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SYSTEMATIC REVIEW

Bibliometric Analysis of Research in Pediatrics Related to Virtual and Augmented Reality: A Systematic Review

Kevser Sevik Kacmaz[1,*] and Cihangir Kaçmaz[2]

[1]*Department of Physical Therapy and Rehabilitation, Izmir Katip Celebi University, TR-35340, Cigli- Izmir, Turkey;* [2]*Youth Vocational School / Child Care And Youth Services, TR-12000, Merkez- Bingöl, Turkey*

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Abstract: ***Introduction*****:** The amount of research exploring the use of virtual reality (VR) and augmented reality (AR) technologies in health care has exploded. This has resulted in a massive body of work, making it difficult to obtain all of the research. The objective of this study was to map out and put together the scientific output of research and global trends in virtual and AR in pediatrics.

Methods**:** Publications were collected from the Web of Science (WoS) database. The R tool was used to categorize and evaluate the research outputs, as well as the most productive and influential countries, journals, institutions, authors, articles, subject areas, and the latest research themes. The most utilized and co-occurring keywords were also examined. Texts, tables, and images were used to assess and describe the retrieval of findings.

Results**:** The research was based on information from 7423 publications. The strongest growth in publications occurred in 2020. The most productive and influential country was the USA. The journal was Pediatrics, the author was G Riva, and the institution was the University of Washington. The most frequently occurring keywords were simulation, rehabilitation, and stroke. The main research themes were therapy, surgical education, and rehabilitation. Pain, stroke, anxiety, depression, fear, dementia, and neurodegenerative illnesses were all common medical issues investigated.

Conclusion**:** VR studies have mainly focused on surgical education or procedures, simulation technologies, and neurological conditions. Neurological conditions are linked to balance, gait, and rehabilitation, reflecting the prevalence of these disease groups.

This article provides a thorough overview of VR and AR studies in the healthcare field. This work will allow academics, policymakers, and practitioners to gain a deeper understanding of the evolution of VR and AR studies in the healthcare field and its potential practical implications. Future VR and AR research should focus on bridging the gap between VR and AR healthcare research and clinical applications. Emerging trends in related fields, such as navigation, rehabilitation, stroke, dementia, and VR exposure therapy, should be given special attention.

Keywords: Virtual reality, augmented reality, pediatrics, bibliometric, simulation, global trends.

1. INTRODUCTION

Since the 1960s, there has been a global acknowledgment of the importance of conducting studies on children [1, 2]. Due to a dearth of pediatric data, pediatric prescriptions are frequently dependent on extrapolation from adult trials. Children are not 'little grownups' but rather a diverse group varying from premature infants to adolescent late pubertal. Children have unique physical, psychological, developmental, and psychotropic traits that differ from adults, and these characteristics vary from birth through adolescence [1, 3-5]. Some drugs may be processed differently in children than in adults. The result of this may cause suboptimal treatment, unanticipated responses, reactions, and toxicity. These can impact their future development and reproductive potential [1, 6].

According to a 2007 survey, over the last 20 years, the number of adult randomized controlled trials published in five high-impact general medical publications has nearly doubled. In contrast, pediatric research has remained steady [7]. While children make up nearly a quarter of the global population, only 16.7% of all trials are in pediatrics [1]. Only 12% of trials on clinicaltrials.gov for specific medical diseases are pediatric trials, even though children are responsible for nearly 60% of the total disease burden [8]. Adult trials are preferred by the pharmaceutical industry and the government for a variety of political, commercial, economic, and

*Address correspondence to this author at the Department of Physical Therapy and Rehabilitation, Izmir Katip Celebi University, TR-35340, Cigli-Izmir, Turkey; Tel: +9023241224928; E-mail: kevser_sevik@hotmail.com

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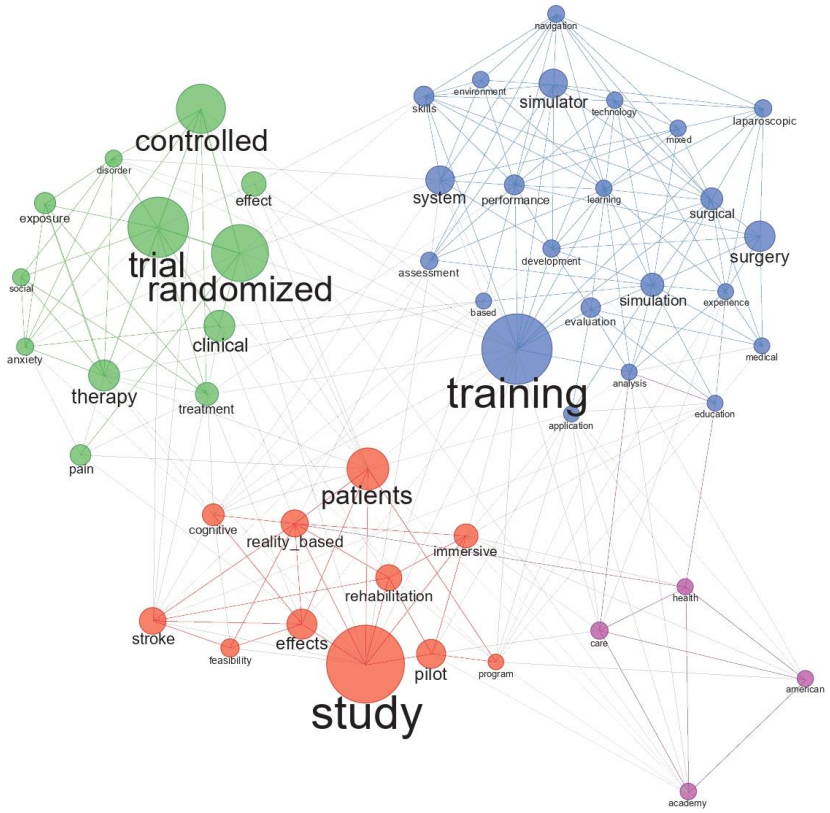


Fig. (1). The 10 most common words in the titles of the publications shown in the word cloud. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

liability reasons. Furthermore, pediatric trials are subjected to more stringent regulatory scrutiny [1, 9].

Virtual reality (VR) is a technique that actively involves the user in an artificially created 3-dimensional environment. Augmented reality (AR) superimposes aspects of VR on a live video of the real-world surroundings presented on a screen. Both provide an experience that engages the senses by generating the illusion of their environment [10]. More immersive and satisfying virtual worlds can be produced as technology improves, assisting health care in transcending previous limitations. In addition to medical education, VR and AR have obvious value in therapeutic interactions, preparation, assistance, guidance, and teleconsultation. They can also help clinicians collect and share real-time data over a period of time based on progress [11, 12].

VR and AR are interactive techniques to engage children in therapy using attractive, game-like environments. They also provide opportunities for practice, active participation, reduced perceived task difficulty, and repetition of movements with variations for motor learning and cortical reorganization [13]. The establishment of a rehabilitative recreation and the maintenance of an analytic procedure in private residences using VR/AR-based games may assist in overcoming geographic and transpositional obstacles to treatment for mental illness. It may also decrease additional obstacles to face-to-face treatments (*e.g.*, stigma, costs) and expand intervention's reach to children who would not otherwise seek aid through established channels [14, 15].

The five-year compound annual growth rate for VR/AR spending will be 54.0%, according to the International Data Corporation Worldwide AR/VR Spending Guide. The total spending on VR/AR products is expected to exceed $72.8 billion in 2024. By 2025, the worldwide healthcare VR/AR market is anticipated to be worth $5.1 billion [16, 17]. As a result, to achieve significant breakthroughs, many major technological and medical industries are working to develop innovative approaches to incorporating treatment methods and computer imaging modalities. This makes a prompt and effective evaluation of the implementation of VR/AR techniques in health critical [16].

The quantity of articles is likewise rapidly expanding, and keeping up with everything is getting increasingly difficult. As a result, literature reviews are becoming more important in synthesizing previous results to make effective use of current knowledge, further research, and provide an evidence-based understanding of the practice [18]. Researchers can convey new ideas from previous and current patterns as a result of bibliometric studies [19]. While citation analyses of disease-specific research have been done, there has not been a bibliometric study on VR/AR in pediatrics as a discipline. An analysis such as this could help to define the influence of specific research and how it shapes the current field.

The present study was conceptualized to analyze the development and trends of VR/AR in pediatric healthcare using a visualization tool. It also aimed to examine their potential benefits or coverage for all researchers, clinicians, patients,

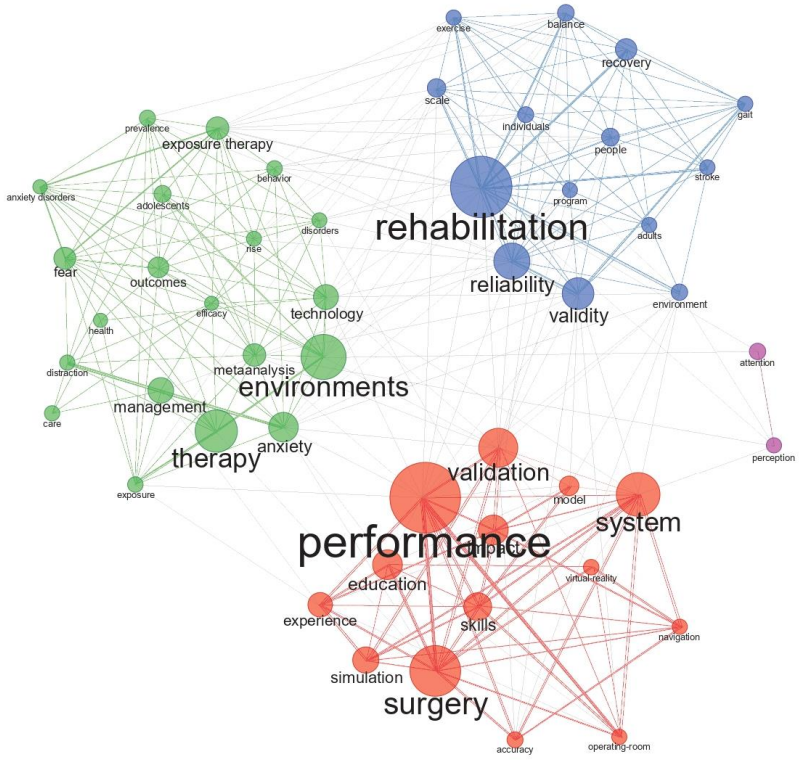


Fig. (2). The 10 most common words in the references of the publications (keywords plus) shown in the word cloud. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

stakeholders, and policymakers in pediatric healthcare and device prospects of the future in pediatric healthcare from the beginning.

The remainder of the paper includes the following sections: Section 2 explains the data, the methodological process, and the software used. Section 3 describes the statistical outcomes obtained from the analyses. The information in this section will assist researchers in recognizing research hotspots that need a more thorough examination, choosing prominent collaborators, and identifying relevant journals to present their findings and the evolution of research themes. Section 4 discusses the future potential and difficulties in VR/AR research in pediatric healthcare and some limitations. The paper is summarized in Section 5 [20].

2. METHODS

2.1. Search and Screening

On March 27th, 2022, the search was administered in the Web of Science (WoS) Core Collection for the keywords 'virtual reality, VR, augmented reality, mixed reality, or computer-mediated reality, and child or pediatrics' to retrieve scientific publications on VR and AR. Studies that dealt with VR as an additional topic were excluded. From 1975 to 03/27/2022, 46,222 publications were identified [10, 21].

By concentrating on papers written in the most common publication language, the dataset was restricted (English). Only journals or papers in health-related areas, such as pediatric medicine, surgery, psychology, *etc*., were included. The bibliometric analysis only included peer-reviewed, original research. The retrieved data were downloaded in plaintext format. As a result of this filtering process, there were a total of 7423 publications in the final data collection [21]. To ensure data accuracy, the titles and abstracts of the published documents were screened carefully. The following data were extracted from the retrieved documents: the title, author name, year of publication, journal, institution, country, and citation count. Two researchers conducted the online search together, and any disagreements related to inclusion and exclusion were resolved by further discussion. The obtained data were exported into Excel, and the values were presented in frequencies and percentages. The graphs were generated using R tool software [22].

2.2. Bibliometric Analysis

Bibliometrics is the study of measurable publication data that may be used to provide objective and repeatable conclusions. It is also used to provide insight into the relationships between the documents being studied. Future research trends based on bibliometric findings might be deduced [10, 21].

The articles were analyzed in two parts with the Bibliometrix R Tool using biblioshiny coding. In the first part of the analysis, an overview was made of the studies on articles, journals, researchers, institutions, and countries.

The number of articles and citations are the most fundamental bibliometric performance measurements (representing impact or influence). Productivity and impact data were examined by year, in addition to data by journal, author, and institution.

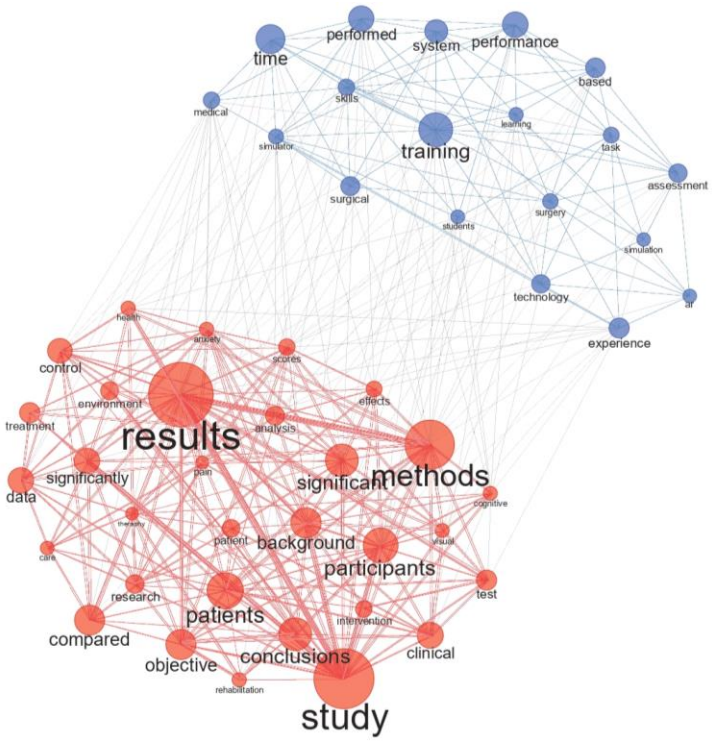


Fig. (3). The 10 most used words in the abstracts of the publications were training, system shown in the word cloud. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

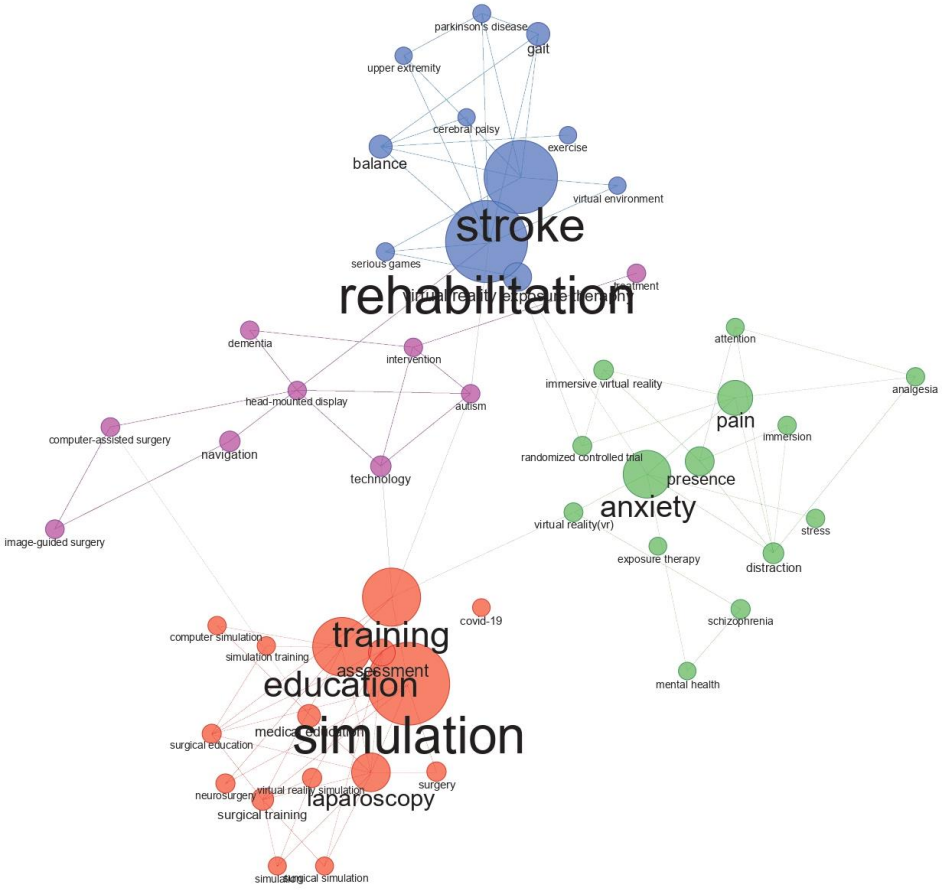


Fig. (4). The 10 most common words provided by the authors shown in the word cloud. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

In the second part, the intellectual structure of the research subject was examined through content analysis using word and citation analysis. Its main topics, thematic development, and research focus were also determined. To locate and organize the main study themes, the most used and co-occurring keywords were investigated. After removing empty terms (words that were included in the search strategy), the 50 most used keywords were determined [10, 21] and visualized in Keyword Plus, Author's Keywords, Titles, and Abstract. Keywords Plus is an algorithm developed by the WoS Core Collection and is a word frequency analysis used in the reference lists of publications. The size of the words in word clouds increases in direct proportion to the frequency of their occurrence. The co-occurring keywords are presented as clusters that are often mentioned together. As a result, they tend to establish groupings that represent shared research topics. Although all of the publications that meet the criteria inside a given cluster are mentioned together, being displayed as a cluster does not imply that they all deal with the same issue [21].

Another method used during the analysis of academic resources is Bradford's Law. According to this law, one-third of all articles published on a particular topic was published by only a small core group of journals. This core group can be described as the most influential journal group in the determined discipline. The second-third part contains approximately n times the number of journals of the core group, and the last part contains approximately n^2 times the number of journals of the core group. The journals in the second group can be considered fewer effective journals, and the journals in the third group can be considered ineffective journals [23].

A strategic diagram is a term used to describe the inner relationships and interactions inside a specific study area and is created further to examine the clustering findings' research and development stage. Strategic diagrams are coordinates in two dimensions constructed using centrality and density. The X-axis indicates centrality, showing the degree of domain coupling and is derived using the strength of ties between all cluster's terms and other clusters' terms, *i.e*., the total linkages between clusters. The density is represented by the Y-axis, which indicates the strength of a field's internal connections, estimates the number of concurrent occurrences of each term in the same cluster of literature, and calculates by computing the mean value of these internal links. It has enormous promise in the entire field of research [24].

3. RESULTS

The search of the literature found 7423 items published between 1975 and 2022. The number of publications published per year increased linearly with the year 2021. The annual growth rate was 13.54%. The year 1975 had 1, and 2022 had 228 papers until the time at which the literature review was completed (03/27/2022). Years on average since the publication was 8.42, and citations per document on average was 19.37. The most cited article was Virtual Reality Training Improves Operating Room Performance (total citations: 1803), published by Seymour *et al*. in 2002.

3.1. Author Productivity and Impact

A total of 27,393 authors were involved in the research. While the number of studies per author was 0.271, the number of authors per study was 3.69, and the cooperation index was 3.95. The following were the top ten most productive authors in terms of the number of publications: Riva G, Hoffman Hg, Botella C, Garcia-Palacios A, Banos Rm, Rothbaum Bo, Koning Ahj, Wiederhold Bk, Alcaniz M, and Konge L. The most productive and influential author was Professor Riva from the Catholic University of the Sacred Heart in Italy, with 65 documents and an H index of 30.

3.2. Institution Productivity and Impact

A total of 6224 institutions worldwide were involved in the publications. The 10 most productive institutions were the University of Washington, University of Toronto, Stanford University, McGill University, Johns Hopkins University, University of Illinois, Cincinnati, Children's Hospital Medical Center, University of California Los Angeles, University of Pennsylvania, and Harvard University. Nine of these were in the USA, and 1 was in Canada. The University of Washington was the most productive university of all, with 229 publications.

3.3. Country Productivity and Impact

The investigation included a total of 98 countries. The 10 most productive countries were the USA, China, Canada, the UK, Italy, Germany, Spain, Netherlands, France, and South Korea. The USA had contributions in 97.88% of the publications, had the highest citations per publication, and had 5 times more contributions than the second most productive country, which was Canada. Following the USA, the UK had the second-highest number of citations per publication, at a rate of 25%.

3.4. Journal Productivity and Impact

The papers were published in 1858 different journals. The 10 most productive journals were Pediatrics, Frontiers in Psychology, Surgical Endoscopy and Other Endoscopic Techniques, Cyberpsychology Behavior and Social Networking, Computers in Human Behavior, Cyberpsychology and Behavior, Journal of Pediatrics, International Journal of Computer Assisted Radiology, Journal of Neuroengineering and Rehabilitation, and Journal of Medical Internet Research. However, the journals that had the highest impact were not identical. The 10 most influential journals were Pediatrics, Surgical Endoscopy and Other Endoscopic Techniques, Computers in Human Behavior, Cyberpsychology and Behavior, Endoscopy, and Other Endoscopic Techniques, Cyberpsychology, Journal of Neuroengineering and Rehabilitation, Frontiers in Psychology, International Journal of Human-Computer Studies, and International Journal of Human-Computer Interaction, and Neurosurgery.

There were 53 core and 1803 noncore journals. These core journals contained 33.22% of the total number of publications, with 2466 publications. When the number of

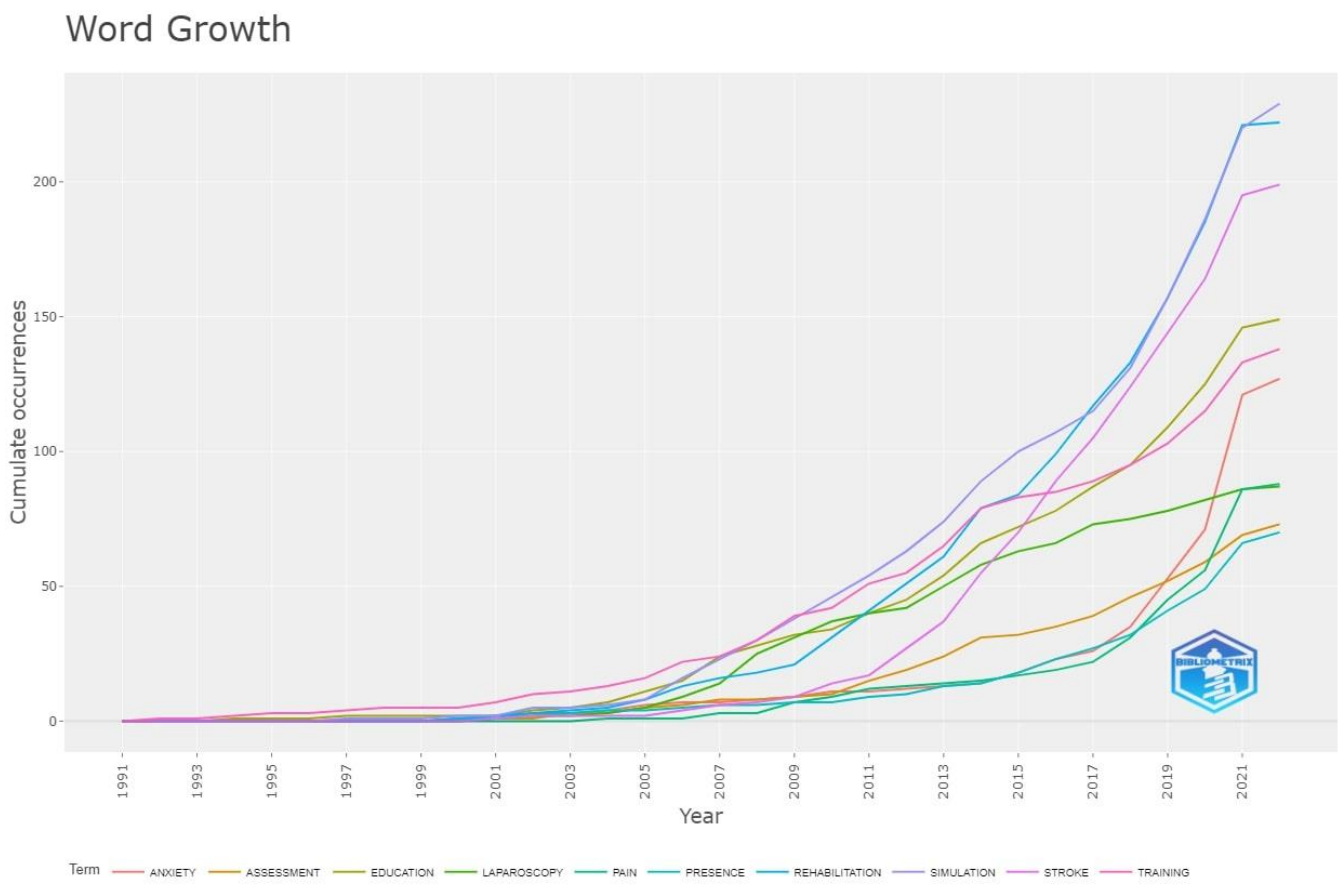


Fig. (5). The dynamic analysis of keywords over time. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

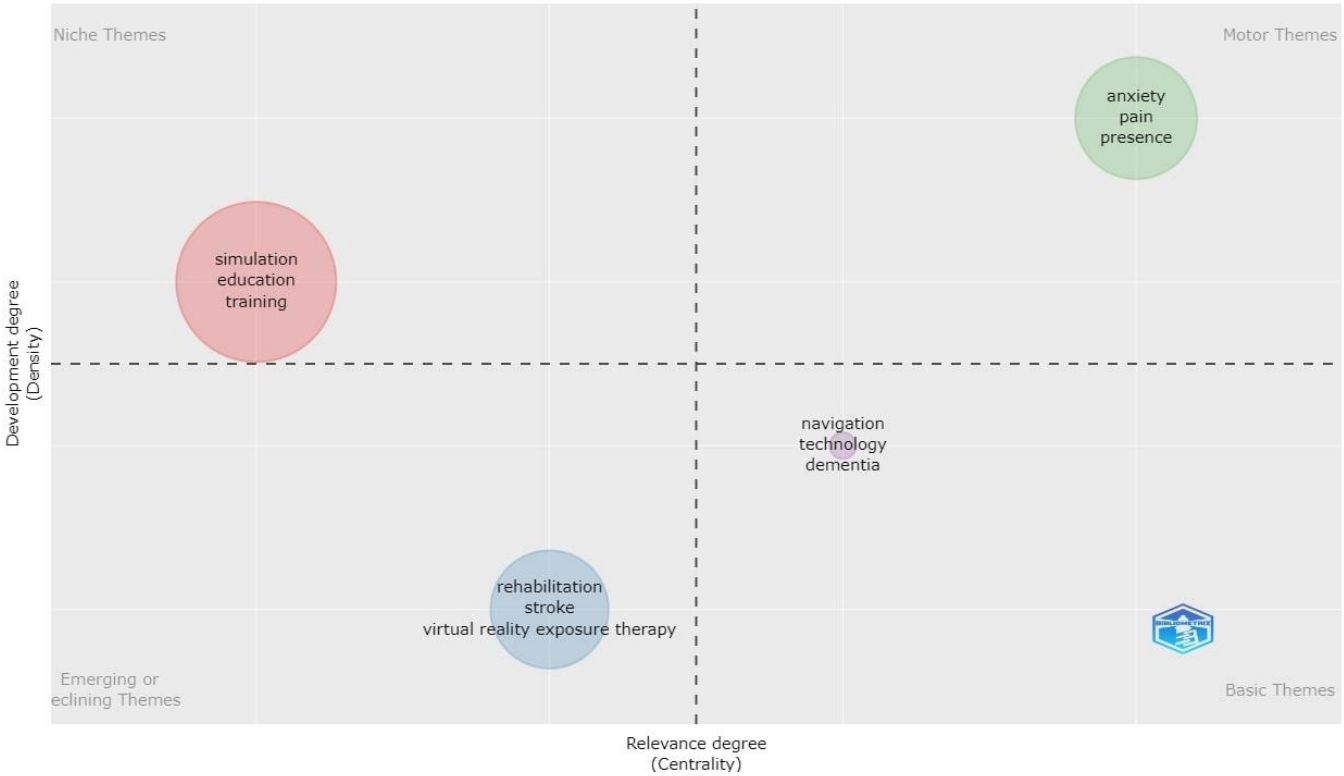


Fig. (6). A strategic diagram of the keywords. (*A higher resolution / colour version of this figure is available in the electronic copy of the article*).

resources in the core group was compared to the total number of resources, it was observed that it had a rate close to 2.93%.

3.5. Most Used and Co-occurring Keywords

When it comes to word relationships, the thickness of the lines must be considered. The thicker the line connecting the words, the more times they will appear together. The inclusion criterion was a frequency of occurrence greater than 50.

The 10 most common words in the titles of the publications were training, surgery, therapy, system, simulator, treatment, effects, simulation, care, surgical, and rehabilitation, as shown in the word cloud (Fig. **1**).

The 10 most common words in the references of the publications (keywords plus) were performance, rehabilitation, surgery, environments, system, therapy, validation, impact, management, education, and skills, as shown in the word cloud (Fig. **2**).

The 10 most used words in the abstracts of the publications were training, system 3225 treatment, time, performance, surgical, AR, care, research, and pain, as shown in the word cloud (Fig. **3**).

The 10 most common words provided by the authors were simulation, rehabilitation, stroke, education, training, anxiety, laparoscopy, pain, virtual reality exposure therapy, and medical education, as shown in the word cloud (Fig. **4**).

The dynamic analysis of keywords over time is presented graphically in Fig. (**5**). Although all of the authors provided keywords were in a constant upward trend over the years, the keyword virtual reality made the most significant increase, making it the keyword with the highest frequency of use. This was followed by augmented reality.

A strategic diagram of the keywords is shown in Fig. (**6**).

- Cluster 1 included the keywords: anxiety, pain, and presence, which had high centrality and density.
- Cluster 2 was the largest in volume and included three keywords, which were simulation, education, and training, with low centrality and high density.
- Cluster 3 included three keywords, which were rehabilitation, stroke, and VR exposure therapy, with low centrality and low density.
- Cluster 4 was the smallest in volume, including the keywords navigation, technology, and dementia, and had high centrality and density.

4. DISCUSSION

In this study, bibliometric methods were used to examine research on VR/AR in pediatrics from 1975 to 2022. A trend analysis, as well as publication and author scores, were the focus of this investigation. Overall, the relevant research has increased gradually, with a current surge in publications highlighting the importance of VR/AR research in pediatric healthcare, similar to the literature [11, 21]. Scientific interest and use increased due to a sudden surge in high-quality technological investments and availability. The gaming business had a significant impact, demonstrating the many (albeit usually unintended) benefits and possibilities available through the creation of new headsets and programs that could be used and changed for other purposes [21]. It is projected that this area will continue to expand based on the previous trends in healthcare-related VR/AR studies.

The literature included contributions from all over the world, not just North America and Europe but also Asia and South America. This indicates that the use of VR/AR in healthcare has gained a lot of attention [10, 21]. However, examining the country-based distribution of research and comparing it to that of other countries might help in better understanding a country's capacity [25]. The findings herein demonstrated that North America is leading the research. The supremacy of the USA, UK, Germany, and China in VR research was also highlighted by other bibliometric investigations. However, there was no single country dominance in the analysis [21, 26]. This was not unexpected, given that North America has a variety of high-tech industries and is home to active medical research [25]. One factor could be the preponderance of portable and less expensive VR/AR gadgets made in the USA. As a result, these authors have easier access to the tools they need to carry out their research [12]. The findings highlighted the need for more context-relevant research from low- and middle-income countries with rising pediatric disease burdens.

The distribution of research output by the institution can aid in our understanding of the study abilities and activities of institutions all over the globe. It can assist in identifying prominent research institutions too. According to the results, nine of the top ten universities are in the USA, and higher education institutions lead scientific research. Higher education institutions are also a key cornerstone of scientific research and innovation systems, according to the findings in the literature [25, 26].

With 65 papers, Giuseppe Riva was the most prolific author. It may be stated that his work on VR for rehabilitation had a significant impact on subsequent relevant research [21, 25]. Five of the top ten writers in this research were also in the top ten lists of other similar research, such as Cipresso *et al*. [26] and Yeung *et al*. [10]. This implied that the available resources and scientific environment have a significant effect on generated science. Their research will impact hotspots and trends directly or indirectly, providing concepts and theoretical support for other investigators.

The most frequently cited article was cited 1803 times from its publication in 2002 to 2022. It could be interpreted as the most influential paper and contained core principles in pediatrics related to VR/AR.

The rate of journals in the core group compared to the total number of journals was close to 2.93%. This rate is lower than the rate specified in Bradford's Law, and it can be said that the core group in the study area is extremely wide. The related publications published in these journals may not be specific to the relevant research area. The most productive

journals highlighted the categories of surgery, neuroscience, and psychology, similar to the literature [10, 16, 21, 26]. The key study areas of these productive journals were psychology and computer science. Thus, keeping track of publications in these journals could be a good way of keeping track of research trends on this topic. These findings also give researchers the ability to study trends in their field. This can help them to make decisions about which journals to publish in to stay up-to-date in the field and disseminate their findings.

4.1. Strategic Diagrams

The detected clusters demonstrated that the interdisciplinary feature of this study was similar to other works in the literature [16, 26]. Their subject fields were very rich, suggesting more room for expansion in these fields [27]. The top three research areas that explored the use of AR/VR were surgery, neuroscience, and rehabilitation, which was similar to the literature [11, 28]. Overall, the studies could be broadly classified into four clusters: surgical education, surgical techniques, physical therapy and rehabilitation, and clinical therapy, also in other studies in healthcare [16, 28].

According to the clusters in analysis, anxiety, pain, and presence were strongly related to the research area. Their research level was advanced, and the external associations had extensive ties to other organizations. They were a part of the fundamental theme of VR and AR in pediatrics, as demonstrated by other studies [11].

The simulation, education, and training keywords were advanced in the field, but they were not tightly linked to other areas of VR/AR similar to the other works [27, 28]. Therefore, it is understandable that the separation of the research was related to surgical training and education.

The keywords: rehabilitation, stroke, and VR exposure therapy had the lowest centrality and density scores. This implied that the fields were still in their early stages, as discussed in the literature [11]. They received much attention, but not that much when compared to other areas in the hot topics of VR/AR in pediatrics research, and it is required that they are explored further. It can be interpreted that studies related to physical therapy and rehabilitation are still at their inception, and there is a wide space for development.

Navigation during surgery and dementia keywords was neither mature nor strongly related to other aspects of VR/AR research, which suggests that additional research is needed related to them [27].

The use of the keywords increased over time [28]. Although all of the keywords were in a constant upward trend over the years, the keywords simulation and rehabilitation showed the most significant increase, making them the keywords with the highest frequency of use. This was followed by keyword training, similar to the literature. These keywords also indicated study hotspots according to previous discussions [21, 27, 28]. The latest trend examines VR/AR in health care, becoming centered around education and exercise for mental and physical health [21].

In the most used keywords in the titles, the words therapy, environments, and exposure therapy were clustered together, with the words management, behavior, anxiety, exposure, fear, and distraction gathered around them. The word rehabilitation had large reliability and validity words around it, indicating therapists' work on psychometric studies. The other smaller words surrounding it were exercise, balance, gait, stroke, and scale. Apparently, the cluster was worked on by physiotherapists. This was consistent with ICD-11 and the study of Liu *et al*., since the environments and exposure therapy were clustered together with the words management, behavior, anxiety, exposure, fear, and distraction that belong to mental, behavioral, or neurodevelopmental disorders. On the other hand, reliability, exercise, balance, gait, stroke, and scale were related to neurology and rehabilitation [11].

The other main large cluster had the words surgery, performance, system, and validation. The words simulation, education, skills, experience, operating room, and navigation surrounded them, indicating the use of VR/AR in surgical education and procedures, as seen in the literature [10, 28]. In addition, the ties between the performance and operating room words were very strong. In another small cluster, the words attention and perception were used together.

The words chosen by the authors are of significant consequence when examining publications in bibliometric analyses. Considering this, the keywords simulation, rehabilitation, stroke, education, training, anxiety, laparoscopy, pain, VR exposure therapy, and medical education were similar to the literature [10, 21]. To represent the content of the article, word analysis is of great importance to examine the main themes of the research topic today and the themes that will evolve in the future.

The words in the references were named Keywords Plus in the literature and were associated with the journals with the highest impact. It is thought that this analysis will provide versatile information about the content of the article. In another study, it was found that the words in the references were at least as effective as the keywords added by the authors of the article in examining the knowledge structure of scientific fields. However, it was stated that the article is narrower in expressing its content [29]. Words related to physical therapy, surgery, and psychotherapy were created in three different clusters indicating the three main work fields.

The most used words in the abstracts were training, system, treatment, time, performance, surgical, AR, care, research, and pain. There were two main clusters related to surgical education and physical therapy and rehabilitation.

Dementia, stroke, and anxiety were the most explored disease areas in VR/AR research, indicating the prevalence of these disease groups, as reported in other works [27]. Most disease types had a large range of research designs, such as psychotherapy, surgical education, physical therapy, and rehabilitation. Some study fields relevant to therapeutic pathways had a noticeable disease-specific preponderance. Dementia, stroke, anxiety, and pain research were mostly focused on therapy and less on other areas [30]. Internationally, there has been a strong desire for further surgical and

rehabilitative research. However, the findings underscored the need to broaden the research to encompass other areas of unmet clinical needs.

The key study themes were diagnostic and surgical procedures. This was in addition to therapy and rehabilitation for neurodegenerative and psychological diseases, which was also similar to the literature [11, 28]. In the study of Walsh *et al*., most studies (86%) had a key focus on medical education/training, defined as a "discipline covering the education and the practice of skills" by students enrolled in medical schools/colleges to become doctors, residency training, continuing medical education, and specializing postgraduate training. Surgery accounted for 45% of the articles [28]. The use of VR and AR in diagnostic and surgical procedures, such as strengthening the skills of new hospital residents, was beneficial. In surgery, VR/AR could be beneficial in education, training, planning, image guiding, and telesurgery by enhancing laparoscopic abilities in terms of error, process time, and suturing skills. By removing some timely, geographical, transfer, and stigmatical constraints, VR/AR could also allow therapists to undertake telerehabilitation on a remote basis with real-time data. Furthermore, gamified features could be incorporated into VR/AR to make the process more motivational, gratifying, and adherent. VR has also been utilized to add cognitive difficulties and virtual impediments to treadmill training for older people and to reduce fall risk by focusing on perception, attention, and dual tasking while walking. As the available studies were so varied, more research is needed to improve the implementation and determine benefit impacts in various demographic groups so that recommendations can be made about how to employ VR/AR in rehabilitation [10, 11, 14, 15]. Meanwhile, VR/AR has proven to be effective in treating a variety of psychiatric disorders, including anxiety, sadness, and autism.

The use of VR and AR allows the subject to experience planned scenarios, which can help with management tactics like cognitive reappraisal and cognitive behavioral therapy. Patients experiencing severe burn injuries, as well as those undergoing invasive medical operations, may benefit from VR [10, 11]. Clinicians are increasingly inclined to use VR/AR simulations in studies because of the encouraging results reported in articles concentrating on various clinical disorders [11].

4.2. Proposed Future Work

VR/AR-based environments and scenes may be employed for practical clinician training in physical therapy, rehabilitation, and psychotherapy in addition to internship programs. This may create a huge impact on their readiness and ability. Additionally, providing health education to the pediatric population with VR/AR technology may develop their health information and health literacy using game and entertainment elements and reduce their anxiety.

4.3. Limitations

The dependence of this study on a single database could be seen as a disadvantage, even though WoS is widely regarded in the scientific community as a reliable source of high-quality scientific papers that provides a good estimate of the field's significant research. In addition, these databases are updated regularly with new journals, and as a result, obtaining a thorough picture of the field of research is impossible.

CONCLUSION

Over 7000 publications have been published in VR/AR in pediatric healthcare. The contributions were made from all over the globe, with the USA contributing the most. Diagnostic and surgical procedures, as well as rehabilitation, were among the major study areas. The most common medical disorders studied were pain, stroke, anxiety, and neurodegenerative diseases. The trends detected in the present analysis suggest that the number of global publications pertaining to the use of AR, VR, and MR techniques in surgery, physical therapy and rehabilitation, and psychology research is likely to increase in the coming years. Particular attention should be paid to emerging trends in related fields, including anxiety, pain, presence simulation, and training.

The massive potential and variety of uses of VR and AR in medicine are already well-known. Further developments in these technologies are likely to increase their functionality while also making them more accessible to patients. The result will be a significant therapeutic or preventive impact.

CONSENT FOR PUBLICATION

Not applicable.

STANDARDS OF REPORTING

PRISMA guidelines and methodology were followed.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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Declared none.

SUPPLEMENTARY MATERIAL

PRISMA checklist is available as supplementary material on the publisher's website along with the published article.

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