Evolving Trends and Emerging Hot-Spots in Virtual Reality Research within Nursing (2013-2023): A Decade of Bibliometric Insights

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Abstract

Background: Virtual reality (VR) is a sophisticated computer technology that integrates various sciences and technologies to create a digital environment. This environment simulates the real world, offering immersive visual, auditory, and tactile experiences. Users interact with virtual objects within this digital space using specialized equipment, which can evoke a sense of presence akin to the real world [1]. Regarded as a pivotal and strategic technology, VR extends human capability to comprehend, modify, and invent within the objective world, beyond mathematical reasoning and scientific experimentation. The concept of “virtual reality” was first introduced by Lanier, founder of VPL Research, in 1987 [2]. Its primary design is educational, assisting in the comprehension of abstract concepts and the practice of operational skills. Initially, in the 1980s, VR hardware was confined to specialized labs. However, with VR's technological evolution, both its hardware and software systems have transitioned from these labs into practical, real-world applications [3,4,5].

Objective: To visualize and analyze the current research status, hot-spots and emerging trends of virtual reality technology in the field of nursing based on CiteSpace.

Methods: We utilized the Web of Science Core Collection (WOS) to retrieve pertinent literature, subsequently employing CiteSpace 5.8 R3 to visualize and analyze data on annual publication volumes, contributions by country or region, institutions, and keyword trends.

Results: The analysis included a total of 547 documents, revealing a consistent upward trend in publication volume. The United States emerged as the leading contributor in terms of publication count. The predominant research hot-spots within these publications are centered around themes such as anxiety, augmented reality, care, education, and balance.

Conclusions: The CiteSpace 5.8 R3 software effectively maps out the global research hot-spots in virtual reality applications within nursing, offering researchers novel insights and perspectives for future investigations. Clinical Trial: Not involved

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[Abstract] Objective: To visualize and analyze the current research status, hot-spots and emerging trends of virtual reality technology in the field of nursing based on CiteSpace. **Methods:** We utilized the Web of Science Core Collection (WOS) to retrieve pertinent literature, subsequently employing CiteSpace 5.8 R3 to visualize and analyze data on annual publication volumes, contributions by country or region, institutions, and keyword trends. **Results:** The analysis included a total of 547 documents, revealing a consistent upward trend in publication volume. The United States emerged as the leading contributor in terms of publication count. The predominant research hot-spots within these publications are centered around themes such as anxiety, augmented reality, care, education, and balance.**Conclusion**: The CiteSpace 5.8 R3 software effectively maps out the global research hot-spots in virtual reality applications within nursing, offering researchers novel insights and perspectives for future investigations.

Keywords: Nursing; Virtual reality; Bibliometric analysis; CiteSpace software; Research hot-spots

Abbreviations VR: virtual reality; WOS: Web of Science; USA: the United States of America

1 Introduction

Virtual reality (VR) is a sophisticated computer technology that integrates various sciences and technologies to create a digital environment. This environment simulates the real world, offering immersive visual, auditory, and tactile experiences. Users interact with virtual objects within this digital space using specialized equipment, which can evoke a sense of presence akin to the real world [1]. Regarded as a pivotal and strategic technology, VR extends human capability to comprehend, modify, and invent within the objective world, beyond mathematical reasoning and scientific experimentation. The concept of “virtual reality” was first introduced by Lanier, founder of VPL Research, in 1987 [2]. Its primary design is educational, assisting in the comprehension of abstract concepts and the practice of operational skills. Initially, in the 1980s, VR hardware was confined to specialized labs. However, with VR's technological evolution, both its hardware and software systems have transitioned from these labs into practical, real-world applications [3,4,5].

The VR technology is now extensively applied across multiple sectors, including healthcare, military, education, and cultural domains. In healthcare, its applications span medical training, surgical navigation, clinical diagnosis, and intervention therapies [6,7]. Its integration into medical education, in particular, aims to enhance the clinical skills of medical students before they engage in clinical

practice [8]. This advancement addresses the limitations of traditional teaching methods [9,10]. As virtual reality technology continues to merge with medical practices, its potential for transforming disease diagnosis, treatment, health education, and medical interventions is expected to expand significantly.

The VR technology has begun to make inroads into various clinical care domains. Currently, VR is effectively utilized in pain management within clinical care settings. By immersing patients in a virtual environment, VR helps divert their attention away from discomfort due to pain and medical procedures [11]. For example, a 'Spider World' game developed by the University of Washington's affiliated burn center employs helmet displays to engage patients fully into the game world, significantly reducing their pain and anxiety [12]. Furthermore, Schneider et al. [13] have conducted several studies to mitigate the negative effects experienced by cancer patients undergoing chemotherapy. VR has been shown to effectively enhance patients' tolerance of chemotherapy treatments. Research suggests that VR can improve the body's pain threshold by alleviating negative emotions and shortening the perception duration of pain [14]. Additionally, VR-assisted network therapy has been used to lessen postoperative pain in cardiac patients, yielding positive therapeutic outcomes [15]. VR also contributes to psychotherapy, reducing patients' negative experiences associated with real-world environments, including post-traumatic phobias and stress disorders [16]. Moreover, VR serves as a therapeutic and rehabilitative tool in geriatric rehabilitation, cardiac rehabilitation, cancer treatment, and managing chronic obstructive pulmonary disease [17,18]. Prominent VR rehabilitation systems include the Kinect in the U.S., Nintendo Wii in Japan, and Bio Master in China [19]. VR technology is well-established internationally, with its application in educational support becoming a focal point of research in the nursing sector and a growing trend. In China, the adoption of VR technology has been more recent and is still undergoing extensive development [20].

Current literature reviews predominantly focus on categorizing virtual reality applications in nursing, detailing application methods—including conditions, forms, and precautions—and evaluating effects on specific diseases, symptoms, or advancements in nursing education. However, there is a scarcity of studies that present this information in the form of visualized scientific knowledge maps, or that offer a macro analysis of research hot-spots and emerging trends. In our study, we utilized CiteSpace software to visually analyze the literature concerning virtual reality applications in nursing from 2013 to 2023, sourced from the Web of Science core database. Our aim was to organize and

summarize both domestic and international research in this arena, and to identify development trends and research hot-spots within the nursing field. This work is intended to inform and guide future research directions.

2 Methods

2.1 Literature search and processing

We conducted a comprehensive search for literature on the application of virtual reality technology within the field of nursing. This search was performed using the Web of Science (WOS) Core Collection, employing the subject terms “virtual reality” OR “VR” AND “nursing.” The search was limited to the period from November 1, 2013, to November 1, 2023, yielding a total of 1048 papers. We then refined our results by removing duplicates, conference proceedings, conference abstracts, editorials, letters, corrections, book chapters, news items, and other non-relevant documents, resulting in 908 valid entries. Further manual screening based on titles, keywords, abstracts, and full texts led to the exclusion of unrelated records, leaving 547 relevant articles. These were exported in plain text format and subsequently imported into CiteSpace 5.8 for visualization and analytical processing.

2.2 Inclusion and exclusion criteria

Inclusion Criteria: Literature must be centered on the application of virtual reality within the scope of nursing research.

Exclusion Criteria: (1) Non-scholarly materials such as conference abstracts, newspaper articles, general news pieces, informational briefs, and promotional releases. (2) Redundant publications reporting the same research, documents with insufficient information, or sources that only marginally address virtual reality applications in nursing.

2.3 Research methodology

In our study, the analysis of keywords derived from the literature was performed using CiteSpace 5.8 R3. This software is designed to map out the foundational knowledge, present research status, developmental trends, and prospective research frontiers within a specific subject field through a Scientific Knowledge Graph. It systematically visualizes and analyzes the geographical distribution of contributions by country or region, institutional affiliations, and the occurrence of keywords. Additionally, it identifies and investigates emergent keywords. Upon running the software, we adjusted the parameters of the nodes and links in the visualization for optimal aesthetics and clarity. The refined scientific knowledge graph thus represents the research findings in an accessible and

visually informative manner.

3 Results

3.1 Volume of publications (Figure 1)

Figure 1 illustrates the increasing trend in the number of published papers on virtual reality technology within the nursing sector internationally since 2013. The volume of publications has consistently remained high over the last four years, exceeding 200 papers annually.

3.2 Analysis by country or region (Figure 2 and Table 1)

The CiteSpace software visualizes the collaborative networks between countries or regions, with each node on the network representing a distinct country or region. The size of the purple ring around each node reflects the centrality, which corresponds to the impact of publications from that region, as illustrated in Figure 3. During the analysis of the international collaboration network, the country names and their corresponding abbreviations from the Web of Science Core Collection were consolidated. The top five countries with the most substantial number of published articles were identified as the USA (154), People's Republic of China (55), South Korea (49), Australia (46), and Canada (43), detailed in Table 1.

3.3 Institutional analysis (Figure 3 and Table 2)

Figure 3 depicts a network of research institutions, each represented by a label. From 2013 to 2023, the most prolific institutions in virtual reality research within the nursing field include the University System of Ohio with 8 articles, Central Queensland University with 7 articles, California State University System with 6 articles, Ege University also with 6 articles, and the Chinese University of Hong Kong with 6 articles. For a detailed account, refer to Table 2.

3.4 Keyword analysis

3.4.1 Keyword co-occurrence analysis (Figure 4 and Table 3)

Keyword frequency within the research literature serves as an indicator of the focal points in the field, with more frequently occurring keywords represented by larger fonts and nodes on the map. Synonyms, abbreviations, and different grammatical forms of keywords have been consolidated, while irrelevant and non-contributory terms have been omitted for the co-occurrence and clustering analysis. The co-occurrence analysis of keywords from international literature has led to the extraction of the top 10 keywords, as depicted in Fig. 4. An analysis of the keyword co-occurrence map and its detailed data reveals that research hot-spots in virtual reality applications in nursing predominantly revolve around “anxiety”, “augmented reality”, “care”, “education”, and “balance”. According to the literature sourced from the Web of Science, seven keywords appeared 10 times or

more. The five most prominent were “anxiety” (42 occurrences), “augmented reality” (39 occurrences), “care” (22 occurrences), “education” (16 occurrences), “balance” (13 occurrences), followed by “children” (12 occurrences), and “Alzheimer's disease” (10 occurrences), detailed in Table 3.

3.4.2 Keyword clustering analysis (Figure 5 and Table 4)

Cluster analysis groups together keywords based on their interrelations, with smaller cluster numbers indicating a larger aggregation of related keywords. The Log-likelihood rate (LLR) clustering algorithm facilitated the identification of the most significant clusters. The high average silhouette scores of >0.8 across the clusters confirm the reliability of the results. Out of the clusters identified, the top 12 were selected for display, as illustrated in Fig. 5. The corresponding keyword clusters have been summarized in Table 4, which outlines their relevance to nursing applications of virtual reality. These clusters include #0 children, #1 augmented reality, #2 phlebotomy, #3 students, #4 big data, #5 aged, #6 dementia, #7 skills, #8 head-mounted display, #9 hydrocephalus, #10 manual ability classification system, #11 artificial intelligence, and #12 ergonomics. Notably, the populations most frequently associated with virtual reality in nursing are children and students, with related keywords encompassing psychological interventions, development, child pain management, anticipatory nausea, inpatient rehabilitation, and educational applications in anatomy and nursing, among others.

3.4.3 Keyword emergence (Figure 6)

Keyword emergence is characterized by the frequency and temporal concentration of specific terms in published literature. The emergence period of a keyword is visually marked by a red horizontal line, signifying the term's relevance and the level of attention it has garnered in the research field. The length of this line indicates the duration of interest, with longer lines suggesting sustained importance and indicating cutting-edge research. To identify emerging keywords in this study, the “Burstness” function in CiteSpace was utilized with a gamma value set to 0.7, while other parameters were left at their default settings. This process generated a table of emerging terms, which can be seen in Figure 6. Our analysis identified a total of 20 emerging keywords, with “environments” (2014-2018) having the longest duration of emergence. The keyword “anxiety” exhibited the highest intensity of burst (8.77), followed by “education” (5.6) and “care” (2.62). Research on virtual reality in nursing has evolved from initial applications in education to encompass clinical care. The volume of research is anticipated to grow, with a sustained research emphasis on clinical care environments, psychological care (including aspects of grief and depression), and clinical simulation teaching. Recently emergent keywords such as “Alzheimer's disease” and

“children” underscore the field's progression towards exploring effective virtual simulation models for managing conditions in Alzheimer's patients and pediatric care.

4 Discussion

4.1 Status of research

In recent years, VR has garnered increasing international attention and has sustained an important role in academic research. The volume of publications on VR's application in nursing has experienced a notable surge since 2019, displaying a sharp, jagged upward trend. This growth has stabilized to over 200 publications annually in the past three years. An analysis of publication numbers, as well as the geographic distribution of contributing countries and institutions, indicates that the United States (154 publications), People's Republic of China (55), South Korea (49), Australia (46), and Canada (43) are at the forefront of VR research in the nursing sector. The United States, in particular, has been a prominent leader, evidenced by the highest number of publications originating from its institutions, highlighting its pivotal role in advancing the application of VR in nursing.

Regarding research themes, a significant proportion of recent publications have concentrated on clinical care applications of virtual reality. This includes psychological patient care, such as the alleviation of anxiety, as well as general patient care and nursing education. Numerous scholars have conducted comprehensive reviews, establishing theoretical frameworks, assessment tools, and intervention strategies for the application of virtual reality in nursing. The scope of related research is expanding, demonstrating a trend towards greater diversity and depth in its development.

4.2 Research Hot Spots and Frontier Analysis

4.2.1 Virtual Reality Technology Applied to Psychotherapy

VR technology has demonstrated significant benefits in the psychological support of patients, assisting in alleviating disease-related fears, facilitating environmental adaptation, and contributing to disease prevention and treatment efforts. Ju et al. [21] have observed positive therapeutic effects on patients with social disorders, anorexia, and schizophrenia using VR interventions. Similarly, Jung et al. [22] implemented VR helmet displays in an eight-week pulmonary rehabilitation program for patients with chronic obstructive pulmonary disease, resulting in a notable reduction in anxiety symptoms. Schweizer et al. [23] employed VR to vividly recreate traumatic scenarios, helping post-traumatic patients overcome their fears and adapt better to their environments, which is advantageous for the management and treatment of their conditions. This method proved promising for treating post-traumatic stress disorder (PTSD), given its ability to evoke subjective stress responses, emotional disturbances, and intrusive memories in simulations of trauma exposure. Jimenez et al. [24]

utilized VR devices to simulate end-of-life experiences for breast cancer patients, which not only diminished anxiety and fear of death but also enhanced their cooperation with medical treatments, thereby aiding in disease recovery. Furthermore, Reger et al. [25] recreated Vietnam War scenes via VR, which significantly mitigated PTSD symptoms by re-engaging patients with their wartime traumatic memories.4.2.2 Virtual Reality for Nursing Education

Virtual reality, as an advanced medium of information technology, has emerged as an innovative teaching method that enhances nursing students' knowledge acquisition, conceptual understanding, and the ability to bridge theory with practice [26]. This aligns with Woon et al.'s findings [27], although the cost-effectiveness and long-term benefits of VR in nursing education warrant further investigation. VR-based learning offers a risk-free environment, allowing students to perform complex procedures or navigate clinical situations that traditional methods cannot replicate. Immersive virtual patient interactions can be repeated, refining nursing skills, promoting clinical reasoning, and bolstering satisfaction and self-confidence [28-30]. Internationally, one notable application is the Cath Sim venepuncture system, which uses a VR-simulated arm for realistic practice. Students navigate the simulation via keyboard and mouse, observing needle angles and arm vasculature on-screen, and controlling the virtual needle's direction and depth. The system provides feedback on unsuccessful attempts, such as redness or swelling, enhancing venipuncture proficiency, reducing stress, conserving resources, and improving the success rate of venipuncture while potentially easing doctor-patient tensions. Chu et al. [31] incorporated VR technology with immersive experiential learning in vascular surgery nursing education, with the experimental group showing superior outcomes in knowledge, skill proficiency, and satisfaction compared to controls. However, some studies [32] highlight technical challenges in deploying VR for teaching, indicating the need for further enhancements to fully realize its potential in nursing education.

4.2.3 Virtual Reality Applied to Rehabilitation Training

VR technology is increasingly being recognized as a promising tool in rehabilitative care for neurological conditions, including Alzheimer's disease. Studies have demonstrated that VR can enhance limb function, walking ability, balance, gait speed, rhythm, and the performance of daily activities beyond what traditional rehabilitation methods offer [33]. However, a systematic review by Hu et al. [34] found that VR's effects on balance in Alzheimer's patients were not significant, potentially due to the short duration of interventions in the reviewed randomized controlled trials (RCTs) and the participants' limited physical mobility. Conversely, a meta-analysis by Miguel-Rubio et al. [35] indicated positive impacts of VR on limb motor function, balance, walking patterns, and daily living skills in patients with spinal cord injuries. Nonetheless, another study [36] suggested that

evidence supporting VR's benefits for motor function in spinal cord injury patients is limited and not significantly superior to conventional methods. This discrepancy may stem from the varied levels of spinal cord injuries or differences in VR immersion levels and modalities. Future research should aim for high-quality, large-sample, multicenter RCTs to ensure uniformity in equipment, intervention frequency, and intensity. This will help to discern the factors influencing outcome validity. Moreover, the effectiveness of VR on cognitive functions in neurological disorders and mental health remains a critical area for further investigation.

4.3 Research Perspectives on Virtual Reality

This study utilized CiteSpace software to analyze existing literature on the application of virtual reality within the nursing discipline. It identified and visualized the main research hot-spots through a knowledge map, which included research subjects (such as students and children) and themes (such as psychological care and nursing education). Furthermore, the study illuminated current trends, like the focus on psychological care and the educational aspects of nursing. Researchers in this field may use these findings to conduct in-depth longitudinal studies on these hot-spots in the future. Additionally, the identified trends could serve as a foundation for undertaking extensive, multi-center, high-quality randomized controlled trials with large sample sizes.

4.4 Limitations

Our study is subject to certain limitations. Firstly, the scope of our literature review was restricted to publications from the years 2013 to 2023. Secondly, we confined our review to sources from the Web of Science Core Collection database. While this database is reputable, it encompasses a relatively limited selection of the available literature. Future studies could broaden their scope by incorporating multiple databases, thus screening a more extensive range of both domestic and international high-quality literature to construct a more comprehensive and precise theoretical foundation. It is important to note, however, that due to varying citation counting methodologies across different databases, concurrent fusion and analysis of these sources may not be feasible.

5 Conclusion

VR technology, renowned for its interactivity, immersiveness, and capacity to simulate complex scenarios, holds significant value in the field of nursing. The adoption of VR has been growing rapidly across various sectors, and it has particularly revolutionized traditional medical education methods in the 21st century [37, 38]. VR is also emerging as a vital tool for innovative nursing training. Currently, the application of VR in nursing is still evolving. Its potential as an auxiliary instrument for nursing industry development is substantial. Future research and development of VR training

systems could emphasize three-dimensional visualization, enhance interactive capabilities, and integrate VR with other advanced nursing training methodologies. This integration is aimed at developing VR systems tailored to the needs of the nursing profession, ultimately elevating the quality of nursing education and training.

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Figure legends:

Supplementary Files

Figures

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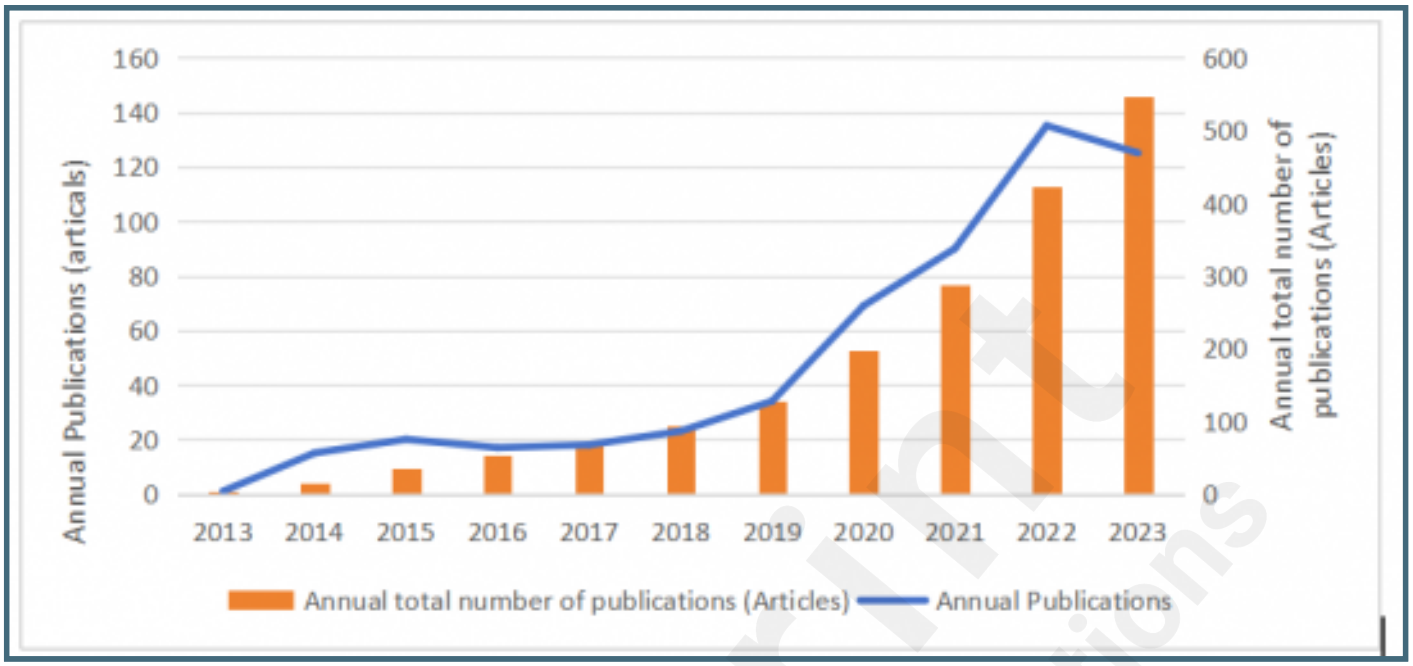

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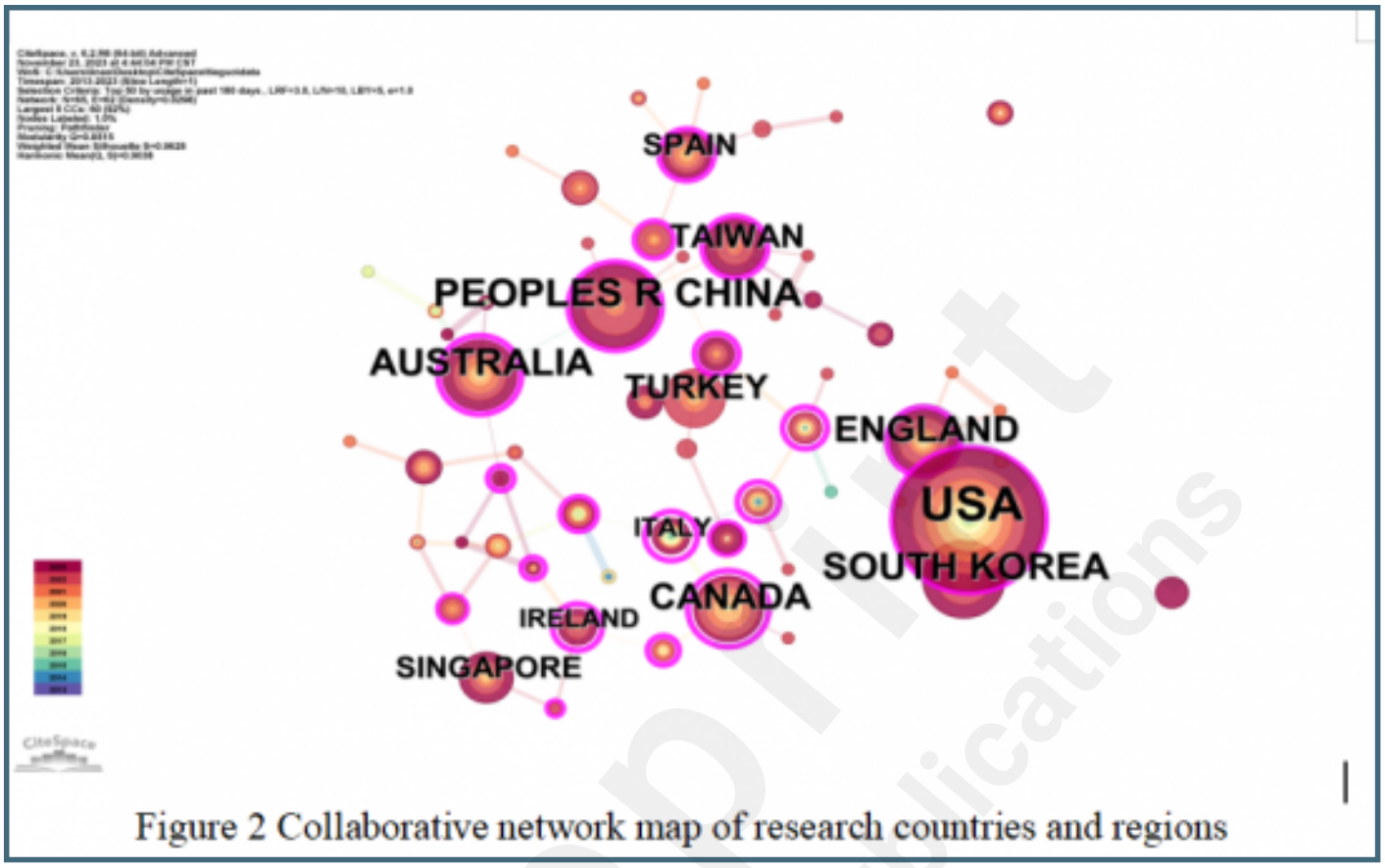

Figure 2 Collaborative network map of research countries and regions

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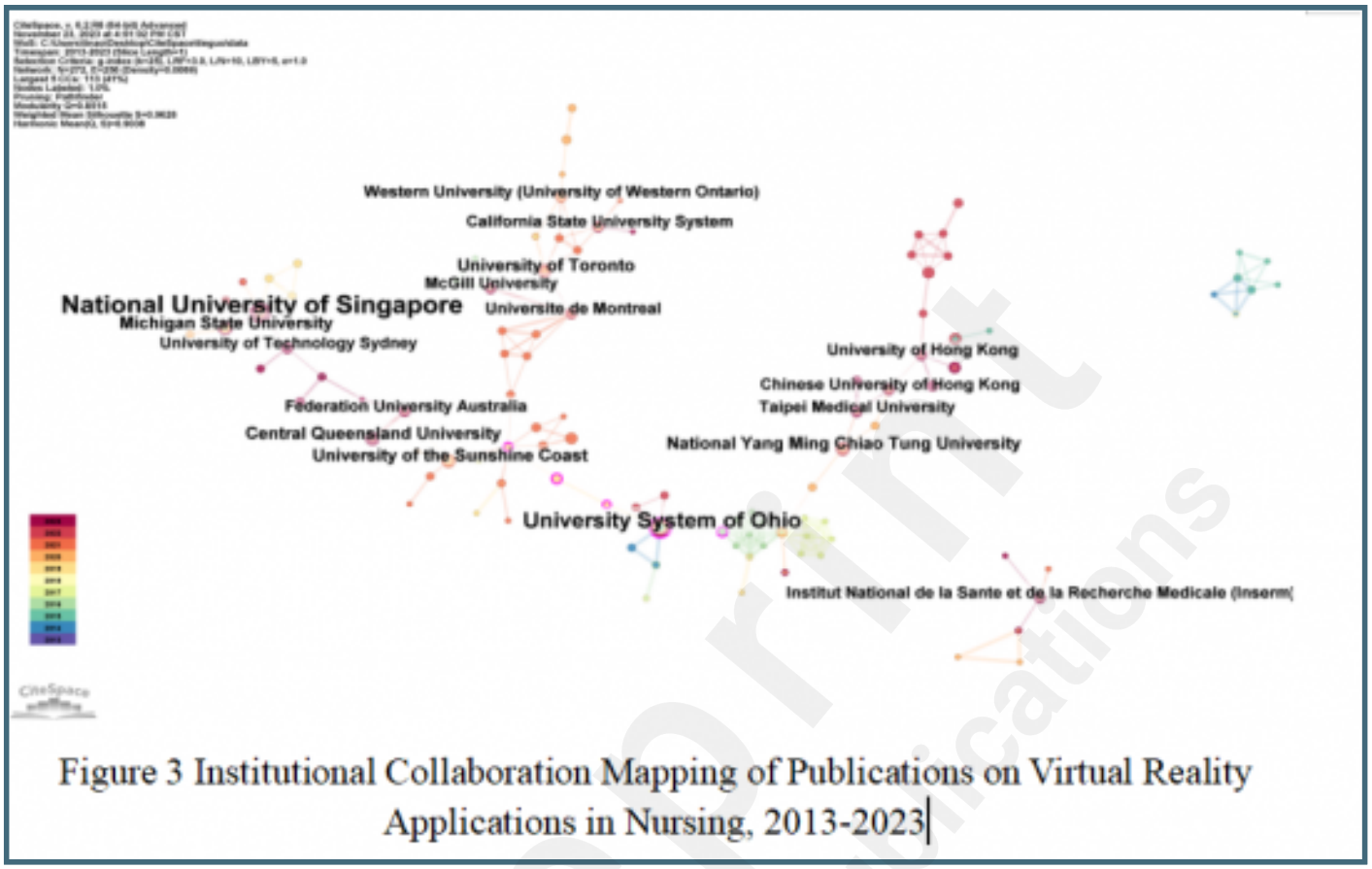

Figure 3 Institutional Collaboration Mapping of Publications on Virtual Reality Applications in Nursing, 2013-2023

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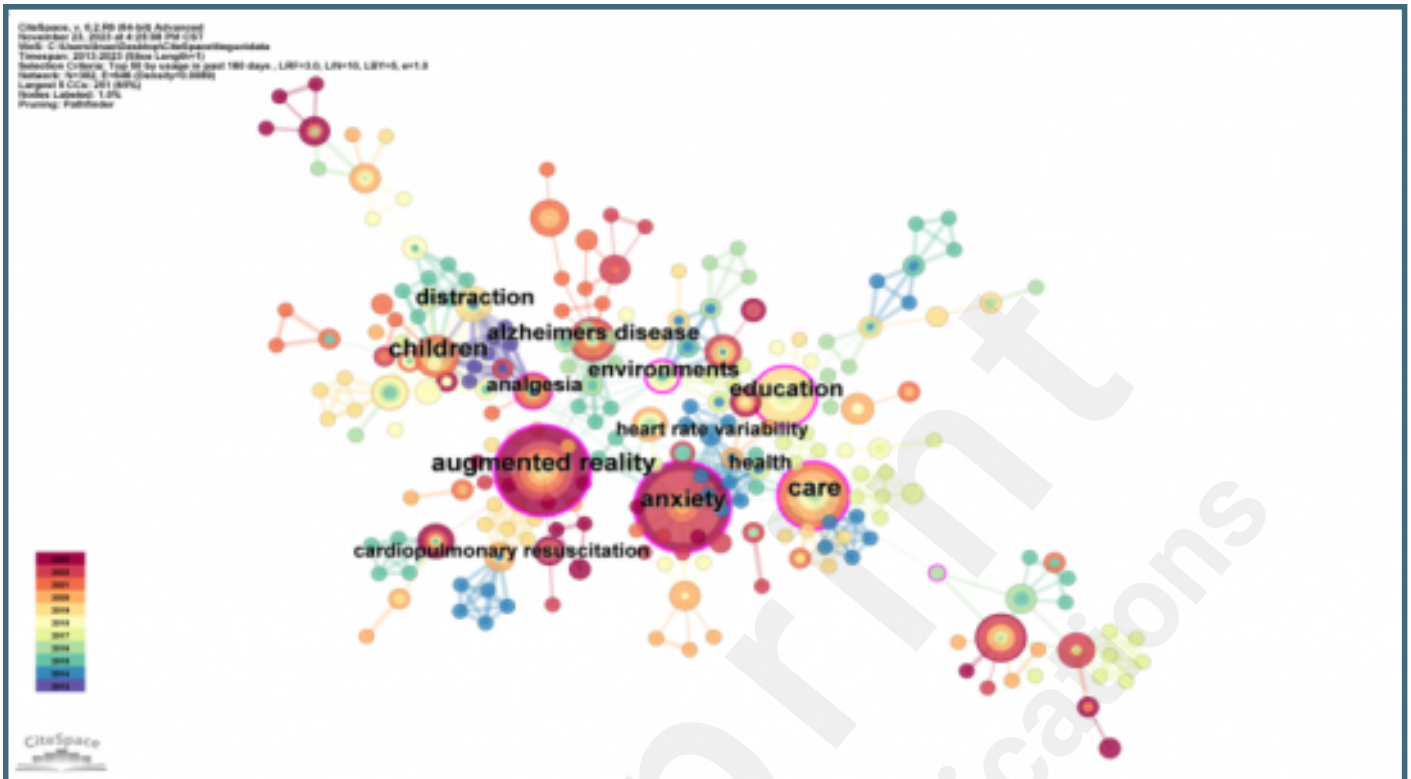

Figure 4 Co-occurrence mapping of keywords for virtual reality applications in nursing (2013 to 2023)

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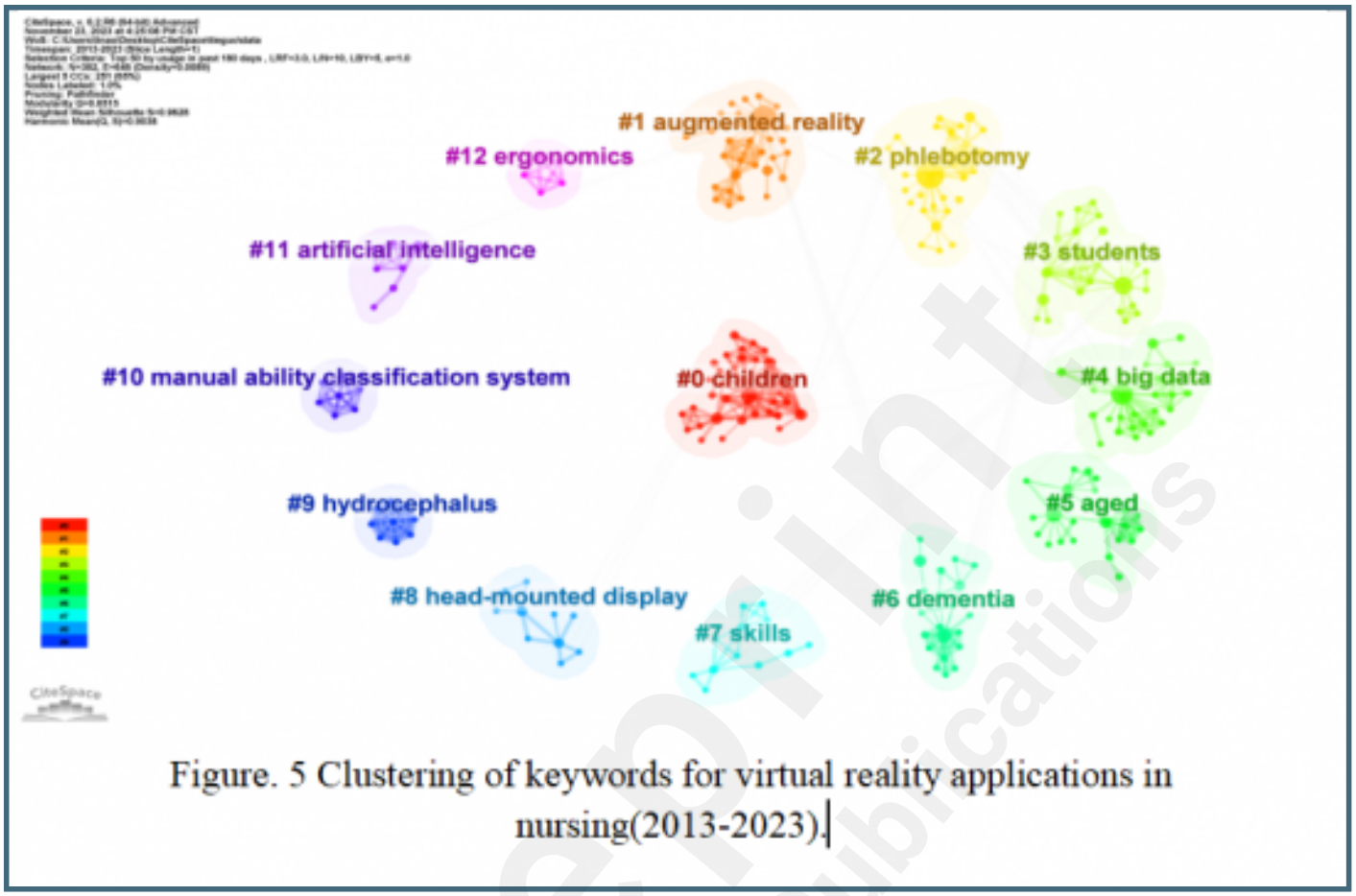

Figure. 5 Clustering of keywords for virtual reality applications in nursing(2013-2023).

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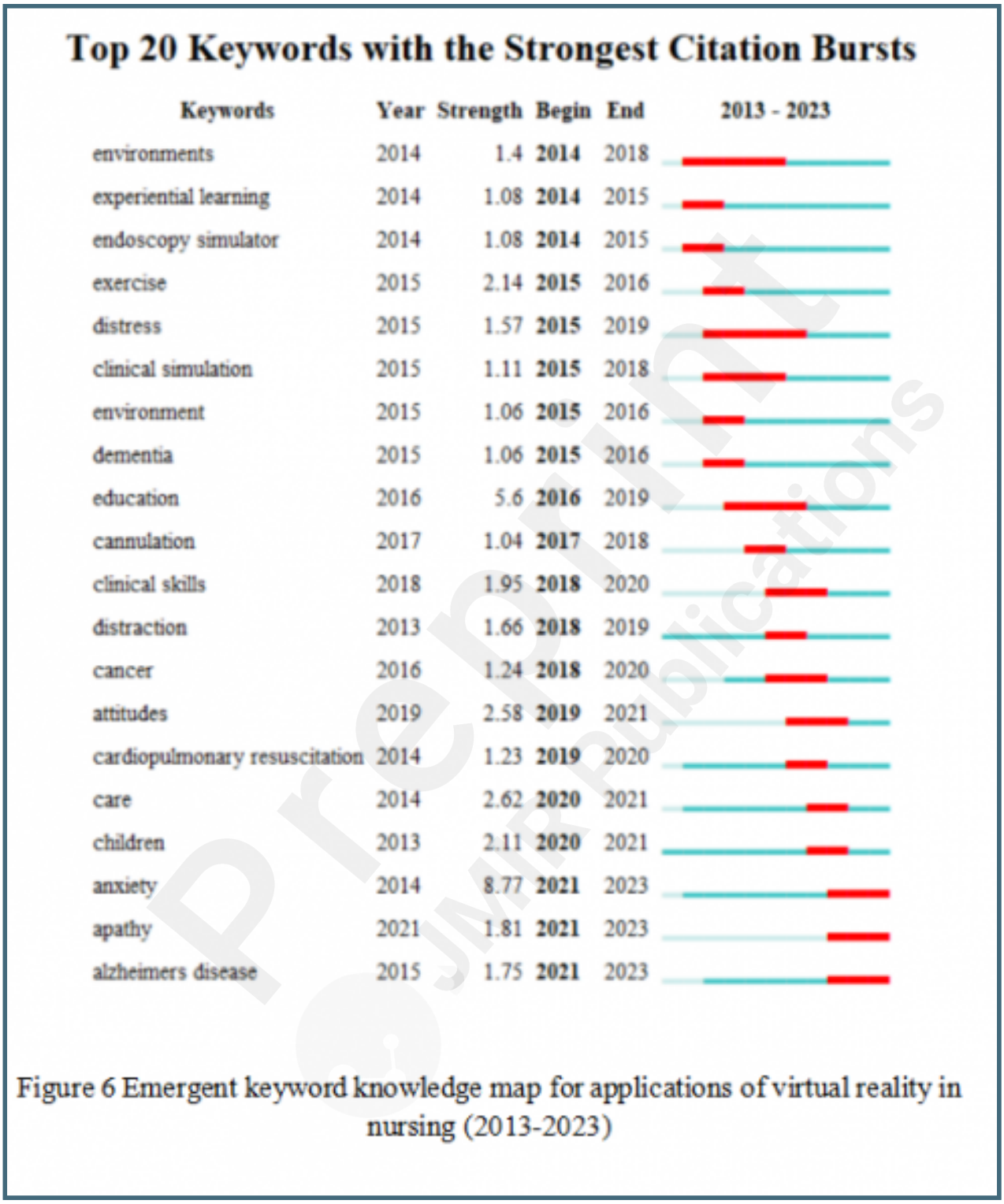

Figure 6 Emergent keyword knowledge map for applications of virtual reality in nursing (2013-2023)

Multimedia Appendixes

Untitled.
URL: http://asset.jmir.pub/assets/534e42bcd922adf4b2c6699f5cf8ee24.docx

Untitled.
URL: http://asset.jmir.pub/assets/422b9d5f1c45d86f68a4b1e1d9e60f27.docx

CONSORT (or other) checklists

Untitled.
URL: http://asset.jmir.pub/assets/80b45d21564a6183cbd9ef587a206e6a.pdf