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The top 100 cited papers on mental health and virtual reality: a bibliometric analysis

Yimin Guan[a,b*], Yaqing Wang[a,b*], Dongmei Zhuang[c*], Wenzhuo Wei[b*], Lijun Ma[b], He Du[b], Chuan Fan[d] and Xiaoming Li[a,b]

[a]Department of Psychiatry, Chaohu Hospital of Anhui Medical University, Hefei, Anhui, China; [b]Department of Medical Psychology, School of Mental Health and Psychological Science, Anhui Medical University, Hefei, Anhui, China; [c]Department of Otolaryngology, Suzhou hospital of Anhui Medical University, Suzhou, Anhui, China; [d]Department of Psychiatry, The First Affiliated Hospital of Anhui Medical University, Hefei, China

ABSTRACT

Virtual reality technology has been widely applied in the field of mental health research. However, to date, no study has employed bibliometric methods to systematically analyze the application of virtual reality in mental health. By searching the Web of Science Core Collection, we have summarized the top 100 cited papers in this field and conducted the first bibliometric study on mental health and virtual reality using CiteSpace. The results indicate that this area has received considerable attention. The United States stands out as the most influential country. The University of London and Emory University are the leading contributing institutions. Rothbaum BO is the most productive author, and Cyberpsychology, Behavior, And Social Networking, is the journal with the most publications in this area. The primary focus of research in this domain is on virtual reality therapy for mental disorders, especially virtual reality exposure therapy for anxiety disorders. These findings may help researchers understand the current state and future trends in the field of mental health and virtual reality.

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KEYWORDS
Mental health; virtual reality; bibliometric analysis

1. Introduction

A report published by the World Health Organization reveals that approximately one-eighth of the global population suffers from mental disorders, which are a leading cause of years lived with disability (World Health Organization, 2022). Compared to the general population, individuals with mental disorders have a decreased life expectancy of 10–15 years (Solmi et al., 2022). In 2019, more than 1 in 100 individuals (1.3%) died by suicide (World Health Organization, 2023). Mental health is a basic human right, and it is not only crucial for individual health and well-being but also intimately connected with social and economic development. However, existing mental health services are inadequate in meeting the needs of the population. Most

CONTACT Xiaoming Li psyxiaoming@126.com Department of Psychiatry, Chaohu Hospital of Anhui Medical University, Hefei, Anhui 230032, China
*These authors contribute equally to this work.
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people suffering from mental health disorders worldwide do not receive any treatment, and those who receive treatment rarely receive effective treatment (Rudd & Beidas, 2020). Mental health issues have thus become a significant public health challenge (Evans-Lacko et al., 2018). Fortunately, due to the rapid advancements in technology, emerging tools like virtual reality (VR) are introducing new possibilities into the field of mental health.

In 1965, Ivan Sutherland introduced the foundational concept of VR in his paper (Sutherland, 1965). By 1968, he had developed the first head-mounted three-dimensional display connected to a computer (Sutherland, 1968). The term 'Virtual Reality' was formally coined by American scientist Jaron Lanier in the 1980s (Steuer, 1992). Since then, VR has seen further refinement and application. Now, common VR systems are desktop VR systems, immersive VR systems, augmented VR systems, and distributed VR systems. While each type of VR system has distinct features, they are collectively described as 'an advanced form of human-computer interface that allows the user to "interact" with and become "immersed" in a computer-generated environment in a naturalistic fashion' (Schultheis & Rizzo, 2001). They can simulate nearly natural, flexible, and intricate virtual environments, supporting natural interactions, behavior tracking, and record-keeping. VR has found applications in various fields, including education (Mikropoulos & Natsis, 2011), training (Ahlberg et al., 2007), healthcare (Hoffman et al., 2000), tourism (Guttentag, 2010), construction (Li et al., 2018), and games (McMahan et al., 2012), among others.

As early as the 1990s, the first set of studies began applying VR to the field of mental health (Gregg & Tarrier, 2007). Since then, subsequent researchers have developed a myriad of VR systems, used in research, assessment, diagnosis, and treatment of mental disorders. One of the seminal contributions in this space is virtual reality exposure therapy (VRET). Drawing upon the principles of exposure therapy, clinicians or researchers can employ computers to create personalized, interactive virtual scenes for users to immerse themselves in, leading to physiological and psychological changes. While researchers can rigorously control conditions and setting different levels as needed, users can safely experience fearful or dangerous situations and facilitates experiential learning through mistakes (Schultheis & Rizzo, 2001). Knowing that the computer-generated environment is virtual, users are often more willing to confront challenges in VR than they are in real life and are more open to trying new therapeutic strategies (Freeman et al., 2017). Importantly, gains in the virtual world can be transferred to real-life (Morina et al., 2015). Even with limitations in image realism and immersion in some VR systems, they can still achieve high ecological validity (Rizzo & Kim, 2005). VR exposure can serve as an alternative to imaginal exposure, obviating the need to rely on the patient's internal imagery or their ability to visualize, as the stimuli can be controlled by the therapist (Gregg & Tarrier, 2007). The sense of 'presence' offered by VR may enhance user motivation and engagement (Bell et al., 2020). Some VR systems incorporate gaming elements, further increasing user enthusiasm (Whyte et al., 2015).

In recent years, the rapid advancements in VR have served as a significant catalyst in this domain. With technological advancements, hardware development, and cost reduction, VR is gradually moving out of the laboratory and even into homes, gaining broader applications. Furthermore, the COVID-19 pandemic has brought a global mental health crisis. While stress and anxiety are increasing (Xiong et al., 2020), face-

to-face mental health services are facing obstacles, which makes people pay more attention to telemedicine. The combination of VR and telemedicine has great potential (Ong et al., 2022).

Citation analysis is a significant method in bibliometrics. Determining the number of times that a publication has been cited by other authors can evaluate its importance in a specific field and is one of the most widely used methods (Feijoo et al., 2014). While the number of citations does not necessarily reflect the quality of a paper, it is considered a direct measure of the recognition that an article has received within its field (Lefaivre et al., 2011). Analyzing the top 100 most-cited papers can help researchers understand the significant achievements in a particular area. This method has been applied across various disciplines and is especially popular in medical-related fields, For example, econometric analysis of trends in drug research and trends in bibliometric analysis (Luo et al., 2024; Taylor, 2024). To date, no bibliometric analysis has focused on the field of mental health and VR. This study aims to identify the areas within this field that have achieved outstanding research results by analyzing the 100 most cited papers. The goal is to highlight the direction of current research and provide a useful resource for researchers interested in studying VR and mental health. Additionally, the study seeks to uncover gaps in the existing research and suggest directions for future work.

2. Materials and methods

2.1. Search methods and inclusion criteria

A literature search was performed on 25 August 2023, using the Web of Science Core Collection (WOSCC). The search terms included two classes: mental health and VR (search terms in Supplementary Figure S1). There were no other restrictions on the search. The number of citations an article receives is considered an objective indicator of the importance and quality of the original research work (Seglen, 1997). The citation of a research article by multiple sources not only helps to disseminate its information within the medical community, but also helps the reader to understand it more carefully (Willis et al., 2011). Objective assessment of the quality of research work and scientific writing is important to raise the standard of future scientific work. The 'impact factor' of a journal is also calculated on the basis of the number of citations received in a year by all articles published in the journal in the last two years, and is a quantitative measure of the quality of the journal, the articles and the authors (Amin & Mabe, 2003). So the results were sorted in descending order by the number of citations.

2.2. Paper selection

Through screening titles, abstracts, and keywords, and reading the full text, when necessary, the 100 most-cited papers were finalized. Two independent reviewers undertook this task, and any disagreement was resolved by consensus involving the corresponding author. Only papers specifically targeting mental health and VR were included, and those partially related were excluded. Duplicate papers and those for which the full text could not be obtained were also omitted.

2.3. Data extraction and analysis tools

The following data were extracted for each paper: title, authors, journal, language, citation count, publication year, country, institution, keywords, paper type (based on the first record), and Web of Science subject categories. The country and institution were recorded based on the first author. The data were analyzed using CiteSpace 6.2.R4 and Microsoft Excel. CiteSpace parameter settings: time span from January 1995 to December 2020, with a time slice of 1 year, and all other settings as default.

3. Results

3.1. Top 100 most-cited papers

Supplementary Table S1 lists the top 100 most-cited papers based on the number of citations in WOSCC, arranged in descending order. The document types are Article (n = 83), Review (n = 15), Editorial Material (n = 1), and Note (n = 1), all published in English. The top 100 most-cited papers have been cited a total of 20 428 times, with a median citation count of 166, ranging from 119 to 793. The most frequently cited paper is 'Cognitive enhancers as adjuncts to psychotherapy – Use of D-cycloserine in phobic individuals to facilitate extinction of fear', with 793 citations, published in 2004 in Archives of General Psychiatry (Ressler et al., 2004). This paper investigated whether D-cycloserine (DCS) facilitates the extinction of fear in phobic individuals undergoing VRET.

The paper most cited in the last 180 days is 'Virtual reality in the assessment, understanding, and treatment of mental health disorders' by Freeman et al. (2017), with 57 citations. To control for the influence of the publication year on citation count, the annual citation rate was analyzed. The highest annual citation rate was also for 'Virtual reality in the assessment, understanding, and treatment of mental health disorders' by Freeman et al. (2017), with 79.17 citations.

3.2. Publication year

The 100 most-cited papers were published between 1995 and 2020, with the most publications occurring in the years 2008 and 2016, each having 9 papers (Figure 1).

3.3. Countries or regions

These papers originate from 17 different countries or regions. The United States contributes the most (n = 39, 39%), followed by the United Kingdom (n = 17, 17%), the Netherlands (n = 10, 10%), and Italy (n = 8, 8%). Other countries include Canada, Spain, Germany, Australia, France, South Korea, Switzerland, China, Brazil, Israel, Portugal, Romania, and Sweden (Table 1).

The papers from the United States have the highest number of citations, totaling 8,788. The network of country collaborations (Figure 2) has 23 nodes and 45 links. A betweenness centrality analysis of the nodes shows that the United States (centrality = 0.62) and the Netherlands (centrality = 0.27) are two key nodes, indicating they play a significant role in this field and have extensive collaborations with other countries or regions. While the

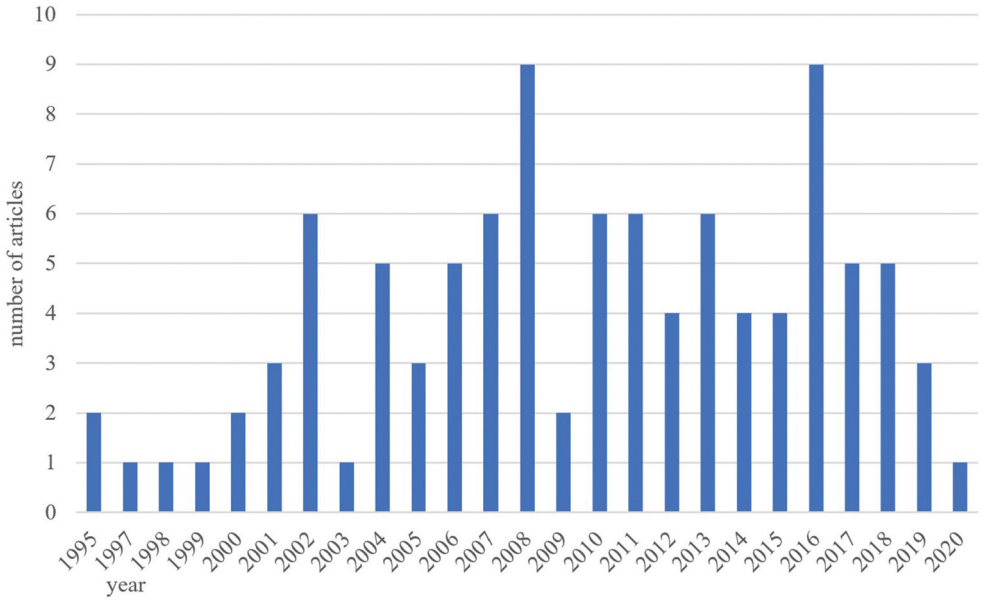

Figure 1. The year of publication and total citation frequency each year.

Table 1. Countries distribution.

Country	Number	Total citations	Average citations
USA	39	8,788	225
England	17	3,151	185
Netherlands	10	2,515	252
Italy	8	1,328	166
Canada	4	598	150
Spain	4	741	185
Germany	3	749	250
Australia	2	271	136
France	2	356	178
South Korea	2	266	133
Switzerland	2	316	158
China	2	286	143
Brazil	1	129	129
Israel	1	136	136
Portugal	1	124	124
Romania	1	349	349
Sweden	1	325	325

number of papers from the United Kingdom is greater than that from the Netherlands, its betweenness centrality is only 0.01, suggesting a less central role in international collaborations. At the same time, it shows that the contribution of the Netherlands in this field cannot be ignored, with a relatively large number of key research results. This may also be due to the concentration of publications by commercial publishers associated with the Netherlands and the United States (Basu, 2010).

We found that research investment is higher in high-income than in low-income areas, and we have also added a table. From the Figure 3, we can see that the publication volume of high-income countries is much higher than that of low-

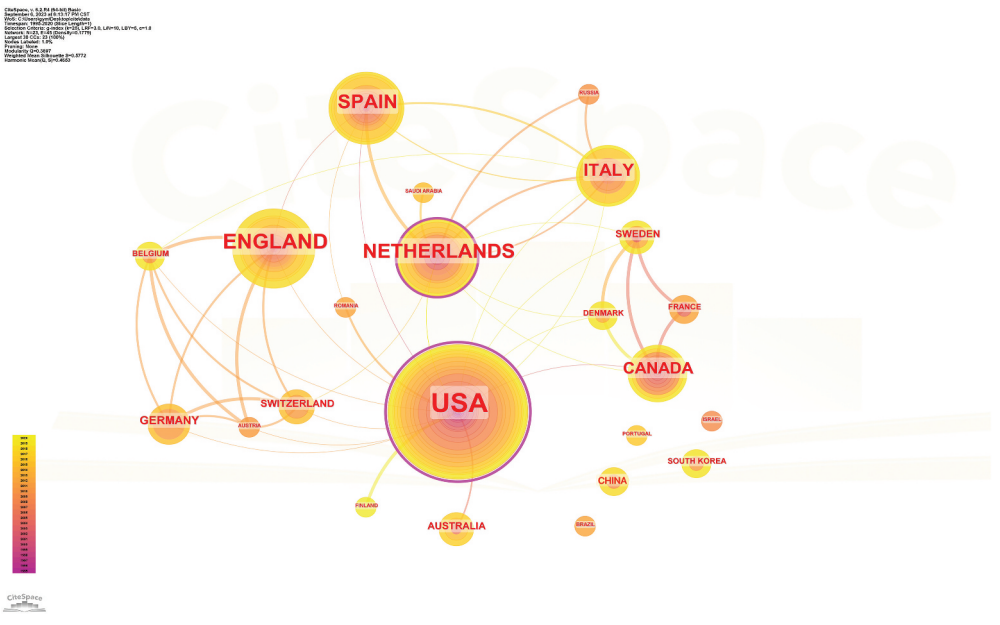

Figure 2. Network map of co-authorship between countries: the size of the points indicates the number of publications; the weight of the lines indicates the degree of closeness of cooperation; the color and thickness of each circle in the node represent the frequency of occurrence in different time periods; the colors of the links represent the time of the first co-occurrence; purple circles indicate nodes with high betweenness centrality (centrality ≥0.1).

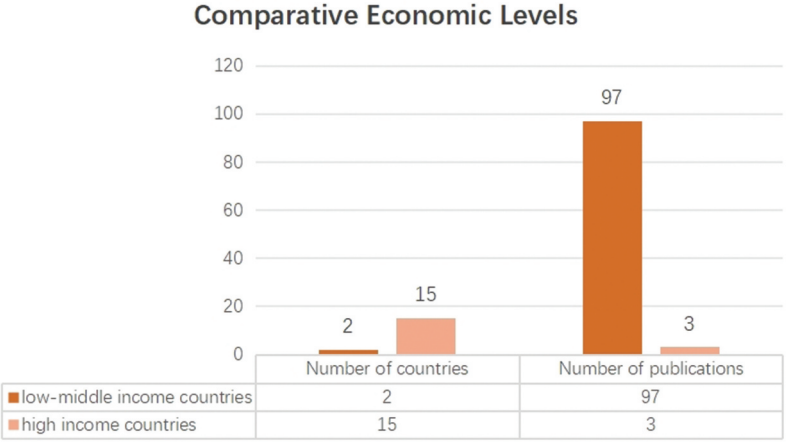

Figure 3. Comparative economic levels.

income countries, and high-income countries have a stronger monopoly in this field, and the constant citation and re-research lead to more and more abundant research in high-income countries, while low-income countries have difficulty in entering this field. Researchers in low-income countries have a need for more in-depth research in this area (Akre et al., 2011).

3.4. Journal distribution

The 100 most-cited papers are published across 60 different journals (Table 2). Of these, 17 journals have published more than one paper in the list, and for each of these journals, we present the number of papers, total citation counts, and the impact factor as of 2022. The journal with the most papers is Cyberpsychology, Behavior, And Social Networking ($n = 14$), followed by Behaviour Research and Therapy ($n = 6$) and Journal of Autism and Developmental Disorders ($n = 5$). Among these 18 journals, Lancet Psychiatry has the highest impact factor of 64.3, and 10 journals have an impact factor greater than 5.

3.5. Affiliation

The most-cited papers originated from 52 institutions, of which 12 institutions published two or more papers (Table 3). The University of London ($n = 10$) and Emory University ($n = 9$) contributed the most. Additionally, the University of Amsterdam, IRCCS Istituto Auxologico Italiano, and the University System of Georgia published seven, six, and five papers, respectively. In the institutional collaboration network created by CiteSpace (Figure 4), there are 162 nodes and 393 links, with Emory University serving as a key node with a betweenness centrality of 0.1.

3.6. Authors

A total of 14 scholars have published two or more of the most-cited papers as the first author (Supplementary Table S2). The most prolific among them is Rothbaum Barbara Olasov ($n = 7$), followed by Freeman Daniel ($n = 5$). Difede JoAnn, Riva Giuseppe, and Rizzo AA each served as the first author for three papers. Additionally, there are 15 individuals who have published two or more of the most-cited papers as the corresponding author (Supplementary Table S3). Rothbaum BO ($n = 7$) and Freeman Daniel ($n = 5$) remain the most prolific in this regard as well. Rothbaum BO has published a total of 12 of the most-cited papers as an author.

3.7. Web of Science subject categories

We extracted the Web of Science categories for each paper, using the first listed category for data analysis in case a paper belonged to multiple categories (Supplementary Table S4). The most frequently occurring category is 'Clinical Psychology' ($n = 27$), followed by 'Psychiatry' ($n = 18$) and 'Communication' ($n = 10$). These categories also have the highest total number of citations, with 'Clinical Psychology' 'Psychiatry' and 'Communication' garnering 6,265, 3,868, and 2,071 citations respectively.

3.8. Keywords

Keyword analysis can reflect popular research themes. This keyword co-occurrence map (Figure 5) revealed 286 nodes and 1,363 links. Based on the frequency and centrality of

Table 2. Journals distribution.

Source Title	Number	Total citations	Impact factor (2022)
Cyberpsychology, Behavior, and Social Networking	14	2661	6.6
Behaviour Research and Therapy	6	1329	4.1
Journal of Autism and Developmental Disorders	5	998	3.9
British Journal of Psychiatry	4	587	10.5
Depression and Anxiety	3	681	7.4
Journal of Anxiety Disorders	3	915	10.3
American Journal of Psychiatry	2	636	17.7
Behavior Therapy	2	286	3.7
Frontiers In Psychiatry	2	307	4.7
Frontiers In Psychology	2	552	3.8
Journal of Clinical Psychiatry	2	497	5.3
Journal of Consulting and Clinical Psychology	2	451	5.9
Lancet Psychiatry	2	330	64.3
Neuropsychologia	2	298	2.6
Plos One	2	257	3.7
Psychiatry Research	2	365	11.3
Psychological Medicine	2	600	6.9
Accident Analysis and Prevention	1	216	5.9
Addictive Behaviors	1	120	4.4
Aerospace Medicine and Human Performance	1	153	0.9
American Journal of Geriatric Psychiatry	1	148	7.2
American Journal of Preventive Medicine	1	267	5.5
American Journal of Surgery	1	139	3.0
Annals of General Psychiatry	1	134	3.7
Appetite	1	164	5.4
Archives of General Psychiatry	1	793	14.48 (2014) [1]
Behavior Modification	1	136	2.3
Biological Psychiatry	1	385	10.6
Bjpsych Open	1	123	5.4
Brain	1	202	14.5
Building and Environment	1	129	7.4
Clinical Interventions in Aging	1	126	3.6
Clinical Psychology & Psychotherapy	1	133	3.6
Clinical Psychology Review	1	270	12.8
Cns Spectrums	1	145	3.3
Computers & Education	1	163	12.0
Computers in Human Behavior	1	185	9.9
Epidemiology and Psychiatric Sciences	1	128	8.1
Harvard Review of Psychiatry	1	299	3.8
Information Sciences	1	140	8.1
Journal of Abnormal Psychology	1	133	4.6
Journal of Behavior Therapy and Experimental Psychiatry	1	541	1.8
Journal of Cellular Physiology	1	132	5.6
Journal of Intellectual Disability Research	1	248	3.6
Journal of Medical Internet Research	1	152	7.4
Journal of Neuroengineering and Rehabilitation	1	124	5.1
Journal of Traumatic Stress	1	173	3.3
Annals of The New York Academy of Sciences	1	151	5.2
Motivation and Emotion	1	123	4.8
Neuroimage	1	220	5.7
Neurology	1	229	9.9
Neuropsychological Rehabilitation	1	268	2.7
Neuropsychopharmacology	1	143	7.6
Neurorehabilitation and Neural Repair	1	153	4.2
Physiology & Behavior	1	325	2.9
Presence-Teleoperators and Virtual Environments	1	257	0.579
Presence-Virtual and Augmented Reality	1	129	1.1
Proceedings of the National Academy of Sciences of The United States of America	1	190	11.1
Social Psychiatry and Psychiatric Epidemiology	1	166	4.4
Urban Forestry & Urban Greening	1	123	6.4

[1]In 2013, Archives of General Psychiatry changed to JAMA Psychiatry.

Table 3. Affiliations distribution.

Country	Number	Total citations	Average citations
USA	39	8,788	225
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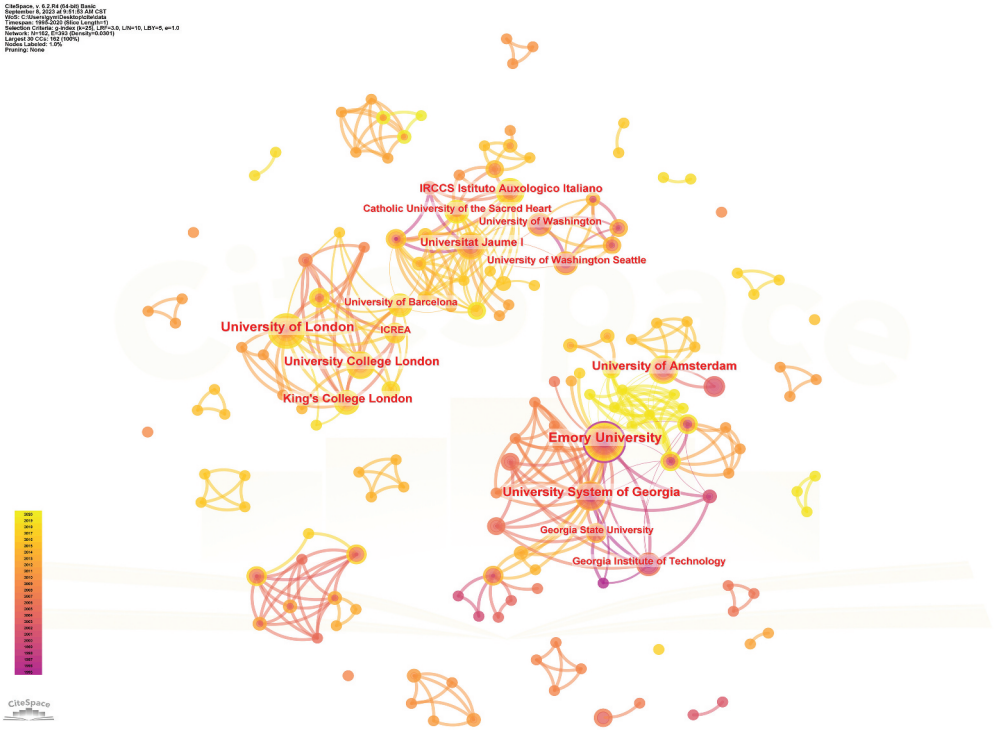

Figure 4. Network map of co-authorship between institutions: the size of the points indicates the number of publications; the weight of the lines indicates the degree of closeness of cooperation; the color and thickness of each circle in the node represent the frequency of occurrence in different time periods; the colors of the links represent the time of the first co-occurrence; purple circles indicate nodes with high betweenness centrality (centrality ≥0.1).

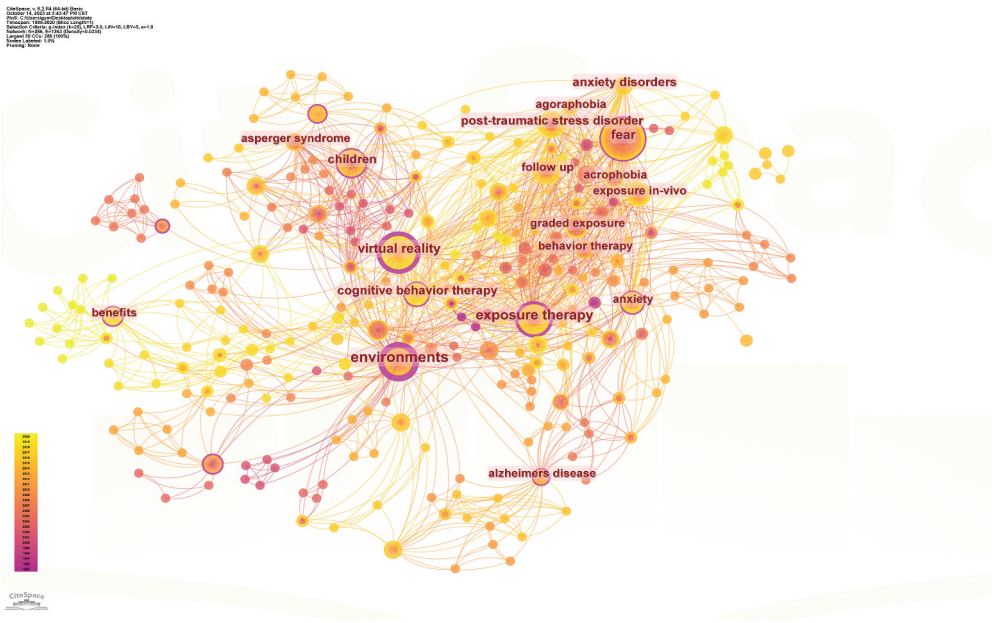

Figure 5. The map of keywords co-occurrence analysis: the size of the points indicates the number of occurrences; the color and thickness of each circle in the node represent the frequency of occurrence in different time periods; the colors of the links represent the time of the first co-occurrence; purple circles indicate nodes with high betweenness centrality (centrality ≥0.1).

Table 4. Top 20 keywords in the list by frequency/centrality.

Rank	Frequency	Keywords	Centrality	Keywords
1	37	virtual reality	0.66	environments
2	28	fear	0.41	virtual reality
3	19	exposure therapy	0.22	exposure therapy
4	17	environments	0.17	cognitive behavior therapy
5	13	cognitive behavior therapy	0.17	anxiety
6	12	graded exposure	0.14	fear
7	11	acrophobia	0.14	children
8	10	anxiety disorders	0.14	Alzheimer's disease
9	9	children	0.11	adolescents
10	9	follow up	0.11	benefits
11	9	post-traumatic stress disorder	0.11	acquisition
12	8	exposure in-vivo	0.11	behavior
13	7	anxiety	0.08	anxiety disorders
14	7	exposure	0.08	disorder
15	6	Asperger syndrome	0.08	eating disorders
16	6	behavior therapy	0.06	exposure
17	6	phobia	0.06	autism spectrum disorders
18	5	adolescents	0.06	dementia
19	5	agoraphobia	0.06	interventions
20	5	Alzheimer's disease	0.06	anticipation

the keywords (Table 4), popular keywords include fear, exposure therapy, environments, cognitive behavior therapy, children, anxiety, adolescents, and Alzheimer's disease. This suggests that popular research themes in this field focus on the use of VR in combination with exposure therapy, cognitive behavioral therapy, and other methods for treating

mental disorders. Additionally, researchers use other therapies such as in vivo exposure as controls or carry out follow-ups to validate the effectiveness of VR therapy.

4. Discussion

In recent years, there has been vibrant research and application activity surrounding VR. We conducted the first bibliometric analysis focused on mental health and VR to uncover the most influential papers, countries, institutions, journals, authors, and research focuses in this field.

The results show that the United States and European countries are at the forefront of this field, which is not surprising because of the advanced technological capacities and science. Meanwhile, the cooperation between them is close. The United States is one of the first countries to enter this field. Of the 100 most-cited papers, the earliest 10 are mostly from the United States ($n = 7$). American papers cover various topics, including VRET for anxiety disorders, VR training and research on autism spectrum disorders, the impact of VR simulated nature on mental health, and the virtual classroom for attention deficit assessment and rehabilitation. The United States is likely to have a significant impact on the future directions. The Netherlands is also among the highly influential countries, with interests in VRET for anxiety disorders, as well as research and intervention in eating disorders. In the highly cited papers from the United States and the Netherlands, the most attention is given to anxiety disorders and VRET.

The institutions contributing the most papers in the top three positions are the University of London, Emory University, and the University of Amsterdam. The University of London's papers cover a wide range of topics including public speaking anxiety, paranoid thinking, psychosis, autism, delusional beliefs, and depression. Although Emory University does not have the highest number of papers, it collaborates more extensively with other institutions, thereby exerting significant influence. Its research primarily focuses on VRET for anxiety disorders and the facilitative role of D-cycloserine in this context.

In the top 100 most-cited papers, Rothbaum BO has published the most papers as the first author. He has contributed to a total of 12 of the most-cited papers, making him one of the most influential researchers in the field. Additionally, he is among the earliest researchers to apply VR to psychotherapy. He has researched various mental disorders, such as acrophobia (Rothbaum et al., 1995a, 1995b), post-traumatic stress disorder (Rothbaum et al., 2014), and fear of flying (Rothbaum et al., 2006). His research has also involved cognitive behavioral therapy (Anderson et al., 2005) and the enhancing effects of D-cycloserine on VRET (Rothbaum et al., 2014). From the United Kingdom, Freeman Daniel has published five of the most-cited papers, all as the first author. These include two literature reviews and three research articles. He employs VR to assess, understand, and treat mental disorders, focusing particularly on delusions and paranoia (Freeman et al., 2010).

Journal analysis can assist researchers in selecting appropriate journals and evaluating the overall quality of papers (Fei et al., 2022). Among the top 100 most-cited papers, some have been published in prestigious journals such as Lancet Psychiatry, and nearly half of the papers have been published in journals with an impact factor greater than 5 ($n = 49$). Some journals have a lower impact factor, which might

indicate varying levels of quality among the top 100 most-cited papers. As we can see, the 100 most cited papers were published in 60 different journals, mostly related to behavioral research and mental disorders, which may be due to the fact that VR is mostly used to treat psycho-behavioral problems such as autism, anxiety disorders. But very few journals related to some mental health topics, Behavioral and Brain Sciences, Psychological Bulletin, have not accepted articles related to this topic, thus we hope that the subsequent journals related to psychology will include more articles in this field and expand the types of articles. This suggests that while the field has garnered academic attention, it is not yet mature and still requires further development.

Based on the keywords and content of these 100 papers, it can be inferred that VRET for mental disorders has been the focus so far. Many studies have also combined VR with cognitive behavioral therapy (Anderson et al., 2005). Attention to children as research subjects is prominent, with numerous studies using VR technology for interventions in children's mental disorders, including autism and attention deficit (Didehbani et al., 2016). Researchers have also explored schizophrenia (Synofzik et al., 2010), eating disorders (Keizer et al., 2016), depression (Falconer et al., 2016), alcohol dependence (Bordnick et al., 2008), and cognitive impairments in Alzheimer's disease (Cushman et al., 2008), although these topics are relatively less studied. VR systems can also simulate natural environments to help users relax and support mental health (Valtchanov et al., 2010). Although most current applications are in psychotherapy, VR holds enormous potential for research, prediction, and assessment in mental disorders (Freeman et al., 2017).

Through the analysis of this article, we found that there is a large gap in research investment in different countries, and the research investment in high-income countries is much higher than that in low-income countries, and the psychological problems in low-income countries should not be ignored, and we hope that the low-income countries can strengthen the research in this field; at the same time, the support of journals will also affect the researchers' research choices. We hope that more psychology-related journals will emphasize the research on VR and mental health treatment.

The integration of VR with mental health continues to face a myriad of challenges. Firstly, despite advancements in technology that have reduced the cost of VR devices, high-quality hardware remains prohibitively expensive. On the software front, specialized technical personnel are needed to create suitable virtual environments through programming, the cost and difficulty of which should not be overlooked. Secondly, compared to VRET, there is limited research on integrating VR with other types of psychotherapy. Existing studies often suffer from methodological limitations, including small sample sizes, high dropout rates, and a lack of follow-up (Valmaggia et al., 2016). The use of VR equipment can also result in adverse side effects, such as motion sickness and headaches. Individuals with risk factors such as heart disease should avoid VRET (Gregg & Tarrier, 2007). Additionally, increasing the acceptance of VR among clinicians and patients remains a significant challenge (Emmelkamp & Meyerbröker, 2021). Lastly, this emerging technology presents ethical and moral dilemmas (Kellmeyer, 2018), such as the potential to blur the lines between virtual environments and reality, which could exacerbate patients' suffering (Lyu, 2021).

Given the aforementioned status and challenges, future research in this field may focus on further expanding the applications of VR in mental health, attempting to integrate it with more diverse kinds of psychotherapy, and addressing a broader range of mental disorders. For example, depression has not yet received adequate attention in this context (Freeman et al., 2017). Importantly, the application of VR in mental health still requires more robust and compelling evidence.

Our research has several limitations. First, there may be a temporal bias in citation analysis; papers often accumulate citations over time, and those published in recent years may not have had enough time to be widely cited (Feijoo et al., 2014). Although we incorporated the average annual citation rate, it is still possible that recent high-impact papers were not included in the analysis. Second, citation count may not fully represent the quality of a paper (Wang et al., 2023). A paper could also be widely read but rarely cited (Feijoo et al., 2014), and open-access papers may receive more citations. Lastly, the WOSCC database does not include all publications and does not record all citations. Some papers were not retrieved because they did not contain terms related to mental health and VR in their titles, keywords, or abstracts. Our data comes only from WOSCC and does not include other databases, and the analysis may not be rigorous enough. The statistical methods used by CiteSpace may also introduce bias (Wang et al., 2023). And, the citespace bibliometric analysis was unable to analyze the research methodology and research model of the article, which was lacking in the article, and we hope that we will be able to conduct an in-depth study of the article model afterwards. Our inclusion criteria excluded a small number of papers for which the full text could not be obtained, which might introduce selection bias.

5. Conclusion

In summary, the field of mental health and VR has made some progress and boasts many high-quality papers. The United States, the Netherlands, and the United Kingdom have made significant contributions. The University of London and Emory University are the most influential institutions. Overall, the United States and the United Kingdom lead the field globally. VRET for mental disorders, especially for anxiety disorders, is a research hotspot. There is still a long road ahead for the application of VR in the mental health sector, and researchers face numerous technical and ethical challenges.

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Data availability statement

The data underlying this article will be shared with the corresponding author upon reasonable request, provided the recipient has a Web of Science license.

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