

# Mapping Trends and Hot-spots of Virtual Simulation Research in Nursing: a Bibliometric Analysis

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## Research Article

**Keywords:** virtual simulation, nursing, bibliometric analysis, hot-spots, Citespace, Vosviewer

**Posted Date:** November 9th, 2021

**DOI:** <https://doi.org/10.21203/rs.3.rs-1038858/v1>

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# Abstract

**Background:** Virtual simulation has been widely used in nursing education and nursing training. This study aims to characterize publications in terms of countries, institutions, journals, authors, and collaboration relationships, and analyze the trends and hot-spots of virtual simulation in nursing.

**Methods:** Publications concerning virtual simulation in nursing were retrieved from Web of Science. Microsoft Excel 2010, VOSviewer, and Citespace were used to analyze the characteristics of this field.

**Results:** We identified 611 papers between 1999 and 2021. The number of publications grew slowly until 2019, and got a sharp increase in 2020 and 2021. The USA, Canada and Australia were three key contributors to this field. Centennial College, University of Ottawa, and Ryerson University were three major institutions with a larger number of publications. Verkuyl M was the most productive and highest cited author. Clinical Simulation in Nursing, Nurse Education Today, Journal of Nursing Education were the three productive journals. "virtual patients," "nursing students," "clinical simulation," and "communication skills" were the frontier topics in recent years.

**Conclusion:** Virtual patients simulated more clinical situations to train nursing students, developing more reliable and objective assessment methods to validate learning outcomes might be the recent and future hot-topics.

## 1. Introduction

Virtual simulation(VS) or virtual reality simulation is a computer system that creates and experiences the virtual world. Users can directly participate in and explore the role and changes of the simulated objects in the environment, experience a sense of immersion[1]. In the last decades, nursing educators have increasingly used VS for nursing education and clinical training. For example, Girao[2]developed a serious virtual reality game for medication preparation and administration training. Weston, Jeannie[3] conducted a virtual simulation with clinical practice for prelicensure pediatric nursing students during COVID-19 pandemic. Chao, YC [4] applied the immersive three-dimensional interactive video program to help nursing students better acquire nasogastric tube feeding skills. However, to the best of our knowledge, no study has focused on research tendency and hotspots in virtual simulation in nursing research.

Bibliometric analysis has been widely accepted to map the knowledge network in one certain field[5], and there existed several bibliometric analysis about topics in nursing[6–8]. Therefore, we utilized Citespace and Vosviewer[9, 10] to comprehensively analyze VS in nursing based on the Web of Science Core Collection (WoSCC). We hope this paper will uncover the development of VS in nursing field and predict possible progression in this field in the future.

## 2. Materials & Methods

### 2.1 Aims

The aims of this study are as following: (1) to uncover the distributions and academic influence of different countries, institutions, journals, authors in virtual simulation related to nursing research. (2) to analyze the co-operation relationships in this field. (3) to map the knowledge network and identify the frontier topics in this field.

## 2.2 Design

A descriptive bibliometric analysis of publications in virtual simulation related to nursing research.

## 2.3 Sample/Participants

The data in this research were retrieved from Web of Science database, so no participants were involved.

## 2.4 Search Strategy

The advanced search was performed using Web of Science (Thomson Reuters, New York, USA) on August 1st, 2021. Formula: TS= ("virtual simulation" or "virtual reality" or "virtual reality simulation" or "virtual learning") and TS= ("nurs\*") was used to screen out publications associated with virtual simulation in nursing. All team members searched and screened the database independently. Any discrepancies were resolved by discussion until consensus was reached.

## 2.5 Inclusion criteria

- (1) Peer-reviewed articles involving virtual simulation related to nursing
- (2) Original articles and review articles
- (3) Written in English.

## 2.6 Exclusion Criteria

- (1) Other types of documents, like meeting abstract, early access, letters, due to lacking keywords and other crucial information
- (2) written in non-English

## 2.7 Data Extraction and Analysis

The full records and cited references of all publications were exported as plain text. The following bibliometric parameters: title, keywords, journal, publication year, citation counts, citations per year, H-index, author, institution, country, and references were extracted, and then imported into Microsoft Excel 2010 (Redmond, Washington, USA), VOSviewer (Leiden University, Leiden, the Netherlands), and Citespce (Version 5.7 R2) to build network visualization maps of coauthor-authorship, coauthor-country, coauthor-institution, keywords-cooccurrence, cocited-references, cocited references burst, and keywords burst [10].

## 3. Results

### 3.1 General data

An initial research of the WoSCC identified 783 publications. After excluded meeting abstract, early access and limited English language, 611 articles were finally identified. Original article was the primary article type (n=523, 86%) (Figure 1). These papers were published from 1999 to 2021. The timing of publication could be divided into three parts (Phase I, 1999-2008; Phase II, 2009-2019; Phase III, 2020-2021). 1999-2008, the number of articles per year was below 10. 2009-2019, it gradually increased to 59. Since 2020, it got a significant increase to 126. The peak year was 2020 (n=126). The total number of citations was 8606, with 14 citations per paper and 374 citations per year (Figure 2A). The annual year publications of the top 10 countries were shown in Figure 2B.

### 3.2 Authors and co-cited authors

The top 10 prolific authors in this area were both from North America (Table 1). Among them, eight from Canada, two from the USA. 95 papers were published by them and accounted for 15.5% of the total. Verkuyl M. from Centennial College was the most productive author in this scope with 18 publications. Followed by Luctkar-flude M from Queens University with 11 publications and Tyerman J from University of Ottawa with 10 papers. In terms of co-cited author, Cook Da, Hoffman HG, and Verkuyl M were ranked the first three positions. Figure S1 showed the author cooperation network and co-cited author network. There were scattered co-operations between them.

Table 1  
Top 10 prolific authors and co-cited authors on virtual simulation in nursing research

Rank	Author	Publications	Citations	Country	Co-cited author	Co-citations	Country
1	Verkuyl M	18	173	Canada	Cook, Da	118	USA
2	Luctkar-flude M	11	20	Canada	Hoffman, HG	108	USA
3	Tyerman J	10	20	Canada	Verkuyl, M	103	Canada
4	Hughes M	9	97	Canada	Jeffries, Pr	81	USA
5	Romaniuk D	9	120	Canada	Inacsl Stand, Comm	64	N/A
6	Farra S	8	115	USA	Cant, Rp	62	Australia
7	Lapum JL	8	85	Canada	Foronda, Cl	60	USA
8	Mastrilli P	8	112	Canada	Foronda, C	59	USA
9	Hodgson E	7	89	USA	Liaw, Sy	49	Singapore
10	St-amant O	7	46	Canada	Hayden, Jk	45	USA

### 3.3 Journals and co-cited journals

The top 10 productive and co-cited journals were identified by VOSviewer. A total of 260 journals contributed to VS in nursing. The top 10 productive journals published 247(39.3%) papers. Clinical Simulation in Nursing was the most productive journal (n=92), followed by Nurse Education Today (n=48) and Journal of Nursing Education (n=24). The top three co-cited journals were the same journals mentioned above, with 820, 667,339 co-citations, respectively(Table2).

Table 2  
Top 10 prolific journals and co-cited journals on virtual simulation in nursing research

Rank	Journal	Publications	Citations	IF*	Co-cited journal	Co-citations	IF
1	Clinical Simulation in Nursing	92	735	2.391	Clinical Simulation in Nursing	820	2.391
2	Nurse Education Today	48	509	3.442	Nurse Education Today	667	3.442
3	Journal of Nursing Education	24	206	1.726	Journal of Nursing Education	339	1.726
4	Journal of Medical Internet Research	18	401	5.428	Nursing Education Perspectives	256	N/A
5	Nurse Education in Practice	17	216	2.281	Medical Education	232	6.251
6	Nurse Educator	13	140	2.082	Medical Teacher	212	3.65
7	Cin Computers Informatics Nursing	11	99	1.985	Journal of Medical Internet Research	210	5.428
8	Burns	8	289	2.744	Simulation in Healthcare	206	1.929
9	Journal of Clinical Nursing	8	165	3.036	Nurse Education in Practice	197	2.281
10	Nursing Education Perspectives	8	62	N/A	Academic Medicine	194	6.892

\*Abbreviation for impact factor(JCR 2020).

## 3.4 Institutions.

The top 10 most productive institutions were presented in figure 3A. Among the top 10 institutions, five located in Canadian, four located in the USA, and one located in Singapore. Centennial College was the most prolific institution (n= 17 publications), followed by University of Ottawa and Ryerson University. In terms of citations and H-index, University of Toronto (Canada, 576 citations, 9 H-index), University of Ottawa (Canada, 329 citations, 8 H-index), Centennial College (Canada, 173 citations, 7 H-index) ranked in the top three. The co-authorship for organization module in VOSviewer was used to map the collaborations among 39 institutions, which published at least 5 papers. As shown in figure3B, There are few and sporadic connecting lines between different institutions.

## 3.5 Countries/regions

A total of 58 countries or regions participated in these publications. The top 10 were shown in Figure 4A. Obviously, the USA led in this field with 250 publications (40.9% of the total), 4289 citations, and 34 H-index. VOSviewer co-authorship for country module was used to visualize the country co-operations network. The smallest publication was settled as five. Finally, 26 countries meet our criterion. The USA, Canada, Australia, and England presented as the largest node. The strongest co-operation links were between the USA and Canada and between the USA and Australia (figure 4B).

## 3.6 Keywords

High-frequency keywords was usually used to describe hot-spots, and it was contribute to constructing a knowledge map[11]. Thesaurus was applied to clean similar keywords. For example, virtual reality simulation and virtual reality were replaced by virtual simulation. We identified 1459 keywords in total, and 72 keywords appeared more than five times were enrolled into analysis. The top five keywords ranked by number of occurrences were: virtual simulation (n=406), education (n=131), nurse education (n=106), nursing (n=65), skills (n=59). As shown in figure 5A, the keywords were classified into five groups. Group one (red) is associated with pain and anxiety management, the primary keywords were "virtual simulation, anxiety, children." Group two (green) associated with virtual patients, the primary keywords were "nurse education, skills, nursing students, virtual patients." Group three (blue) associated with clinical simulation training, the primary keywords were "nursing, clinical simulation, simulation training, gaming." Group four (yellow) and Group five (purple) referred to non-technical-skills, the primary keywords included "performance, communication, impact, surgery, patient, nurses, environments, experience, patient simulation." As shown in Figure 5B, keywords were colored according to their average publication years. The blue indicated early time, and the yellow suggested more recently. During the early phase, "virtual patients, pain, and distraction" were the primary focus in this field. In recent years, the trend has shifted to "nurse education, clinical simulation, and communication skills". The Citespace burst module were also used to identify the research trends and frontier topics[12]. The burst duration was set to 2 years. The blue and red bar indicated infrequently and frequently cited time. The top 19 keywords

with strongest citation bursts were displayed in figure 5C. Among them, virtual patient has the highest burst strength (n=4.09). During the early stage, "distraction, adolescent, medical education" were the primary topic. In recent years, 2015 to 2021, the following topic: program, rehabilitation, balance, nursing education, reality attracted more attention.

### **3.7 Top cited articles and co-cited references**

The top 10 most cited articles were listed in Table 3. To date, the most cited article was by Cook, David A[13] published in Academic Medicine by 2010 with 246 citations, entitled computerized virtual patients in health professions education: a systematic review and meta-analysis. The top 10 co-cited articles were identified through 18420 cited references from 611 papers, 17 references co-cited more than 20 times were used to form a co-citation network. As shown in Figure 6A, these publications have an active relationship with each other. Among them, the highest link strength article was published by Foronda, Cynthia[14] in Nurse Education Today by 2014, entitled use of virtual clinical simulation to improve communication skills of baccalaureate nursing students: a pilot study. CiteSpace citation burst could identify references focused by researchers in a specific period[9, 15]. The burst duration was set to 2 years. At last, 23 references with strongest citation bursts were identified in Figure 6B. Among them, Kidd Li, 2012, J PSYCHOSOC NURS MEN, V50, P28[16] had the highest burst strength(n=7.21). Articles with citation bursts ending in 2021 were: "Kyaw BM, 2019, J MED INTERNET RES, V21, P0[17]", "Liaw SY, 2014, J MED INTERNET RES, V16, P0[18]," and "Smith PC, 2015, CLIN SIMUL NURS, V11, P52[19]." Kyaw BM performed a meta-analysis study and found virtual reality could improve the knowledge and skills of health professionals compared with traditional education or digital education[17]. Liaw S Y conducted a randomized controlled trial and found that although there were no significant differences in improving nursing students' clinical performance, virtual simulations were more convenient and promising than mannequin-based simulations[18]. Smith PC designed a virtual reality simulation to evaluate Foley catheter skill proficiency in nursing students, and found virtual reality simulation could be a supplemental tool for teaching students critical steps in clinical skills[19].

Table 3  
Top10 most cited papers related to virtual simulation in nursing research

Rank	Title	Author	Journal	Year	Total Citations
1	Computerized Virtual Patients in Health Professions Education: A Systematic Review and Meta-Analysis	Cook, David A.	Academic Medicine	2010	246
2	Mastery Learning for Health Professionals Using Technology-Enhanced Simulation: A Systematic Review and Meta-Analysis	Cook, David A.	Academic Medicine	2013	153
3	Evaluation of trauma team performance using an advanced human patient simulator for resuscitation training	Holcomb, JB	Journal of Trauma-Injury Infection And Critical Care	2002	152
4	A pilot and feasibility study of virtual reality as a distraction for children with cancer	Gershon, J	Journal of The American Academy of Child And Adolescent Psychiatry	2004	151
5	Current trends in stroke rehabilitation. A review with focus on brain plasticity	Johansson, B. B.	Acta Neurologica Scandinavica	2011	149
6	Patient Outcomes in Simulation-Based Medical Education: A Systematic Review	Zendejas, B.	Journal of General Internal Medicine	2013	148
7	Effects of distraction on pain, fear, and distress during venous port access and venipuncture in children andAdolescents with cancer	Windich-Biermeier, A.	Journal of Pediatric Oncology Nursing	2007	127
8	Intravenous catheter training system: Computer-based education versus traditional learning methods	Engum, SA.	American Journal of Surgery	2003	123
9	The Insertion and Management of External Ventricular Drains: An Evidence-Based Consensus Statement	Fried, Herbert I.	Neurocritical Care	2016	120
10	A randomized trial of teaching clinical skills using virtual and live standardized patients	Triola, M.	Journal of General Internal Medicine	2006	116

Virtual patient had the strongest burst citations and last from 2012 to 2019. Nursing education colored yellow in VOSviewer keyword network and had a moderate burst strength in 2021. Therefore, We chosen

virtual patient and nurse education as hot topics in recent years.

## 4. Discussion

In this study, we mapped a knowledge network of VS in nursing from 1999 to 2021 and analyzed the contributions of different authors, journals, institutions, and countries. The number of publications in a field reflects the activity and productivity over the years[15]. We found the overall trend of publication was upward, and the publication time could be divided into three phases. Before 2008, the number of articles per year slightly increased. It may be restricted by technology such as internet access or computer popularity. Likewise, other study found before the year of 2005, the number of virtual patient publications were small[20]. Since 2020, the number of papers got a sharp increase. We speculate that there are several reasons accounted for this. First, due to social isolation, educators were forced to change the way of program delivery during the COVID-19 pandemic [21]. Numerous online programs have emerged during the COVID-19, such as virtual lab environments[22], three-dimensional virtual world (3DVW)[23], personal protective equipment (PPE) virtual simulation games[24]. Such virtual simulation programs can facilitate nursing student interest and provide nurse educators with novel and engaging means of content delivery[21]. Second, COVID-19 pandemic accelerated the demand for more nursing staff and higher quality nursing care. Third, during the COVID-19 pandemic, nurses sustained high levels of workload and stress. Developing virtual simulation relaxation, could help to reduce perceived stress on nurses in the frontlines[25].

In terms of research category, Nursing, Health Care Sciences Services, Education Scientific Disciplines dominated in this field, suggests that education and health care services is the primary focus on VS in nursing.

Without surprising, the USA leads the VS in nursing research, which requires the collaboration of multiple disciplines, such as medical informatics, education, computer science, and software engineering. Similar leading position can be seen in other areas, such as radiation-induced lung injury [26], and human-computer interaction[27], etc. Interestingly, in terms of the number of productive authors and institutions, Canada ranked ahead of the USA. Collaborations tend to be stronger between institutions or countries with shorter geographical distances[7], and we found co-operation links between authors and institutions within Canada were stronger than that in the United States(Figure S1 and Figure 4B). Considering the scattered collaborations in this field, we hope there will be more inter-institutions and international research in the future.

Key journals, institutions, and authors provide the essential information for a given research field. Clinical Simulation in Nursing, Nurse Education Today, and Journal of Nursing Education are the top three productive and co-cited journals. Researchers should continue to pay attention on them, because some important frontier articles may be published in these journals. In addition, researchers could choose these journals for their draft submission. Institutions like Centennial College, University of Toronto, University of

Ottawa, and scholars like Verkuyl M, Luctkar-flude M, Tyerman J, Cook Da, and Hoffman, HG should be followed and maybe the potential cooperation partner.

Keyword network and references analysis facilitates researchers to get insight into a certain field[10]. We found the keywords primarily focused on the following areas: virtual simulation, education, nurse education, nursing, and skills. From the color assigned to keywords by VOSviewer, pain, distraction, intervention, and skills were the primary foci during the early stage. Then, the trend shifted to nurse education, students, clinical simulation, and communication skills. One of the fundamental principles of registered nurses is "do no harm" to patients [28]. However, the traditional apprenticeship learning model does not ensure nurses' acquisition of adequate theory and practical skills before handling the clinical workplace [29]. 3D virtual environment such as second Life laboratory to practice the students' experience of learning decision-making skills and communication skills is a good way to train these students before and after becoming qualified nurses [30–33]. Moreover, another advanced VS program is virtual patients. It was developed to provide a realistic standard clinical situation to train the students' skills, like clinical reasoning[34–36], communication skills[37–39], situation awareness, and teamwork capability[40]. While a number of studies have shown the positive feedback of VS in nursing education, previous research has largely overlooked the significance of assessment methods of learning outcomes. Currently, the predominant methods for assessing learning outcomes are combinations of paper-based exams and observations from clinical teachers[41], effective and objective assessment methods related to learning outcomes are still lacking[42–44]. Despite Carina,Georg[45]developed the modified visual patient Lasater Clinical Judgment Rubric (vpLCJR) to evaluate nursing students' clinical reasoning, limited studies investigated the method of assessing outcome of nursing students' non-technical skills. Thus, we speculate that virtual patients simulated more clinical situations to train nursing students, develop more reliable and objective assessment methods to validate learning outcomes, maybe the recent and future topics.

## 4.1 Limitations

First, the papers on virtual simulation in nursing were searched based on the WOS. Although WOS is recognized as one of the most authoritative databases, PubMed, Scopus, and Google scholar are also widely accepted by scientists. Second, the number of citations and H-index are influenced by time and remain controversial as a comprehensive indicator of the quality of one paper or the author. Likewise, the larger number of publications was not the only indicator of influence for the journal, as other indicators (e.g., impact factor, SNIP, CiteScore, SJR) are widely used[46]. Third, we included only English papers in this study, several papers with non-English languages were excluded, such as Chinese, Japanese, and Russian. Finally, The published articles in 2021 only include the first seven months, and database updates may result in discrepancies. However, we believe that the low citation frequency of new publications has less impact on our conclusions.

## 5. Conclusions

This bibliometric analysis mapped the knowledge network of virtual simulation in nursing research. Further work should strengthen the co-operation between authors, institutions, and countries. Virtual patients simulated more clinical situations to train nursing students, and developing reliable and objective assessment methods to validate learning outcomes deserve more attention in the future.

## 6. List Of Abbreviations

WoSCC: Web of Science core collection

VS: virtual simulation

IF: impact factor

## 7. Declarations

7.1 Ethics approval and consent to participate

Not applicable

7.2 Consent for publication

Not applicable

7.3 Availability of data and materials

The datasets used and/or analysed in this study are available from the corresponding author on reasonable request

7.4 Competing interests

The authors declare no competing of interest.

7.5 Funding

This study was supported by the Hunan Science and Technology Innovation Platform and Talent Plan [Grant.: 2017TP1004].

7.6 Authors' contributions

Z.Q. conceived of the study, participated in its design, and drafted the manuscript. L.J. involved in study design, obtained data and contributed to interpretation, and helped to draft the manuscript. C.J. provided the theoretical frameworks and performed much of the editing of the manuscript. All authors read and approved the final manuscript.

7.7 Acknowledgements

## 8. References

1. Kilmon CA, Brown L, Ghosh S, Mikitiuk A: **Immersive virtual reality simulations in nursing education.** *Nursing education perspectives* 2010, **31**(5):314-317.
2. Girao ALA, Dos Santos MNO, Chaves EMC, Gomes EB, de Oliveira SKP, de Carvalho REFL: **NurseVR: Development of a Serious Virtual Reality Game for Medication Preparation and Administration Training.** *Computers, informatics, nursing : CIN* 2021.
3. Weston J, Zauche LH: **Comparison of Virtual Simulation to Clinical Practice for Prelicensure Nursing Students in Pediatrics.** *Nurse Educator* 2021, **46**(5):E95-E98.
4. Chao YC, Hu SH, Chiu HY, Huang PH, Tsai HT, Chuang YH: **The effects of an immersive 3d interactive video program on improving student nurses' nursing skill competence: A randomized controlled trial study.** *Nurse Education Today* 2021, **103**.
5. Tan Y, Yu Q, Ma L, Chang J, Zhan X, Cui H, Liu Y, Sui Y: **A bibliometric analysis of the application of procalcitonin in patients in the intensive care unit.** *Annals of palliative medicine* 2021, **10**(6):6367-6378.
6. Taskaya S, Aksoy A: **A bibliometric analysis of workplace incivility in nursing.** *J Nurs Manag* 2021, **29**(3):518-525.
7. Yanbing S, Hua L, Chao L, Fenglan W, Zhiguang D: **The state of nursing research from 2000 to 2019: A global analysis.** *Journal of advanced nursing* 2021, **77**(1):162-175.
8. Jarden R, Narayanan A, Sandham M, Siegert R, Koziol-McLain J: **Bibliometric mapping of intensive care nurses' wellbeing: development and application of the new iAnalysis model.** *BMC nursing* 2019, **18**:21.
9. Chen CM: **CiteSpace II: Detecting and visualizing emerging trends and transient patterns in scientific literature.** *Journal of the American Society for Information Science and Technology* 2006, **57**(3):359-377.
10. van Eck NJ, Waltman L: **Software survey: VOSviewer, a computer program for bibliometric mapping.** *Scientometrics* 2010, **84**(2):523-538.
11. Liao HC, Tang M, Luo L, Li CY, Chiclana F, Zeng XJ: **A Bibliometric Analysis and Visualization of Medical Big Data Research.** *Sustainability* 2018, **10**(1).
12. Dong J, Wei W, Wang C, Fu Y, Li Y, Li J, Peng X: **Research trends and hotspots in caregiver studies: A bibliometric and scientometric analysis of nursing journals.** *Journal of advanced nursing* 2020, **76**(11):2955-2970.
13. Cook D, Erwin P, Triola M: **Computerized virtual patients in health professions education: a systematic review and meta-analysis.** *Academic medicine : journal of the Association of American Medical Colleges* 2010, **85**(10):1589-1602.

14. Foronda C, Gattamorta K, Snowden K, Bauman EB: **Use of virtual clinical simulation to improve communication skills of baccalaureate nursing students: a pilot study.** *Nurse education today* 2014, **34**(6):e53-57.
15. Chen D, Zhang G, Wang J, Chen S, Wang J, Nie H, Tang Z: **Mapping Trends in Moyamoya Angiopathy Research: A 10-Year Bibliometric and Visualization-Based Analyses of the Web of Science Core Collection (WoSCC).** *Frontiers in neurology* 2021, **12**:637310.
16. Kidd L, Knisley S, Morgan K: **Effectiveness of a second life(®) simulation as a teaching strategy for undergraduate mental health nursing students.** *Journal of psychosocial nursing and mental health services* 2012, **50**(7):28-37.
17. Kyaw B, Saxena N, Posadzki P, Vseteckova J, Nikolaou C, George P, Divakar U, Masiello I, Kononowicz A, Zary N *et al.*: **Virtual Reality for Health Professions Education: Systematic Review and Meta-Analysis by the Digital Health Education Collaboration.** *Journal of medical Internet research* 2019, **21**(1):e12959.
18. Liaw S, Chan S, Chen F, Hooi S, Siau C: **Comparison of virtual patient simulation with mannequin-based simulation for improving clinical performances in assessing and managing clinical deterioration: randomized controlled trial.** *Journal of medical Internet research* 2014, **16**(9):e214.
19. Smith PC, Hamilton BK: **The Effects of Virtual Reality Simulation as a Teaching Strategy for Skills Preparation in Nursing Students.** *Clinical Simulation in Nursing* 2015, **11**(1):52-58.
20. Su W-S, Chang C-Y: **Virtual patient in interactive learning environments: a review of 1989-2020 publications in selected SSCI journals.** *INTERACTIVE LEARNING ENVIRONMENTS.*
21. Saab MM, Hegarty J, Murphy D, Landers M: **Incorporating virtual reality in nurse education: A qualitative study of nursing students' perspectives.** *Nurse Education Today* 2021, **105**:7.
22. Cantey DS, Sampson M, Vaughn J, Blodgett NP: **Skills, community, and rapport: Prelicensure nursing students in the virtual learning environment.** *Teach Learn Nurs* 2021, **16**(4):384-388.
23. Liaw SY, Choo T, Wu LT, Lim WS, Choo H, Lim SM, Ringsted C, Wong LF, Ooi SL, Lau TC: **Wow, woo, win"- Healthcare students' and facilitators' experiences of interprofessional simulation in three-dimensional virtual world: A qualitative evaluation study.** *Nurse Education Today* 2021, **105**:6.
24. Tyerman J, Luctkar-Flude M, Baker C: **Rapid Development of a COVID-19 Assessment and PPE Virtual Simulation Game.** *Clinical Simulation in Nursing* 2021, **56**:125-132.
25. Nijland JWHM, Veling W, Lestestuiver BP, Van Driel CMG: **Virtual Reality Relaxation for Reducing Perceived Stress of Intensive Care Nurses During the COVID-19 Pandemic.** *Front Psychol* 2021, **12**:706527.
26. Wang D, Li Z, Zhang Y, Li Y, Wang X, Wang S, Gui Y, Dong J, Hou W: **Bibliometric analysis of research relating to radiation-induced lung injury (2001-2020).** *Annals of palliative medicine* 2021.
27. Wang J, Cheng R, Liu M, Liao P: **Research Trends of Human-Computer Interaction Studies in Construction Hazard Recognition: A Bibliometric Review.** *Sensors (Basel, Switzerland)* 2021, **21**(18).
28. Sutcliffe H: **Understanding the NMC code of conduct: a student perspective.** *Nursing standard (Royal College of Nursing (Great Britain) : 1987)* 2011, **25**(52):35-39.

29. Nicol M, Glen S: **Learning clinical skills: the return of the practical room?** *Nurse education today* 1998, **18**(6):427-428.
30. Jenson C, Forsyth D: **Virtual reality simulation: using three-dimensional technology to teach nursing students.** *Computers, informatics, nursing : CIN* 2012, **30**(6):312-318; quiz 319-320.
31. McCallum J, Ness V, Price T: **Exploring nursing students' decision-making skills whilst in a Second Life clinical simulation laboratory.** *Nurse education today* 2011, **31**(7):699-704.
32. Wiecha J, Heyden R, Sternthal E, Merialdi M: **Learning in a virtual world: experience with using second life for medical education.** *Journal of medical Internet research* 2010, **12**(1):e1.
33. Bahrami M, Hadadgar A, Fuladvandi M: **Designing Virtual Patients for Education of Nursing Students in Cancer Course.** *Iranian journal of nursing and midwifery research* 2021, **26**(2):133-136.
34. Forsberg E, Georg C, Ziegert K, Fors U: **Virtual patients for assessment of clinical reasoning in nursing – a pilot study.** *Nurse education today* 2011, **31**(8):757-762.
35. Forsberg E, Ziegert K, Hult H, Fors U: **Clinical reasoning in nursing, a think-aloud study using virtual patients - a base for an innovative assessment.** *Nurse education today* 2014, **34**(4):538-542.
36. Everett-Thomas R, Joseph L, Trujillo G: **Using virtual simulation and electronic health records to assess student nurses' documentation and critical thinking skills.** *Nurse education today* 2021, **99**:104770.
37. Shorey S, Ang E, Ng E, Yap J, Lau L, Chui C: **Communication skills training using virtual reality: A descriptive qualitative study.** *Nurse education today* 2020, **94**:104592.
38. Shorey S, Ang E, Yap J, Ng E, Lau S, Chui C: **A Virtual Counseling Application Using Artificial Intelligence for Communication Skills Training in Nursing Education: Development Study.** *Journal of medical Internet research* 2019, **21**(10):e14658.
39. Chapelain P, Morineau T, Gautier C: **Effects of communication on the performance of nursing students during the simulation of an emergency situation.** *Journal of advanced nursing* 2015, **71**(11):2650-2660.
40. Peddle M, Mckenna L, Bearman M, Nestel D: **Development of non-technical skills through virtual patients for undergraduate nursing students: An exploratory study.** *Nurse education today* 2019, **73**:94-101.
41. Stayt L, Merriman C, Ricketts B, Morton S, Simpson T: **Recognizing and managing a deteriorating patient: a randomized controlled trial investigating the effectiveness of clinical simulation in improving clinical performance in undergraduate nursing students.** *Journal of advanced nursing* 2015, **71**(11):2563-2574.
42. Cook DA, Triola MM: **Virtual patients: a critical literature review and proposed next steps.** *Med Educ* 2009, **43**(4):303-311.
43. Ward R, Muckle T, Kremer M, Krogh M: **Computer-Based Case Simulations for Assessment in Health Care: A Literature Review of Validity Evidence.** *Evaluation & the health professions* 2019, **42**(1):82-102.

44. Chen S, Huang T, Liao I, Liu C: **Development and validation of the Simulation Learning Effectiveness Inventory.** *Journal of advanced nursing* 2015, **71**(10):2444-2453.
45. Georg C, Karlgren K, Ulfvarson J, Jirwe M, Welin E: **A Rubric to Assess Students' Clinical Reasoning When Encountering Virtual Patients.** *The Journal of nursing education* 2018, **57**(7):408-415.
46. Mingers J, Yang LY: **Evaluating journal quality: A review of journal citation indicators, and ranking in business and management.** *Eur J Oper Res* 2017, **257**(1):323-337.

## Figures

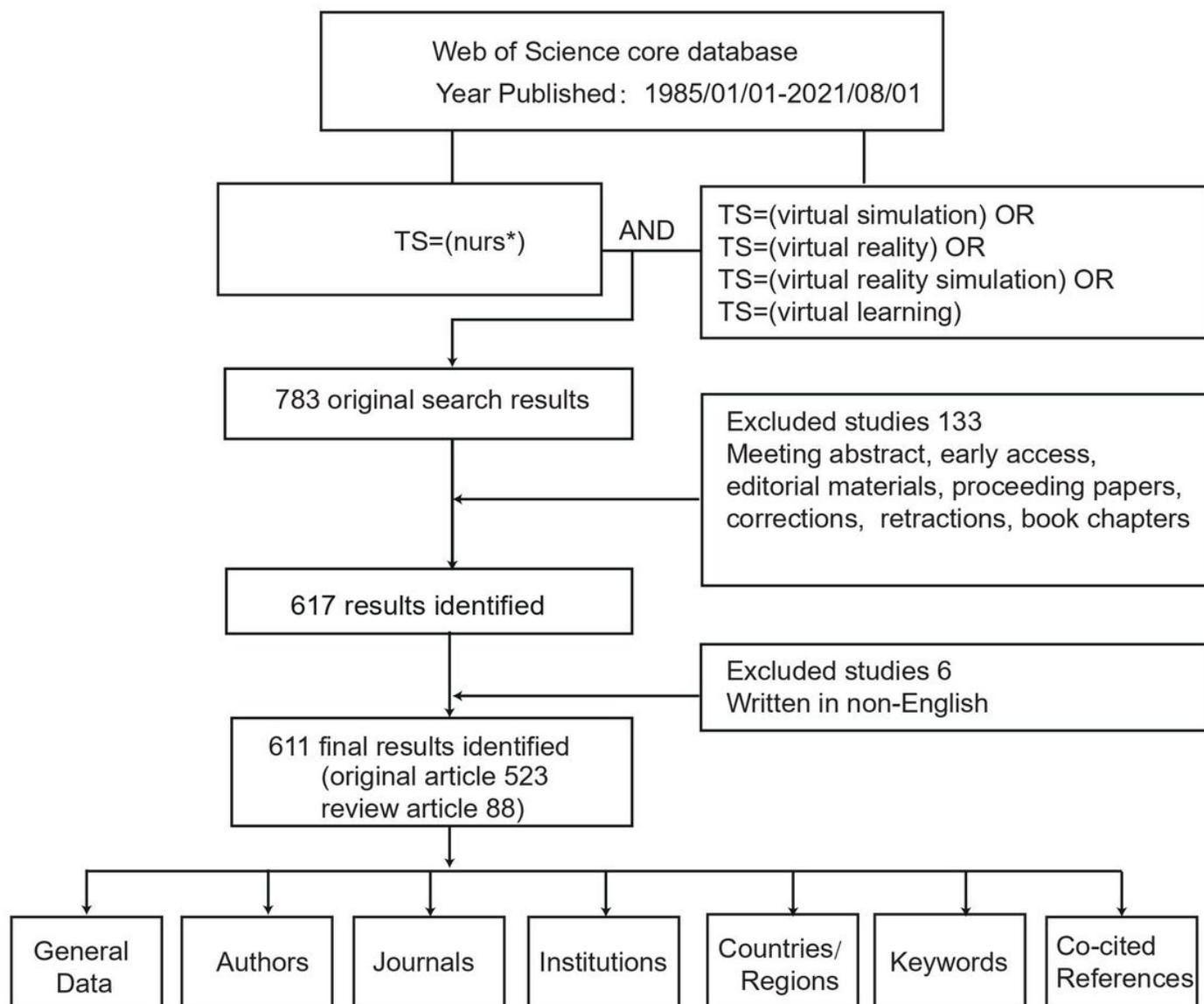
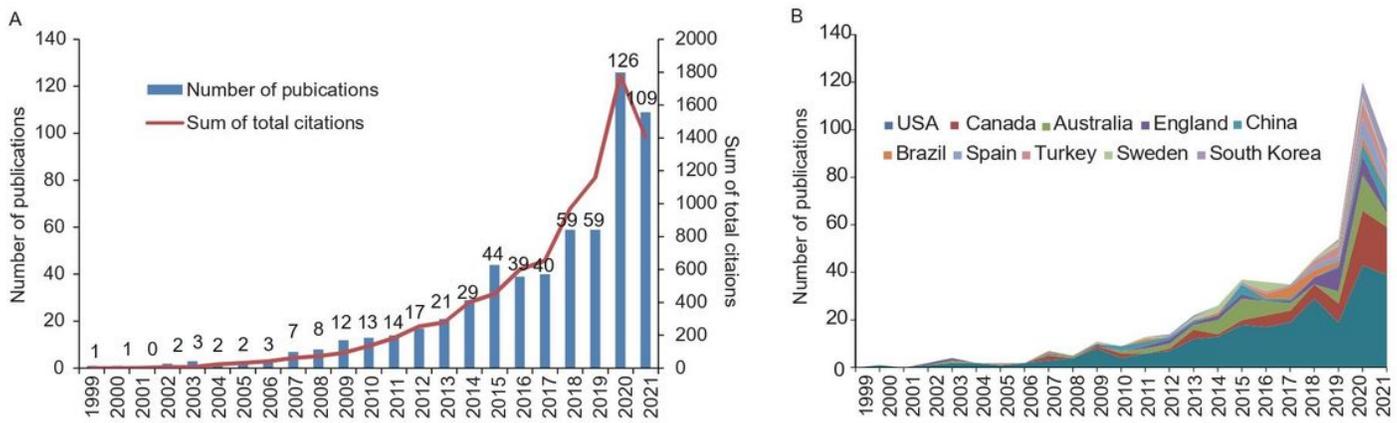


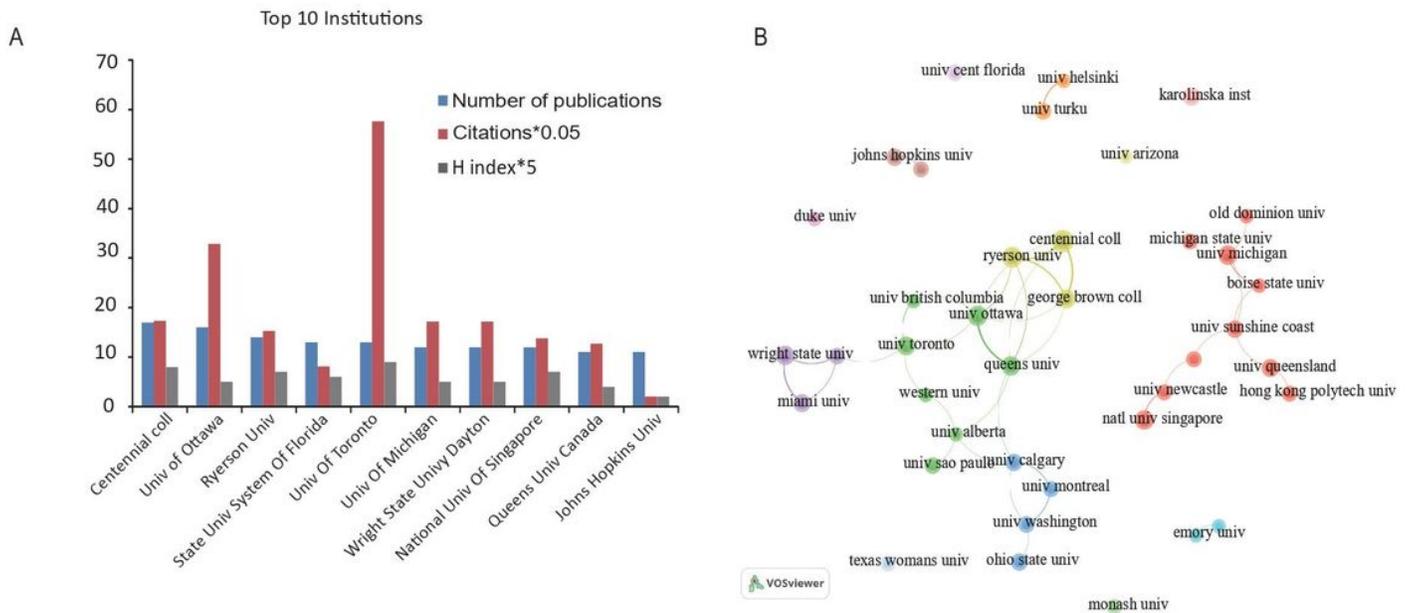
Figure 1

Data screening flow chart. The literature search was performed on WoSCC and language limited to English, and steps of bibliometric analysis



**Figure 2**

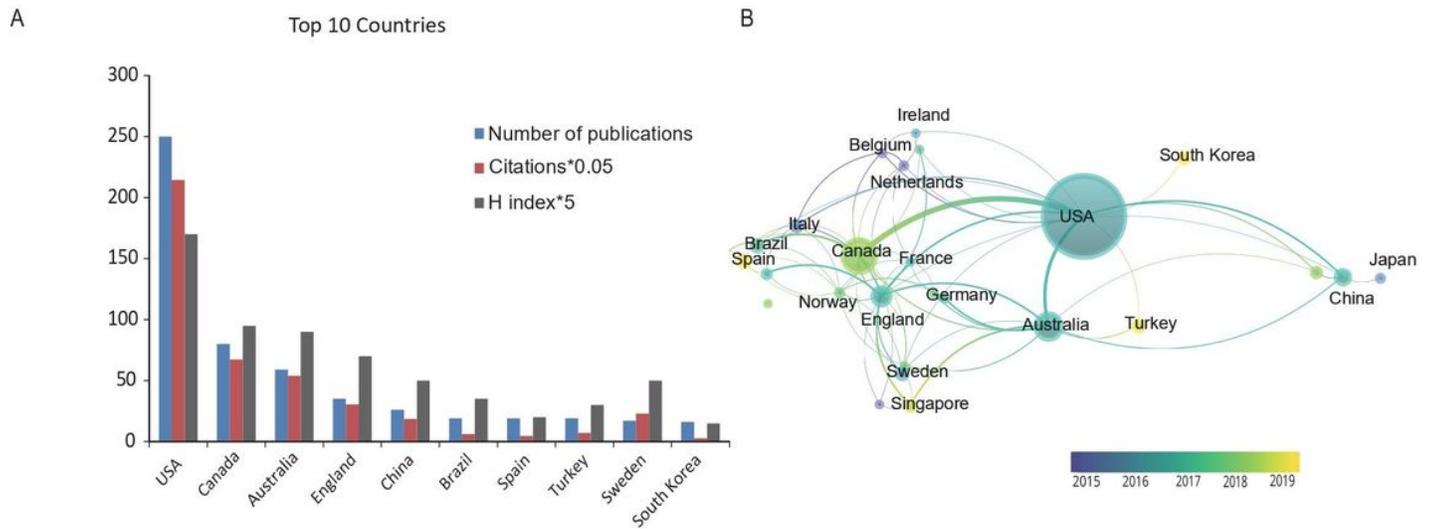
The number of publications and total citations related to virtual simulation in nursing studies. (A) The number of papers published and total citations each year. (B) The top 10 countries/regions annual publications.



**Figure 3**

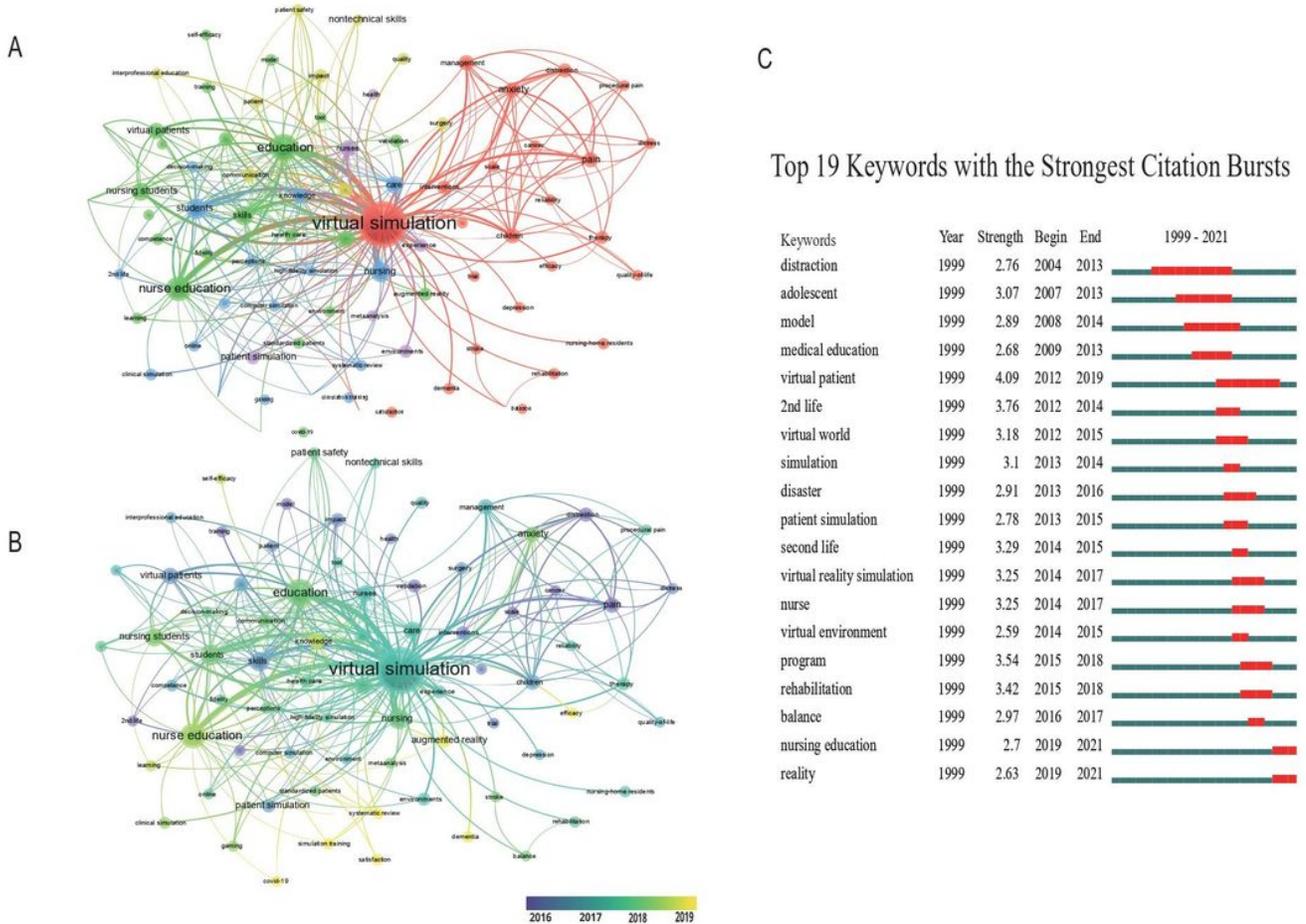
The top 10 most productive institutions and inter-institution co-operation relationships on virtual simulation in nursing research. (A) The number of publications, citation frequency ( $\times 0.05$ ), and H-index ( $\times 5$ ) in top 10 institutions. (B) The co-authorship network visualization map of institution for virtual simulation in nursing research.

simulation in nursing research. Node size indicated the number of articles produced. The distance between any two nodes positively associated with the cooperation strength.



**Figure 4**

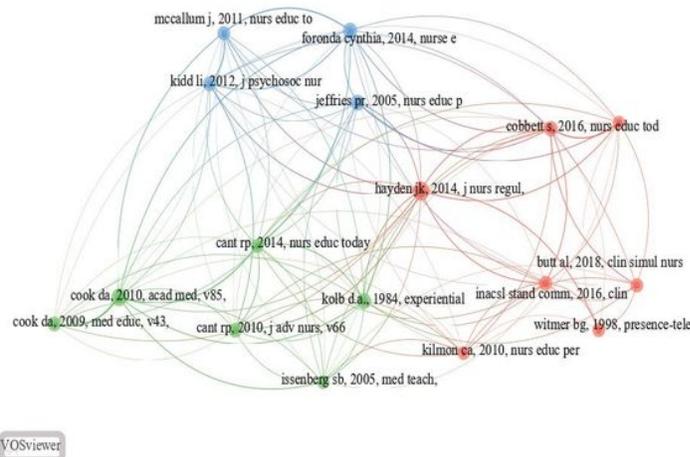
The top 10 prolific countries/regions and inter-national collaboration network on virtual simulation in nursing research. (A) The number of publications, citation frequency ( $\times 0.05$ ), and H-index ( $\times 5$ ) in top 10 countries/regions. (B) The co-authorship network visualization map of countries for virtual simulation in nursing research. Node size indicated the number of articles produced. The distance between any two nodes positively associated with the cooperation strength. The color indicated the average publication year for the author, The blue color represented for early stage and yellow color represented late stage.



**Figure 5**

Analysis of keywords related to publications of virtual simulation in nursing field.(A) The co-occurrence network visualization map of keywords related to virtual simulation in nursing field. The keywords clustered into five groups according to their color. Large nodes represented keywords with high frequency; (B) Keywords were colored according to the appearance for the average time. The blue color represented for early stage and yellow color represented late stage. (C) The top 19 keywords with the strongest citation bursts on virtual simulation in nursing field between 1999 and 2021. The red segment of the blue line denoted the burst duration of a keyword.

A



B

### Top 23 References with the Strongest Citation Bursts

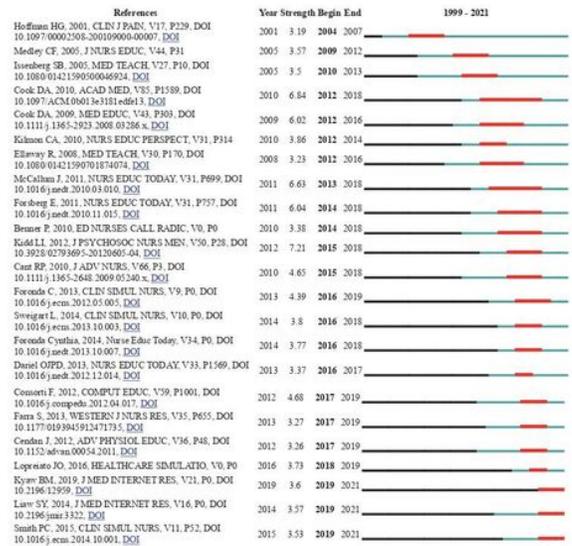


Figure 6

Analysis of most cited references and co-cited references of virtual simulation in nursing field. (A) The co-citation network visualization map of references on virtual simulation in nursing field between 1999 and 2021. (B) The top 23 references with the strongest citation bursts on virtual simulation in nursing field between 2010 and 2019. The blue line represented the time from its first appearance to 2021, the red line represented the burst time.

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [figureS1.pdf](#)