mindfulness
Mobile VR	Exposure Therapy	Helps individuals face and reduce phobias or PTSD symptoms by recreating real-life scenarios in a controlled virtual space.	Limbix, Bravemind

3. Materials and Methods

The methodology comprises bibliometric analysis to identify immersive or novel technologies that have been employed to promote mental wellness with the help of VR based on the literature. A systematic examination of the literature in a particular topic serves as the foundation for bibliometric analysis, a method commonly employed to gauge scientific output [38]. The research does not include original data acquisition. The study depends on bibliometric analysis of published literature which faces potential limitations from the original research sources' scope accuracy and biases.

Its goal is to record and thoroughly describe the behavior of various variables evaluated across a number of predetermined intervals in order to quantify and assess the research that has already been done on a certain topic [38, 39, 40]. There are three phases to this study: Document search, bibliometric analysis, and Comparative analysis. Figure 3 represents the complete methodology of this study.

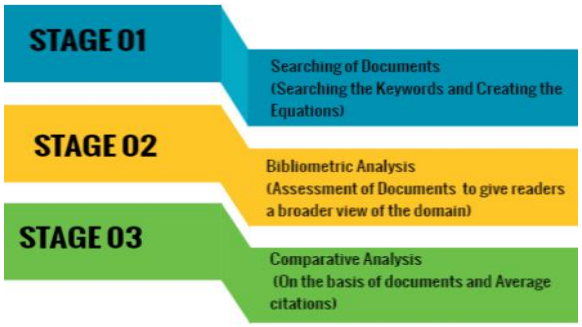

Fig. 3. Various stages of methodology

3.1 First Stage: Searching for Documents

The papers that will be used in the bibliometric study were found through search. The set of keywords that would be used in the search equation were first defined. Based on the searching methodology, we were able to extract seven datasets, and the precise search equation utilized in this study for each dataset is as follows where TITLE-ABS-KEY function is denoted by Φ:

Φ ("mental illness "∩" Virtual Reality")
Φ ("schizophrenia "∩" Virtual Reality")
Φ ("Dementia "∩" Virtual Reality")
Φ ("Fibromyalgia "∩" Virtual Reality")

3.2 Second Stage: Bibliometric Analysis

After the initial stage, a bibliometric analysis has been carried out and for this purpose "Biblioshiny" has been used. The bibliometric data was extracted from the Scopus database because of its broad coverage of peer-reviewed literature. The analysis was performed using VOSviewer and Bibliometrix (R package) to create co-authorship networks, keyword co-occurrence maps, and citation trends. The datasets have been extracted in the form of Comma separated values (CSV) files having an extension .csv and later on they were loaded into the bibliophagy tool to retrieve annual growth rate, average number of citations per document, most frequent words used for all the papers published till 2023 for all the seven datasets. Bibliometric analysis was chosen over traditional systematic reviews or meta-analyses because it allows for the quantitative assessment of research trends, key contributors, and thematic evolution in large-scale literature, which is particularly suitable for mapping emerging interdisciplinary fields like VR in mental health.

3.3 Third Stage: Comparative Analysis

Finally, a comparative analysis will be conducted for all the seven equations on the basis of average citations per document, annual growth rate and total number of documents for the common timespan viz. 2009-2023.

4. Results and Discussions

This section aims at identifying the trends and patterns of using Virtual Reality in Medical domain specifically for the patients suffering from mental illness. For this purpose, a detailed bibliometric analysis was done covering various indicators such as annual scientific production, 3 field plot, average article citations per year and word cloud for all the seven equations which are described below:

4.1 Φ ("mental illness "∩" Virtual Reality")

4.1.1 Annual scientific Production

Figure 4 represents the annual scientific production from years 1995 to 2003 for the amalgamated usage of virtual reality with mental illness. The data reveals a temporal evolution in the number of articles published from 1995 to 2023, reflecting shifting trends in research activity. In the earlier years, notably from 1996 to 2004, there was a scarcity of publications, with intermittent spikes in 1995, 1997, and 1998. A notable upswing commenced in 2010, reaching its zenith in 2021 with 43 articles, suggesting a heightened interest or increased research focus during this period. While 2023 witnessed a decline from the peak, the 26 articles still indicate sustained activity. The data implies dynamic patterns in research output, possibly influenced by evolving academic interests, technological advancements, or external factors shaping the scholarly landscape over the years.

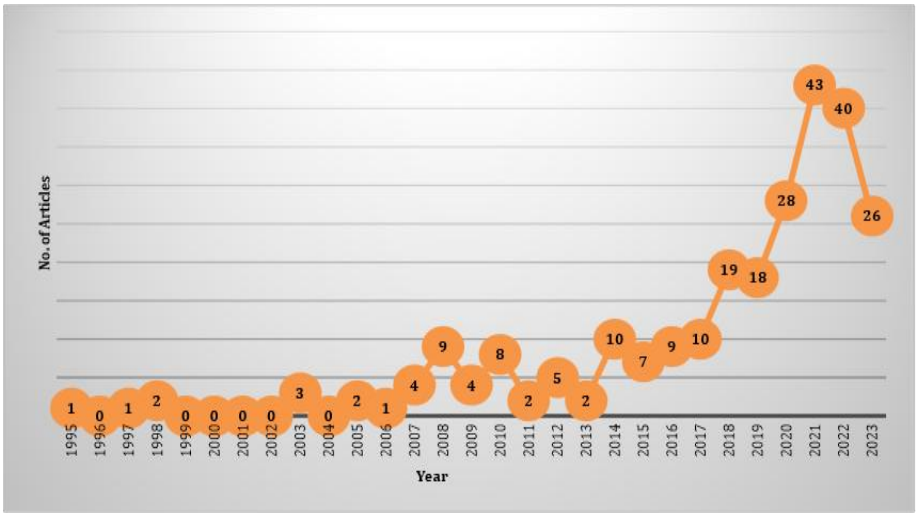

Fig. 4. Annual Scientific Production from 1995 to 2023

4.1.2 Average Article Citations per Year

Figure 5 depicts the average number of articles which are cited from 1995 to 2003 for the combined usage of Virtual Reality and mental illness. The provided data encompasses multiple variables related to research, including MeanTCperArt (Mean Total Citations per Article), N (Number of Articles), MeanTCperYear (Mean Total Citations per Year), and CitableYears (Number of Years with Citations). Notably, there is a diverse range of MeanTCperArt values across the years, suggesting variations in the impact of individual articles. The year 2017 is noteworthy, for its citation impact (MeanTCperArt) of 46.4 indicating a significant influence on average. However, there is a decrease in the citation impact dropping to 0.62 in 2023. Furthermore, the data on MeanTCperYear shows fluctuations in the citation impact with certain years exhibiting higher values like 5.60 in 2008 and 6.63 in 2017. This decline in MeanTCperYear over years culminating at 0.62 in 2023 suggests a shift in the overall influence and dynamics of citations within research output. Additionally, CitableYears reflects the number of years with citations which provides insights into the lasting impact of research over time. The decreasing trend observed in CitableYears reaching 1 by 2023 implies a decline in the long-term impact of articles published during that year. Overall, this data offers a nuanced depiction of evolving citation patterns and research impact throughout the years inviting investigation, into the factors influencing these trends.

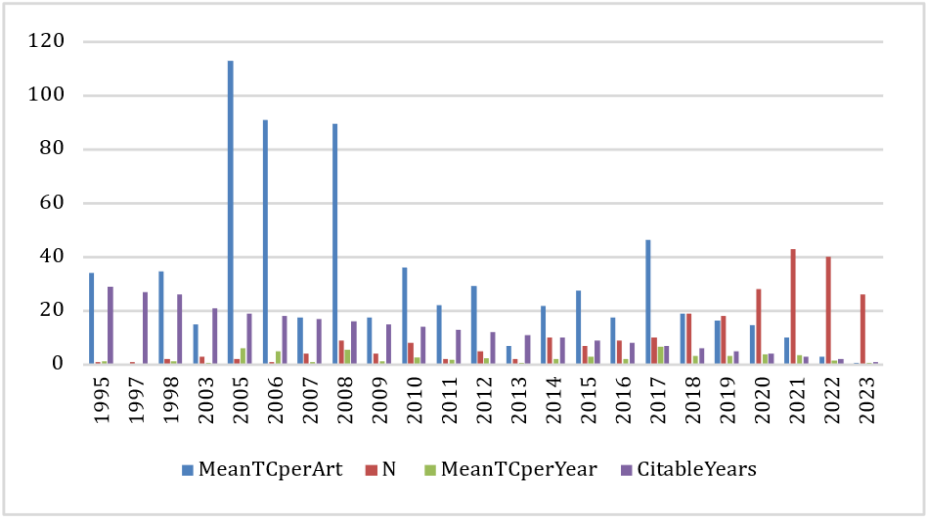

Fig. 5. Average Number of Articles cited per year from 1995 to 2023

4.1.3 Most Frequent words used and word cloud

In Figures 6 and 7 we can observe the words that appear frequently and their representation, in a word cloud. Analyzing the distribution of these terms gives us insights into the themes present in the dataset. It is noteworthy that "virtual reality" stands out as the used term with 204 mentions indicating a significant focus on this technology throughout the corpus. Additionally, there is an occurrence of terms related to "human," including variations such as "humans," "male," and "female." This further emphasizes the studies concentration, on subjects. The terms "mental health" and "mental disease" suggest a significant interest in psychological well-being, with "depression,"

"schizophrenia," and "anxiety" reflecting specific mental health concerns. The prevalence of terms like "adult," "middle-aged," and "young adult" indicates a diverse demographic focus within the research. Notably, the occurrence of "controlled study" suggests a methodological emphasis on rigorous experimental design. The word cloud generated from this data is likely to highlight "virtual reality," "human," and mental health-related terms as central themes, providing a visual representation of the key focus areas in the corpus.

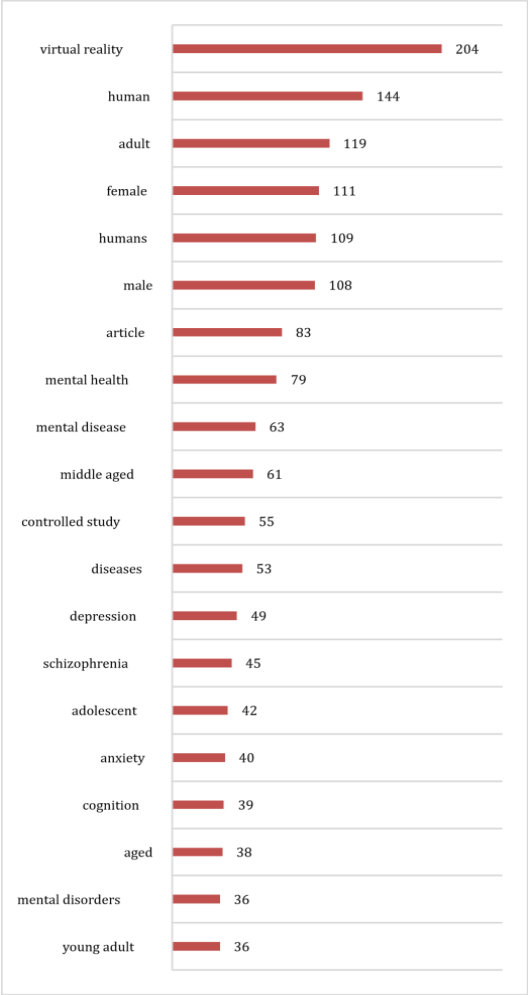

Fig. 6. Most Frequent words used in Mental Illness and VR Articles

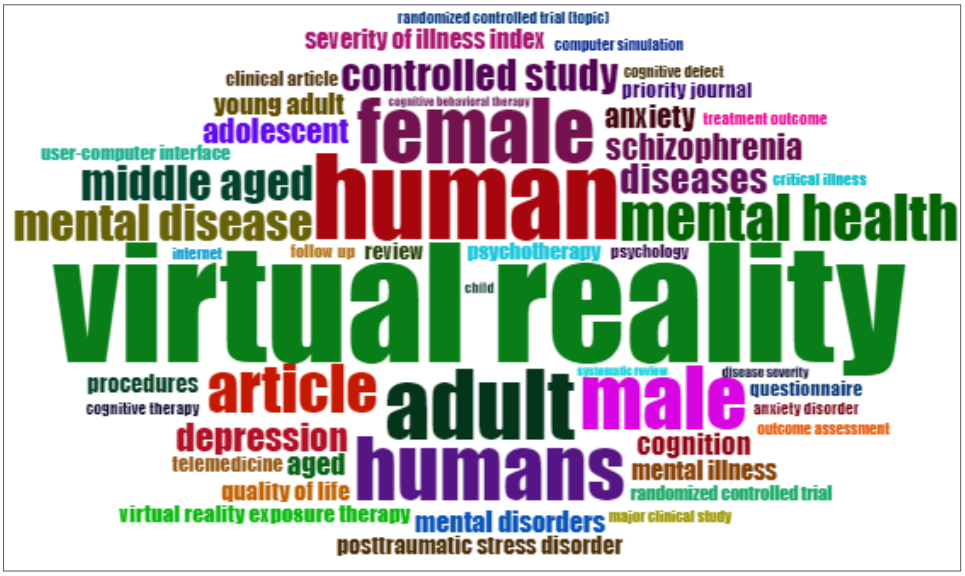

Fig. 7. Word cloud of Commonly used words in Mental Illness and VR Articles

4.2 Φ ("schizophrenia "∩" Virtual Reality")

4.2.1 Annual scientific Production

Figure 8 portrays the annual scientific production of Schizophrenia when combined with Virtual Reality. The data illustrates a notable and consistent upward trend in the number of articles focused on treating schizophrenia using Virtual Reality (VR) from 1995 to 2023. The early years show limited activity, with sporadic publications until 2003. Subsequently, there is a substantial increase, with the number of articles steadily rising each year. The data indicates a particularly significant surge in research output starting in 2014, reaching a peak of 63 articles in 2023. This suggests a growing interest and recognition of the potential of VR as a therapeutic tool for schizophrenia treatment. The progressive increase in the number of articles over time may reflect advancements in technology, a deepening understanding of VR's applications in mental health, or an expanding community of researchers and clinicians exploring these novel treatment approaches. The substantial growth in publications underscores the evolving landscape of schizophrenia research and the growing importance of VR interventions in the field.

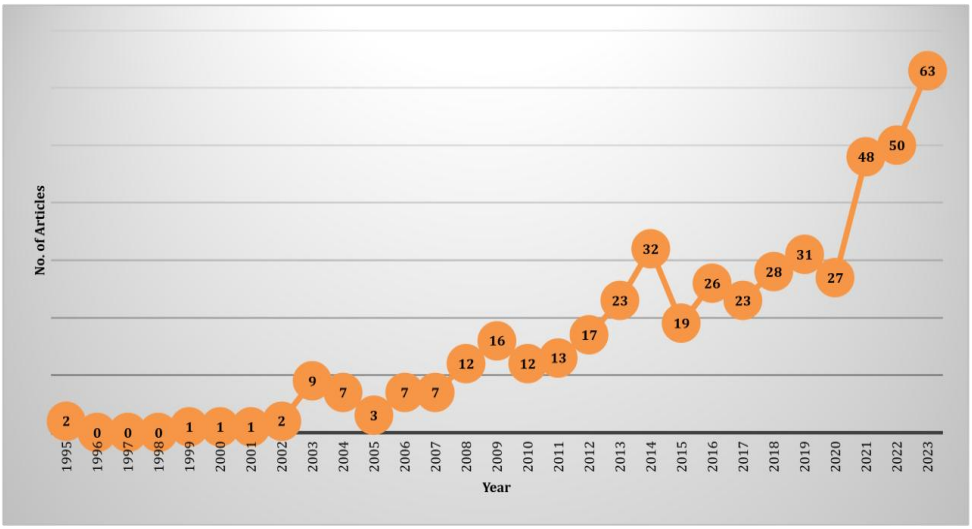

Fig. 8. Annual Scientific production for Schizophrenia and VR

4.2.2 Average Article Citations per Year

In Figure 9, we can see the number of articles that have cited the use of reality (VR), in treating schizophrenia. This data shows how these articles have influenced the field over the years. It is interesting to note that there are variations in the impact of studies as indicated by MeanTCperArt, which represents the total citations per article. From 1995 to 2005 there was a citation impact with a few spikes in certain years like 2003 and 2004. However, starting from 2006 there was a surge in MeanTCperArt reaching a peak of 38.14. This high peak continued in years such as 2007 and 2010 showing a lasting impact of VR based interventions for schizophrenia during this period. The trend of MeanTCperArt values persisted in 2013, 2016 and 2017 indicating that research conducted during these years continued to be significant. Even though there was a decline in MeanTCperArt in 2018 and 2019 compared to years the values

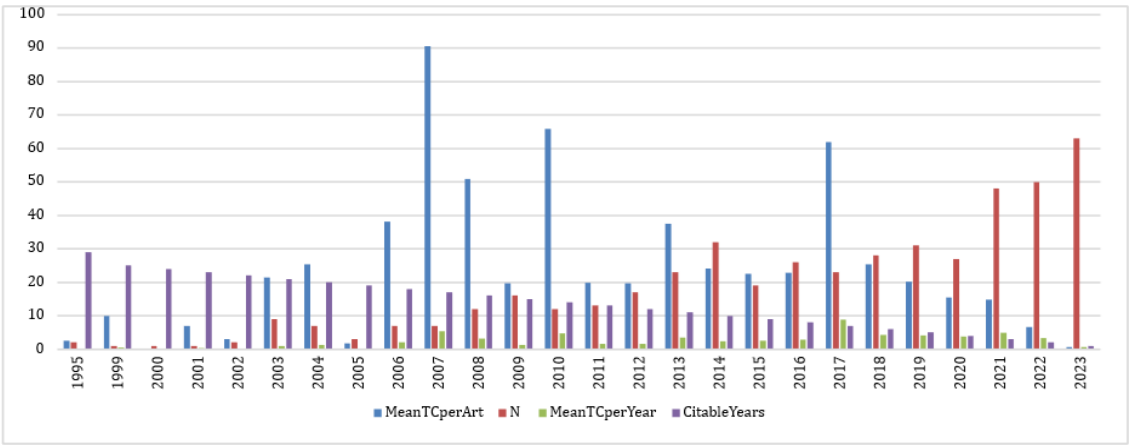

Fig. 9. Average Number of Articles cited for Schizophrenia and VR

remained relatively substantial suggesting an interest in the field. In years (2020 -2023) there seems to be a decreasing trend in MeanTCperArt which could potentially indicate that research, on this topic is maturing or becoming saturated. Nevertheless, it is important to acknowledge the impactful contributions and ongoing relevance of studies exploring how reality can be utilized for treating schizophrenia based on high MeanTCperArt values observed in earlier years.

4.2.3 Most Frequent words used and word cloud

In Figures 10 and 11, we can observe the used words when it comes to treating schizophrenia with the assistance of Virtual Reality (VR). Analyzing the frequency of these words, in the dataset helps us gain insights into the themes and areas of focus related to using VR for schizophrenia treatment. The term "schizophrenia" appears frequently indicating an emphasis on this mental health condition within the context of VR treatment where we can see a presence of " reality " suggesting extensive exploration of VR technologies in interventions for mental health. Words like "human," "adult," "male," and "female" highlight considerations regarding demographics emphasizing how VR treatments can be applicable across groups. Furthermore, terms such as "controlled study," " article," and "priority journal" demonstrate a scientific approach to investigating VR interventions for mental health. The inclusion of terms like "cognition," "psychosis," and "psychology" indicates a focus on aspects and psychological dimensions in research. Notably, specific therapeutic modalities like "virtual reality exposure therapy" are prominently featured, showing an interest in these types of interventions. Lastly mentioning the importance of the "user computer interface" reflects attention given to technological interface aspects, within VR applications. In general, the analysis thoroughly examines the use of reality (VR), in treating schizophrenia. It places importance on rigor demographic factors, cognitive elements and targeted therapeutic approaches.

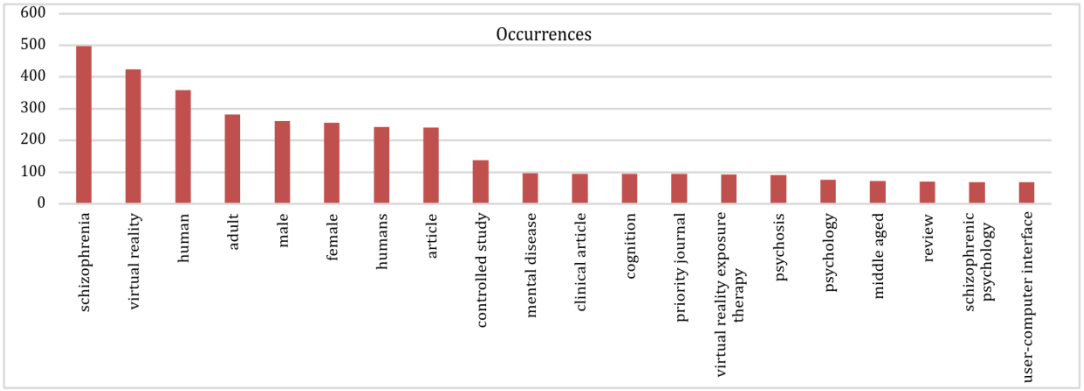

Fig. 10. Most Frequent words used for treating Schizophrenia with VR

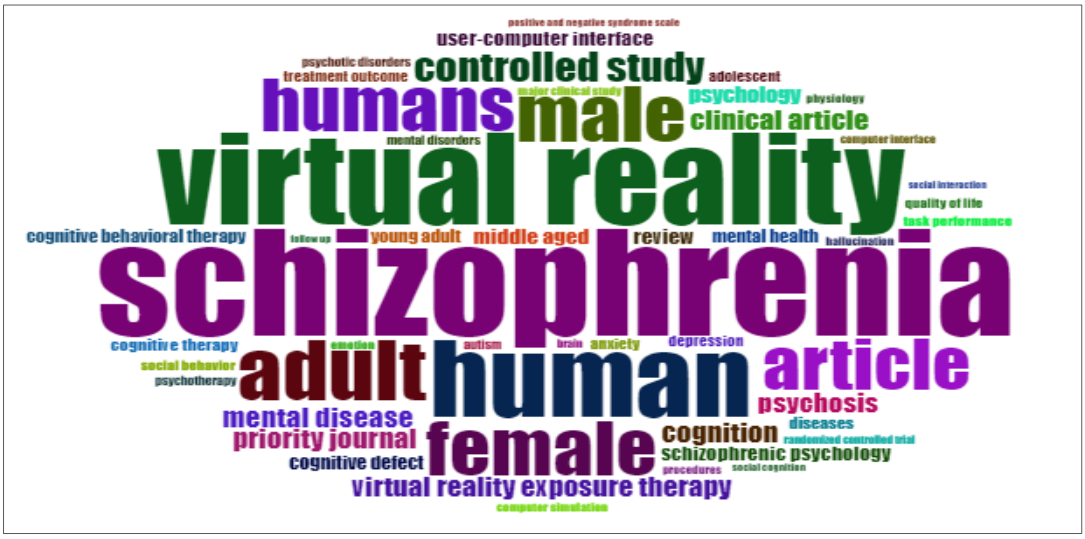

Fig. 11. Word Cloud for schizophrenia

4.3 Φ ("Dementia "∩" Virtual Reality")

4.3.1 Annual scientific Production

Figure 12 exemplifies the annual scientific production for treating Dementia using VR from 1998 till 2024. The dataset illustrates the annual distribution of articles over a substantial time span, from 1998 to 2024. The progression reveals a relatively modest output in the earlier years, with occasional peaks, such as in 2006 and 2007. Notably, a

significant upswing in the number of articles begins in 2011, marking a turning point in research activity. Subsequently, there is a steady and remarkable growth in publications, with particularly notable spikes in 2015, 2017, 2018, and 2021. The peak of 106 articles in 2022 is striking, signifying a substantial surge in research output. However, the data also indicates a decline in 2023, potentially suggesting a saturation or stabilization in the field. Overall, the dataset underscores a dynamic evolution in the quantity of publications, hinting at shifts in research interest, funding, or technological advancements, with the recent decline suggesting a potential re-evaluation or maturation of the topic in the most recent years.

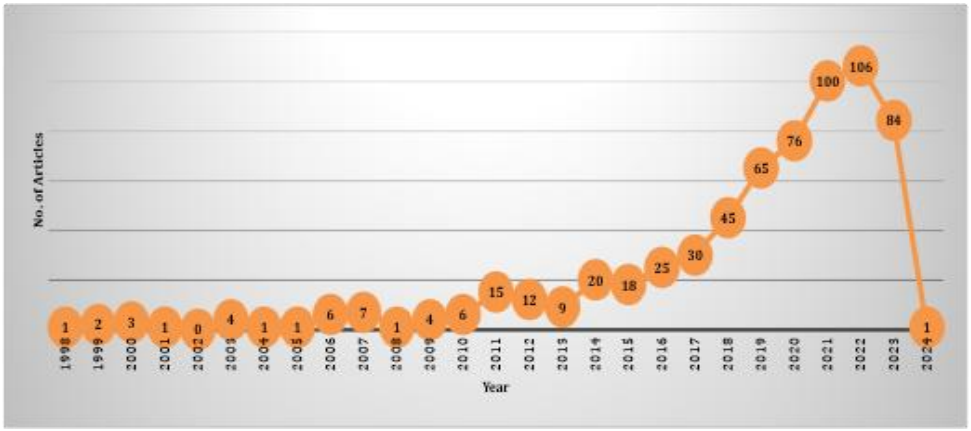

Fig. 12. Annual Scientific Production for treating Dementia with VR

4.3.2 Average Article Citations per Year

Figure 13 shows the number of articles cited from year 1998 to 2024 for the reducing the effectiveness of Dementia using VR. The dataset provides a comprehensive view of the citation impact and research dynamics over time. The "MeanTCperArt" column, representing the mean total citations per article, shows considerable variations across the years. The early years exhibit sporadic values, with a notable peak in 2004, likely indicating a singular high-impact article. The subsequent years show a mix of peaks and troughs, with 2012 standing out for a particularly high mean citation impact, suggesting a cluster of influential publications. The "MeanTCperYear" column, representing the mean total citations per year, provides insights into the average annual impact of the research. There is a general trend of variability, with peaks in 2004, 2008, 2012, and 2017, indicating years of heightened impact. The "CitableYears" column, representing the number of years with citations, shows a consistent pattern of sustained impact over time, with a decrease in recent years, potentially suggesting a decrease in the longevity of impact. Overall, the data suggests a dynamic landscape of research impact, with certain years and publications exerting a more profound and lasting influence, while recent years exhibit a decline, possibly indicative of a shift in research focus or saturation in the field.

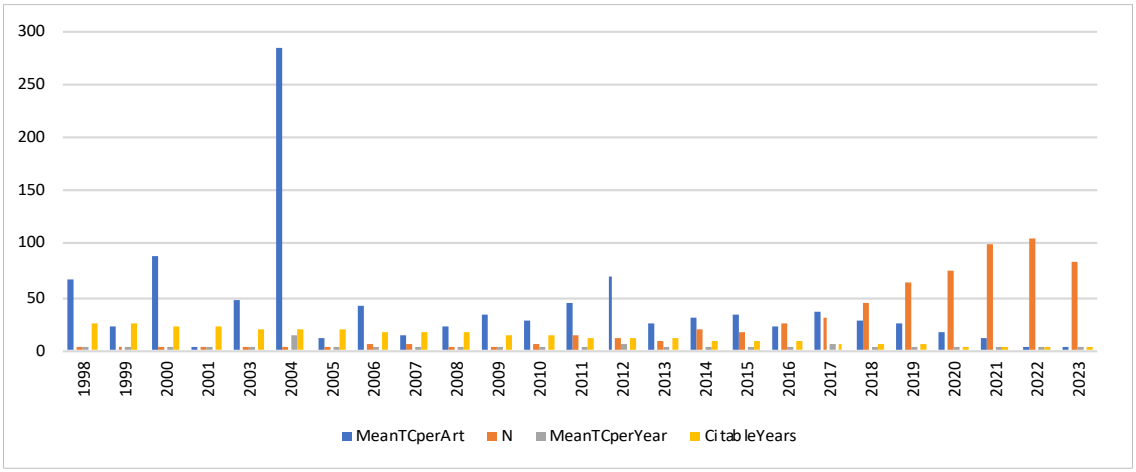

Fig. 13. Average number of Articles cited for treating Dementia using VR

4.3.3 Most Frequent words used and word cloud

In Figures 14 and 15 we can see the words that have proven effective in the treatment of Dementia using Virtual Reality (VR). The word cloud provides a representation of the distribution of these words. The term "virtual reality" appears frequently with a total of 577 mentions indicating an emphasis, on VR technology in relation to dementia treatment. The terms "dementia" and "human," were mentioned 417 and 365 times respectively highlighting the

intersection between reality and dementia research specifically its impact on human subjects. The terms "aged," "female," and "male" suggest that there is a focus on considering age and gender when exploring VR as a treatment for dementia. Additionally, terms like "cognition " " defect," and "cognitive dysfunction" reflect an interest in understanding and addressing aspects within VR based interventions. The presence of terms such as "controlled study" and "neuropsychological test" indicates that rigorous scientific methods are being employed in this research. Furthermore, including terms like "quality of life" demonstrates an approach, to dementia treatment that extends beyond factors. In general, the distribution of word frequencies highlights the dimensions of research focused on using reality to treat dementia. This research includes advancements, clinical considerations and psychosocial factors.

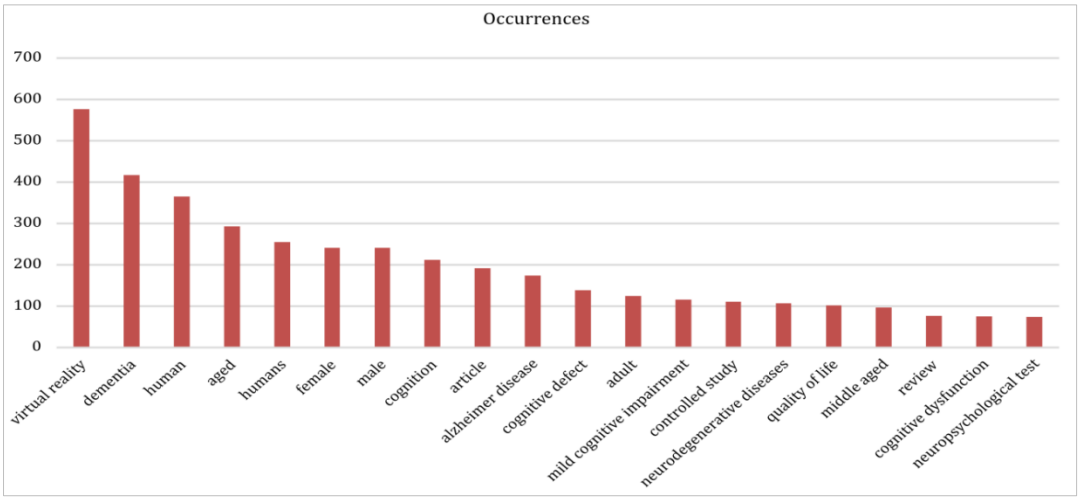

Fig. 14. Most Frequently used words for Dementia

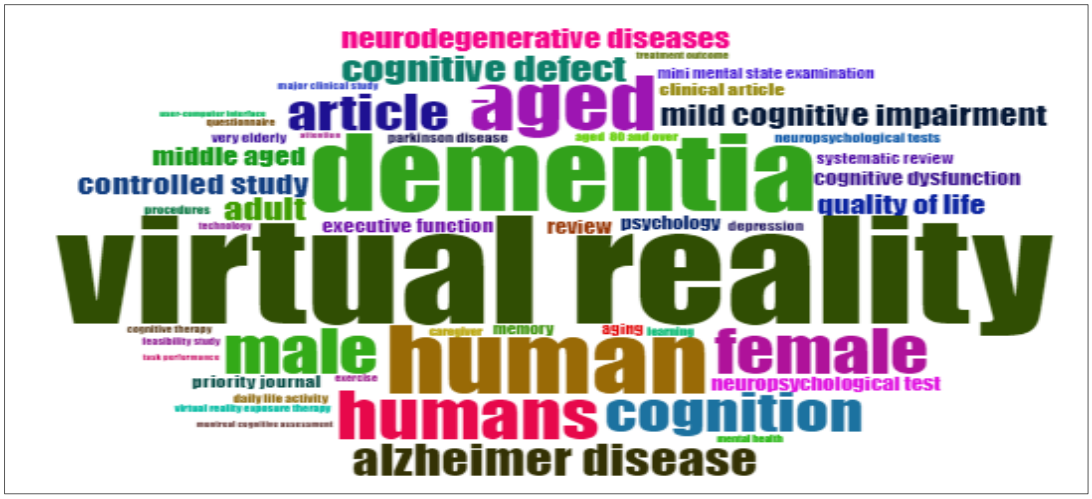

Fig. 15. Word Cloud of Dementia

4.4 Φ ("Fibromyalgia "∩" Virtual Reality")

4.4.1 Annual scientific Production

Figure 16 describes the annual Scientific Production for reducing the effect of Fibromyalgia using VR. The data presents the annual distribution of articles focusing on using virtual reality (VR) for the treatment or management of fibromyalgia. The trend indicates a gradual increase in research activity over the years, with a single article in 2009 and 2010, followed by a small but consistent rise in subsequent years. The highest number of articles is observed in 2019 with 7 publications, suggesting a peak in research interest during that period. The years 2020 and 2021 also show a relatively high number of articles, indicating sustained attention to the application of VR in addressing fibromyalgia-related concerns. The stability in the number of articles from 2020 to 2023 suggests a sustained and ongoing focus on this topic within the research community. The data implies a growing recognition of virtual reality as a potential tool in the exploration and development of interventions for fibromyalgia, possibly reflecting advancements in technology and a deepening understanding of its potential therapeutic applications in managing this condition.

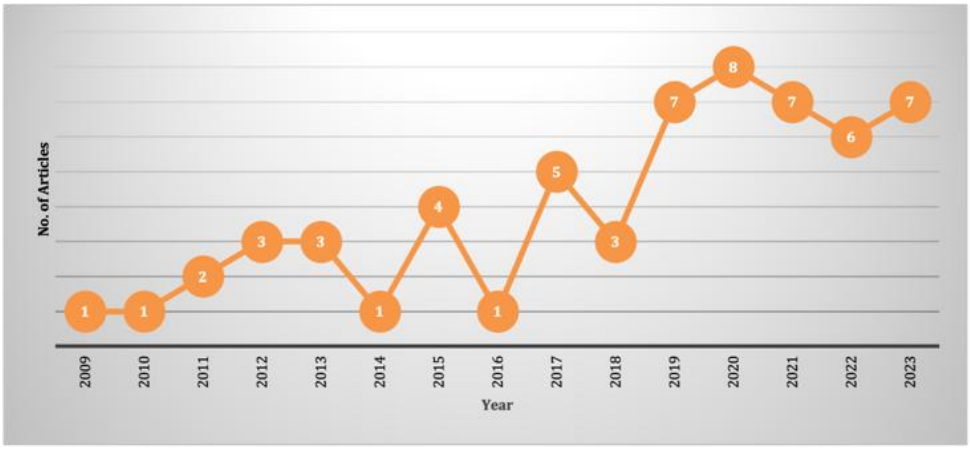

Fig. 16. Annual Scientific Production for treating Fibromyalgia using VR

4.4.2 Average Article Citations per Year

In Figure 17, we can observe the number of articles cited from 2009 to 2023 regarding the use of reality (VR), for treating Fibromyalgia. This dataset provides insights into the citation impact and research trends surrounding articles that focus on VR as a treatment for fibromyalgia over years. The column labeled "MeanTCperArt," which represents the citations per article demonstrates fluctuations over time. Notably, there was a peak in 2013 with an average of 155.67 citations per article indicating that a specific set of articles received attention and citations in that year. Subsequent years showed varying degrees of citation impact with a decline in 2023 suggesting either reduced impact or newer research being conducted. The "MeanTCperYear" column reveals the citations per year and highlights the variability in annual impact. In particular, 2018 stands out with a mean suggesting sustained attention and impact during that time period. The "CitableYears" column indicates the number of years with citations for each article which showcases a decrease over time. This might imply that recent articles have had a duration of impact compared to earlier ones. Overall, these findings demonstrate a landscape in terms of research impact where certain years and publications exerted longer lasting influence while recent years have shown a decline potentially due to shifting research focus or saturation, within the field.

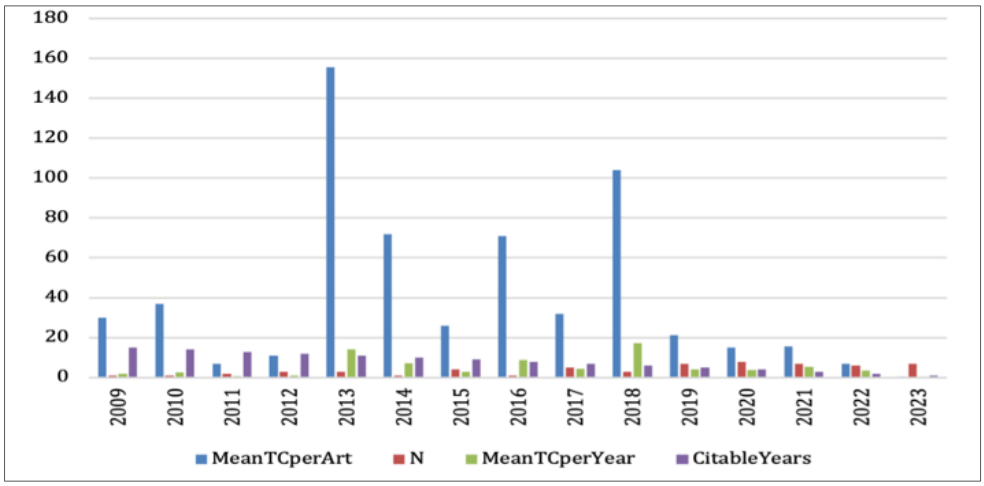

Fig. 17. Average number of Articles cited per year for Fibromyalgia

4.4.3 Most Frequent words used and word cloud

Figure 18 and 19 exemplifies the words which are used momentously by various authors for reducing the reverberations of Fibromyalgia along with the word cloud respectively. The data presents a frequency distribution of words related to the use of virtual reality (VR) for fibromyalgia. "Fibromyalgia" is the most frequently mentioned term, indicating a primary focus on this chronic condition. The occurrence of "human" and "humans" underscores the human-centric nature of the research, while the terms "virtual reality" and "virtual reality exposure therapy" emphasize the technological approach in managing fibromyalgia symptoms. The prominence of terms such as "chronic pain," "pain," and "analgesia" highlights the emphasis on addressing pain aspects, indicative of the therapeutic goals of VR interventions. The demographic focus on "female," "adult," and "middle-aged" suggests consideration of gender and age factors in the context of fibromyalgia research. Additionally, the presence of terms like "controlled study" and "review" signifies a methodological rigor and a systematic exploration of the existing literature. "Quality of life," "depression,"

and "exercise" underscore a holistic approach, acknowledging the broader impact of fibromyalgia and the potential role of VR in improving overall well-being. The data thus provides a snapshot of the key themes and considerations within the realm of using virtual reality for fibromyalgia, spanning technology, demographics, pain management, and psychosocial aspects.

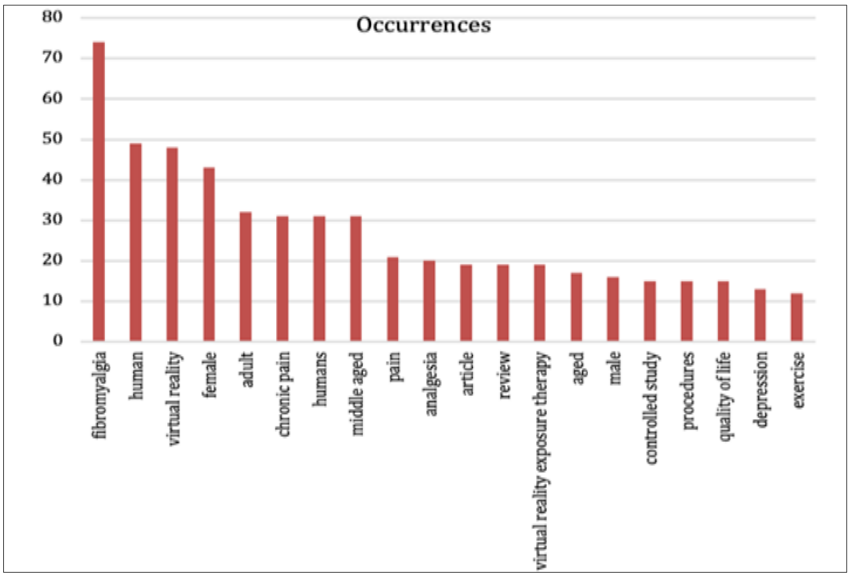

Fig. 18. Most Occurred words for Fibromyalgia

Fig. 19. Word Cloud for Fibromyalgia

5. Discussion

VR presents strong technological possibilities for mental health care but its successful implementation depends on multiple healthcare system components and human factors. The successful implementation of VR depends on healthcare provider readiness as well as patient engagement and structural healthcare system limitations.

5.1 Role of Healthcare Providers

The implementation success of VR in mental health interventions heavily depends on how much healthcare providers support and use the technology. Healthcare providers need to receive training for VR tools and also need to implement them effectively within current therapeutic approaches. Health providers tend to resist using VR because they are unfamiliar with technology and do not have enough time to train or doubt its clinical effectiveness. Healthcare providers need to modify their clinical procedures to support VR-based treatment sessions that differ substantially from standard therapeutic approaches. The implementation of VR in clinical settings requires training mental health professionals and establishing VR infrastructure and technical support systems. The adoption will remain limited without institutional readiness and professional development programs.

5.2 Patient Engagement and Acceptance

The willingness of patients to use VR determines its overall success rate. The adoption of VR technology depends on multiple factors including digital competency and comfort with immersive scenarios and the perceived value of VR scenarios and acceptance of new therapeutic methods. Older adults together with individuals who have little experience with digital technologies tend to feel uncomfortable and skeptical about using VR. The success of VR tools depends on their ability to be user-friendly and customizable and culturally sensitive to build trust and therapeutic alliance.

5.3 Healthcare System Constraints

The successful implementation of VR technology faces barriers from limited funding alongside unequal access to technology and fragmented mental health services. Public mental health services and those operating with limited resources face difficulties supporting and maintaining advanced digital interventions because they struggle to maintain sufficient staff and basic infrastructure. The absence of standardized guidelines together with regulatory frameworks for VR therapy acts as a barrier for institutions to adopt the technology on a large scale.

5.4 Interoperability and Integration

VR interventions must integrate with existing electronic health record (EHR) systems and follow standardized diagnostic and treatment protocols. VR applications will fail to achieve long-term sustainability because they need to integrate seamlessly with core healthcare procedures and data systems. VR deployment in mental health care requires a holistic approach which combines prepared providers with accepting patients and functional healthcare infrastructure. VR technologies require multidisciplinary approaches with system-oriented strategies to achieve their full potential in clinical practice.

6. Conclusion

It is concluded that through bibliometric analysis, the impact of virtual reality (VR) on mental health has been investigated. This research has yielded important insights into the current status of mental health research. The findings indicate a rising body of research examining the relationship between virtual reality technology mental health, indicating the acknowledgement of these variables as putative enhancers of wellbeing. More thorough study is obviously required, even though the literature now in publication offers encouraging directions for utilizing VR interventions in treating mental health concerns. The study has a limitation that it only includes publications that are indexed in the Scopus database, which may not include relevant research from other databases or grey literature. Furthermore, publication bias and differences in indexing standards may affect the comprehensiveness of the analysis. Although there are still knowledge gaps and the field is constantly developing, the selected studies provide a basis for comprehending the possible benefits. In the nutshell, it is clear that the field of using VR for mental health is dynamic and evolving, even though the bibliometric study only provides a picture of the current landscape. To fully realize the benefits of these therapies and offer evidence-based approaches to treating mental illness, further research and cooperation are required. For enhancing the comprehension and utilization of virtual reality therapies in mental health treatment, scientists, clinicians, and legislators must collaborate to create thorough investigations, exchange information, and give ethical concerns first priority. Most studies focus on short-term outcomes of VR therapy. Longitudinal studies are needed to evaluate its long-term effectiveness, retention of therapeutic gains, and potential adverse effects. The effectiveness of VR interventions shows different results among various demographic groups. The usability of VR technology becomes difficult for older adults to use while socioeconomic differences restrict the availability of VR technology to certain groups. Future research needs to analyze results through demographic variables to achieve inclusivity.

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Authors' Profiles

Sheena Angra is currently pursuing her Ph.D. in Virtual Reality (VR) with a focus on immersive technologies. With a robust academic background, including a BTech and MTech in Computer Science and Engineering, she brings a wealth of knowledge to her research. Boasting a decade of teaching experience, she is a dedicated educator specializing in immersive technologies in medical domain and data mining. Her valuable insights are evident in various research articles, reflecting her commitment to advancing the understanding of technology.

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