Journal of Scientometric Research, 2024; 13(1):9-24.
https://www.jscires.org

Research Article

Usability Testing: A Bibliometric Analysis Based on WoS Data

Mahdie Shojaei Baghini[1], Mehdi Mohammadi[1], Narges Norouzkhani[2,*]

[1]Information Management, Medical Informatics Research Center, Institute for Futures Studies in Health, Kerman University of Medical Sciences, Kerman, IRAN.
[2]Department of Medical Informatics, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, IRAN.

ABSTRACT
Usability is a qualitative characteristic that evaluates the ease of use of user interfaces. This study aims to conduct a systematic bibliometric analysis of usability testing and to understand the research context and trends in this field. A total of 5273 scientific publications from the Web of Science core collection were included in the study. Performance analysis, scientific mapping, and visualization were done using the RStudio package and the VOSviewer software tool. The results show that the interest in the area of usability testing has significantly increased, especially from 1991 to 2022. The United States has the highest number of publications, citations, co-citations, and ratios. Toronto University was top in terms of institutional contributions. The JMIR mHealth and uHealth led in the number of publications and citations. Khajouei has the highest number of publications, but Jaspers has received the most citations on usability testing. With 10264 total link strength, Nielsen has the most potent co-citation papers. This study reveals the latest research trends and hotspots and the current state of international collaboration in usability testing research, to indicate the most influential research channels. These findings include; the prominent countries, institutions, journals, original articles, and authors. To the best of the author's knowledge, this study is the first of its kind to conduct the bibliometric analysis on usability testing. These findings can be useful in shaping the direction of future studies on usability testing, and the understanding how usability testing.

Keywords: User-Centered Design, Usability Testing, Bibliometric Analysis, Citation Analysis, Bibliometric Mapping.

Correspondence:
Narges Norouzkhani
Department of Medical Informatics, Faculty of Medicine, Mashhad University of Medical Sciences, Mashhad, IRAN.
Email: narges.norouzkhani@yahoo.com
ORCID: 0000-0001-9734-9126

Received: 22-09-2023;
Revised: 06-01-2024;
Accepted: 09-03-2024.

INTRODUCTION

The capabilities of Health Information Technology (HIT) tools are expanding quickly.[1] Numerous potential advantages for healthcare could result from HIT adoption.[2] While the integration of technology in medicine has brought significant improvements in care quality and efficiency, it also introduces potential risks and negative consequences for clinical safety and quality, including the possibility of unforeseen errors that could seriously harm patients.[3-5] Efforts must be made to achieve the benefits of health information technology and avoid its negative consequences.[5] Studies emphasize the critical role of human factors and human-centered design in ensuring well-designed health information technology systems that align with clinical workflows and patient compliance. Developing and implementing human-centered design methods within existing information technology infrastructures can deliver value to patients and physicians through the creation of user-friendly technologies.[6]

It is essential to Focusing on the usability of HIT is essential, considering users, tasks, and the environment, to ensure the optimal utilization of health information technology.[7] Usability encompasses various parameters that define the quality of a system and is a critical dimension of quality assessment.[8] The primary objective of usability is to make user interfaces clear and intuitive, enabling users to complete their tasks efficiently. It is regarded as an essential aspect of quality assessment.[9,10] Bevan *et al.*, citing ISO-9241-11, define "usability in terms of effectiveness, efficiency, and satisfaction in a particular context of use."[11] Usability testing is a technique employed to identify specific usability issues with products and enhance their usability.[12] Research indicates that usability can impact user satisfaction, adoption rates of HIT, healthcare quality, effectiveness, efficiency, professional clinical decision-making, and the rate of medical errors.[10,13-16] Therefore, addressing usability issues in health information systems is crucial to prevent unintended adverse effects.[17] Consequently, usability testing is an established practice in HIT development.[6]

Despite the substantial volume of recent research on usability testing, as of our knowledge, no bibliometric analysis on this topic has been published. Several review studies have systematically examined usability testing, usability challenges in the use of medical devices in the home environment,[18] system usability

DOI: 10.5530/jscires.13.1.2

scale benchmarking for digital health apps,[19] usability of robotic and virtual reality devices in neuromotor rehabilitation,[20] usability of web-based applications in advocating consumers on food safety,[21] tools for evaluating the content, efficacy, and usability of mobile health apps,[22] usability of mobile health apps for postoperative care,[23] and effectiveness and usability of digital tools to support dietary self-management of gestational diabetes mellitus.[24] However, bibliometric indicators play a vital role in contemporary scientific reviews.[25] Bibliometrics' application is growing and will eventually reach all academic fields.[26] These studies have proven their utility in providing a global perspective on research hotspots, long-term trends, and the influence of contributing scholars, journals, and countries/regions. Therefore, bibliometric studies have become standard tools for assessing the quality of scientific work.[27-29] Academics can benefit from well-executed bibliometric studies in various ways, including gaining a comprehensive understanding of their field, identifying research gaps, developing novel study concepts, and establishing their position within the academic community.[30]

For the abovementioned reason, the research objective in this paper is a quantitative bibliometric approach and network visualization to summarize research trends, hotspots, growing issues, and emerging issues in usability testing. To the best of our knowledge, this is the first study to provide a comprehensive review and analysis of the citation network in usability testing literature. Its results could help determine future research directions in this field. Therefore, initially, this study presents a publication and citation trend analysis spanning from 1983 to 2022. Secondly, it provides a global analysis, focusing on countries with notable numbers of articles and citations. Thirdly, it documents the most active higher institutions in this field. Fourthly, it identifies significant journals contributing to this area of research. Fifthly, it acknowledges the authors who have been most prolific in usability testing research, based on their publication and citation counts. The research utilizes bibliometric linkage and co-citation analysis to explore the interconnections among these journals, countries, and authors. Lastly, the study employs keyword co-occurrence analysis to pinpoint the most prevalent terms in usability testing research. Additionally, based on the statistical analysis conducted, we propose a prospective research agenda for further exploration in the field of usability testing.

METHODOLOGY

According to Zupic and Cater, there are five stages in the typical workflow of scientific mapping: Study design; Data collection; Data analysis; Data visualization; and Interpretation.[31]

A Bibliometric analysis study was designed. The Web of Science (WoS) Core Collection, a database from Clarivate Analytics, was used to search for relevant publications. WoS is a widely used resource for bibliometric studies due to the superior quality of its bibliometric data compared to that of competing databases. WoS has a lower rate of duplicate records and more extensive coverage of high-impact journals.[32] The WoS Core Collection is a reliable collection of scholarly journals, books, and conference proceedings, that contains more than 21,100 peer-reviewed, high-quality scholarly journals published worldwide (including Open Access journals) in more than 250 subject areas in the sciences, social sciences, and arts & humanities. It is the top source on the WoS platform and the first global index of citations for scholarly and scientific research. This Collection is one of the world's leading citation databases. The database contains records of articles published in the highest impact journals worldwide, including open access journals, conference proceedings, and books. There is coverage of some titles dating back to 1900.[33-35] Therefore, a comprehensive search was conducted in the WoS on July 25, 2022. Title, abstract, author keywords, and keywords plus searches were conducted in the "Topic" category, covering the three predetermined research areas. searches were not limited by publication type, date or language.

The search strategy was ((((TS=("User-Centered Design")) OR TS=("Usability Testing")) OR TS=("Usability evaluation")) OR TS=("Usability experiment")) OR TS=("Usability study"). The acquired data were exported to Mendeley Desktop version 1.19.8, to identify and remove duplicates. With the earliest article dating back to 1983, our initial search turned up 11,415 records. We chose all works published between 1983 and 2021 for the bibliography because the publication of 2022 articles were not yet complete. The remaining works were then reduced by 11053. The PRISMA checklist was used to screen the results. Only documents classified as articles were chosen for qualitative reasons because they were probably subject to a thorough review before publication.[36] As a result, there were only 5288 documents left after all were gone. Also, 5273 records were left after removing duplicates. All articles that were published in WoS before 2022 were entered into bibliometric analysis, and excluded results such as book chapters, book editorials, and anthologies. The relevance of the remaining articles was determined by evaluating their titles, and abstracts. Two reviewers independently extracted the necessary data and independently evaluated the study eligibility. In cases of doubt regarding study eligibility, a third reviewer was consulted, and a decision was made based on consensus. Because WoS does not support bibliometric analysis based on addresses or citations, performance analysis and citation network analysis were carried out using the RStudio package and the VOSviewer software for Windows, version 1.6.18 (https://www.vosviewer.com). VOSviewer is a software application for seeing and navigating network-based maps.[37] RStudio supplies complete tools to analyze and visualize quantitative survey data.[38]

RESULTS

Bibliometric analysis was conducted on the final sample. A general review of the findings showed that 5273 documents were published in 1666 journals between 1983 and 2021. In total, 146832 references have been used to write these documents. The annual growth rate is 11.3%, and the average number of citations per document was 12.92%. Another dataset overview shows that the authors used 11044 keywords to categorize their studies. In addition, the documents had a total of 18871 authors. Additional main information about the usability test data has been presented in Table 1.

As shown in Figure 1, published articles on usability testing from 1991 have gradually increased, and in recent years, special attention has been paid to it. Also, the number of citations has shown a gradual trend, indicating high academic interest and popularity. According to the journal classification on WoS, the most predominant categories are: 803 Medical Informatics (15.185%), Health Care Sciences Services (13.843%), Computer Science Information Systems (13.162%), Computer Science Cybernetics (11.460%), Ergonomics (10.817%), Information Science LibraryScience (9.020%), Computer ScienceSoftware Engineering (6.902%), Computer Science Interdisciplinary Applications (7%), Public Environmental Occupational Health (6.4%), and Computer Science Theory and Methods (6.1%) (Figure 2).

Performance Analysis

Performance analysis of documents

According to the findings, the study "IBM Computer Usability Satisfaction Questionnaires: Psychometric Evaluation and Instructions for Use" has been ranked first in Table 2's list of the ten studies with the highest amount of citations, outpacing all other studies by a factor of at least two. This publication describes IBM's most current work on subjective usability measurement. This study examined the psychometric properties of questionnaires created for scenario-based usability testing.[39]

Performance analysis of authors

For authors, citations are useful.[40] The most active authors were classified according to the *h*-index. Table 3 reveals the top 10 authors with the most academic publications. Khajouei R, with a total number of 15 publications, Jaspers MWM, and Kubler A, with a total number of 14 publications, have the highest number of publications on usability testing. Nevertheless, in terms of the number of citations, Kubler A. has received the most citations, with 647 cases. While, Jaspers MWM. with 638 cases and an *h*-index of 12, it has the highest rank among authors.

Performance analysis of journals

The best scientific journals are authentic sources of information on recent scientific advances.[41] 1733 journals have published articles from 1983 to 2021. Table 4 reveals the most influential

Table 1: Main information about data on usability testing.

Description	Results
Timespan	1983:2022
Sources (Journals, Books, etc.,)	1666
Documents	5273
Annual Growth Rate %	11.3
Document Average Age	7.58
Average citations per doc	12.92
References	146832
Document contents	
Keywords Plus (ID)	4519
Author's Keywords (DE)	11044
AUTHORS	
Authors	18871
Authors of single-authored docs	429
Authors collaboration	
Single-authored docs	475
Co-Authors per Doc	4.43
International co-authorships %	20.59

journal lists from 1983 in the research concerning usability testing.

The most productive journal in usability testing research was the JMIR mHealth and uHealth. JMIR mHealth and uHealth is at the top of this list with 125 studies published JMIR mHealth and uHealth (JMU) focuses on health and biomedical applications in mobile and tablet computing, pervasive and ubiquitous computing, wearable computing, and domotics. JMU is indexed in PubMed, PubMed Central, MEDLINE, and Science Citation Index Expanded (SCIE).[42] After, there is the Journal of Medical Internet Research (JMIR). JMIR is the leading peer-reviewed journal for digital medicine and health and health care in the internet age. JMIR is indexed in more than 18 bibliographic databases and abstracting services.[43] Besides technology-related journals, journals do not excel in productivity; thus, thematic specialization can be a strategic choice.[44]

Figure 3 compares the growth of top publications to 2021. The top 10 journals have published 16% of the articles. Further investigation shows that 1441 publications have published one article each in the field of usability. In other words, 1441 publications have published only 27% of the articles. The findings indicate that only a small percentage of journals are responsible for a high percentage of scientific production in a specific field.

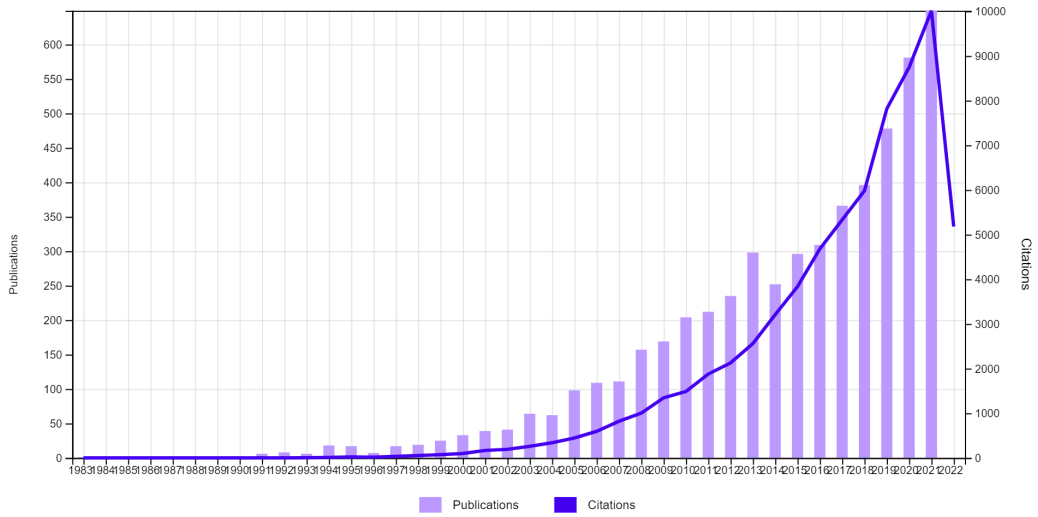


Figure 1: Timespan and trends of publications and citations in usability testing from 1983 to 2021.

Figure 2: Subjects area of usability testing research.

Table 2: Top-10 most cited studies in usability testing research.

AU	TI	PY	SO	TC
James R. Lewis.	IBM computer usability satisfaction questionnaires: Psychometric evaluation and instructions for use.	1995	International Journal of Human-Computer Interaction	999
Robert A. Virzi.	Refining the Test Phase of Usability Evaluation: How Many Subjects Is Enough?	1992	Human factors	497
Ángela Di Serio, María Blanca Ibáñez, Carlos Delgado Kloos.	Impact of an augmented reality system on students' motivation for a visual art course.	2013	Computers & Education	446
Ritu Agarwal, Viswanath Venkatesh.	Assessing a Firm's Web Presence: A Heuristic Evaluation Procedure for the Measurement of Usability.	2002	Information systems research	444
Zhao Huang, MoradnBenyoucef.	From e-commerce to social commerce: A close look at design features.	2013	Electronic Commerce Research and Applications	429
Laura Faulkner.	Beyond the five-user assumption: Benefits of increased sample sizes in usability testing.	2003	Behavior Research Methods, Instruments, & Computers	381
Joseph A Cafazzo, Author Orcid Image, Mark Casselman, Nathaniel Hamming, Debra K Katzman, Mark R Palmert	Design of an mHealth App for the Self-management of Adolescent Type 1 Diabetes: A Pilot Study.	2012	Journal of medical Internet research	359
Roberto Verganti.	Design, Meanings, and Radical Innovation: A Metamodel and a Research Agenda.	2008	Journal of product innovation management	352
T. Boren, J. Ramey.	Thinking aloud: reconciling theory and practice.	2000	IEEE transactions on professional communication	298
Monique W.M.Jaspers.	A comparison of usability methods for testing interactive health technologies: Methodological aspects and empirical evidence.	2009	International Journal of Medical Informatics.	285

AU: author; TI: title; PY: publication year; SO: source; TC: total citations.

Performance analysis of Authors' Affiliations

Performance analysis of Authors' Affiliations is a bibliometric method that examines the distribution and impact of authors' affiliations in a given research field or topic. It can help to identify the most productive and influential institutions, countries, or regions, as well as the patterns of collaboration and mobility among them. It can also reveal the diversity and interdisciplinary of research groups and their contributions to scientific knowledge.[45] The analysis of author affiliations really affects how research is interpreted.[46] This method can be useful for evaluating the quality and relevance of research outputs, as well as for informing policy and decision-making regarding research funding, support, and development.[45] The top twenty most active institutes in usability testing research are shown in Figure 4 (a). According to the findings, Toronto University is at the top of the list with a huge difference. On the other hand, based on the growth trend of scientific production at scientific institutions, it can be seen that Toronto University has the highest growth rate of scientific production around; on the other hand, this growth at Toronto University has a very steep slope. It is so fast that from 1989 to 2021, from 1 scientific production to 19 scientific publications (Figure 4 (b)). In the 2022, Toronto University is ranked 16th among the universities worldwide and first in Canada by the SCImago Institutional Rankings.[47] It should be noted that this count is based on all the authors of the publications.

Performance analysis of Authors' countries

The results of study clearly demonstrate the dominant position of certain countries in the field of usability testing. 101 countries participated in usability testing-related research output. At the same time, 74% of the publications were produced by the top 10 countries. Table 5 and Figure 5 (a) show that the USA, by a large margin over the others, published the most papers (n=5499) and had the highest total citations (28412). Other abundant countries were Canada (n=1458) and the United Kingdom (n=933), respectively. It should be noted that this count is based on all

Table 3: Top 10 contributing authors'indexes in field of usability testing research.

Element	*h*_index	*g*_index	*m*_index	TC	NP	PY_start
Jaspers MWM	12	14	0.75	638	14	2007
Hornbaek K	10	12	0.588	271	12	2006
Kubler A	10	14	1	647	14	2013
Schnall R	10	12	0.909	550	12	2012
Cafazzo JA	9	12	0.692	577	12	2010
Khajouei R	9	15	0.692	264	15	2010
Stinson Jn	9	12	0.529	408	12	2006
Straus Se	9	10	0.692	236	10	2010
Bates DW	8	13	1.143	227	13	2016
Hertzum M	8	9	0.364	366	9	2001

*h*_index: h number of publications cited at least h times; *g*_index: g number of publications receiving at leastg^2 citations; *m*-index: is defined ash/n, whereh is theh-index andn is the number of years since the first published paper of the scientist; TC: total citations; NP: number of publication; PY_start: publication year start.

Table 4: Top 10 preferred journals for publication in usability testing research.

Sources	Articles
JMIR mhealth and uhealth	125
Journal of medical internet research	117
International journal of human-computer interaction	91
Interacting with computers	89
Journal of usability studies	83
International journal of human-computer studies	76
International journal of medical informatics	74
JMIR research protocols	71
Behaviour & information technology	58
Journal of biomedical informatics	56

the authors of the publications. About 91% of the studies were conducted in domestic and international collaborations between the authors. The Netherlands had the highest average article citation rate (*n*=17.08), followed by the USA (*n*=16.55), Canada, and Italy (*n*=15.48).

Figure 5 (b) shows the tendency of the corresponding author's countries with their number of publications and examination of the number of Single Country Publications (SCP), Multiple Country Publications (MCP), and multiple country publication relatives. According to the figure, most publications are published by single country publications. Also, according to the figure, most of the publications are written by authors from the same country, and therefore most are SCP. The USA was the top country with a total of 1717 publications. Of these, 1523 were single country, and 194 were multiple country publications with an MCP ratio of 0.113, indicating that the majority of usability testing publications in the United States were published in only one country. In the analysis of MCP ratios, Bulgaria, Malawi, Yemen, and Zimbabwe have the highest MCP ratios (MCP ratio=1), with one article being written as an MCP. The MCP ratio (MPC articles/total publications per country) was calculated based on the number of MCPs obtained from inter-country collaborations.[48]

Keyword analysis

In bibliometric studies, authors' keywords analysis is an important topic. A hot spot in a discipline can be identified by counting the frequency with which keywords appear.[49] Figure 6 (a) illustrates the most preferred title words used in papers. Among the top 20 keywords, usability occurred in 1960 (19.22%) records, Design in 1119 (10.97%) records, Study in 907 (8.9%) records, and evaluation in 894 (8.76%) records.

The trend of title keywords over time, based on the calculation of word weight, showed that "Usability" had the highest weight from 2009 to 2019. After that, "Design" from 2011-2020, "Study" from 2014-2020, "Evaluation" from 2010-2019, and "Testing" and "User" from 2010-2019 have the highest weight. Figure 6

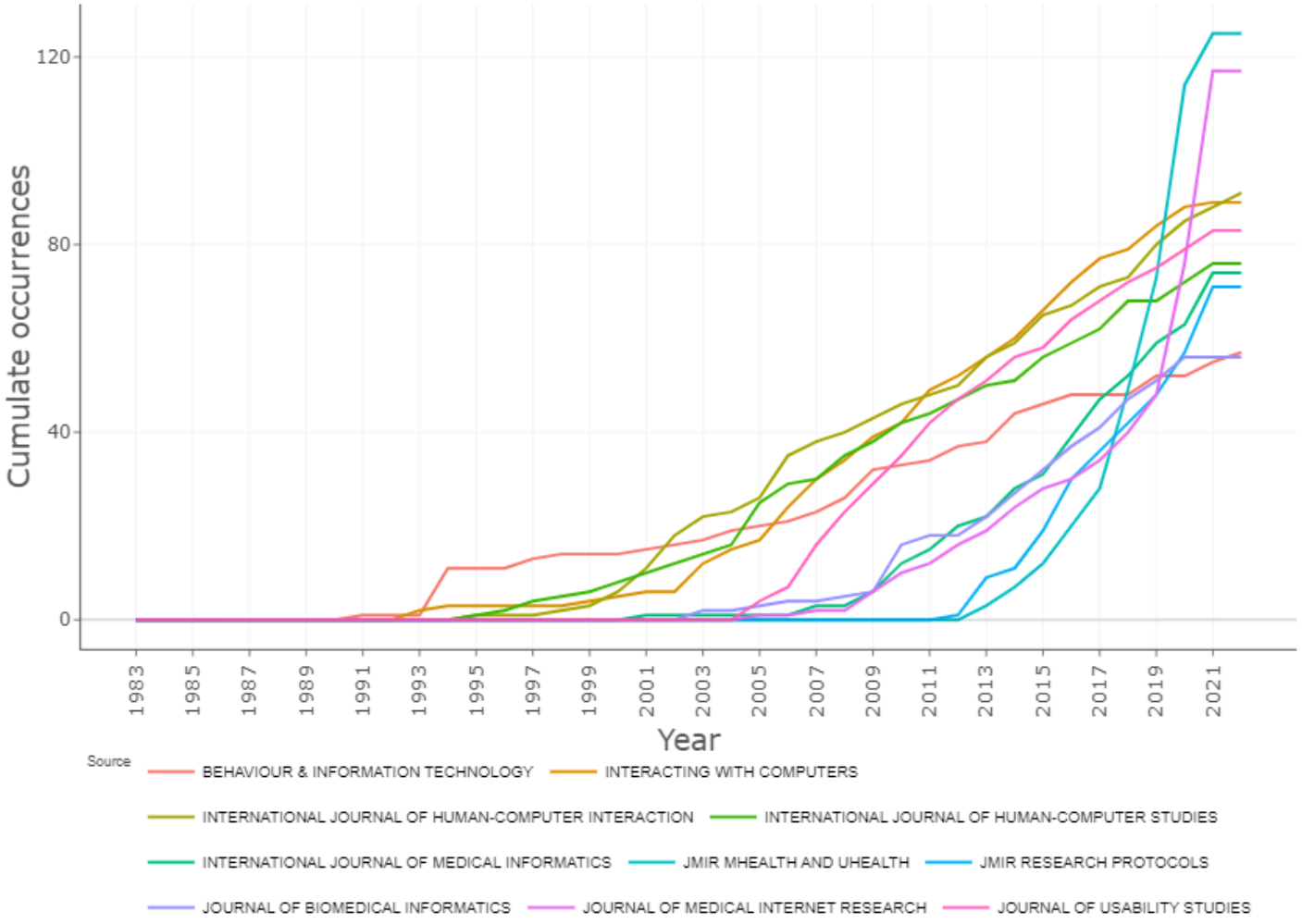


Figure 3: Trend of the growth of scientific production of usability testing research.

(b) shows the most preferred author keywords used in papers. Among the top 20 keywords, "mobile health" occurred in 69 (15.3%) records, "user-computer interface" in 45 (9.98%) records, and "human computer interaction" in 43 (9.53%) records.

The trend of author keywords over time, based on the calculation of word weight, showed that "user-centered design" had the highest weight from 2012 to 2020. After that, "usability" from 2012-2020, "usability testing" from 2012-2019, and "usability evaluation" from 2009-2019 have the highest weight. It should be noted that "user-centered design" has been introduced as a MeSH term. The Medical Subject Headings (MeSH) are the subject headings that appear in MEDLINE/PubMed, the NLM Catalog, and other NLM databases.[50]

The second category of bibliometric analysis is scientific mapping. Science mapping techniques encompass various methods such as citation analysis, co-citation analysis, bibliographic coupling, co-word analysis, and co-authorship analysis.[30]

Cocitation authors network visualization

Co-citation authors network is a method in scientometrics that involves visualizing the relationships between authors based on their TLS (Total Link Strength) scores. By measuring how often authors cite the same sources, co-citation analysis reveals useful insights into the field of scientometrics.TLS scores enhance this analysis by considering the strength of these citation relationships, providing a nuanced understanding of scholarly collaboration and influence.[51] Figure 7 shows the network visualization map of the cocitation analysis of cited authors with a minimum number of 100 citations. In total, from 92709 authors, only 49 authors met the threshold. The result of the cocitation analysis of cited authors is given in four different clusters. The circle shape observed in different sizes illustrated the number of cocitations. The larger the circle, the more cocitations were specified in the usability field, and the circle of the same color was mentioned as a similar issue among these publications. Jakob Nielsen, with 10264 TLS, has

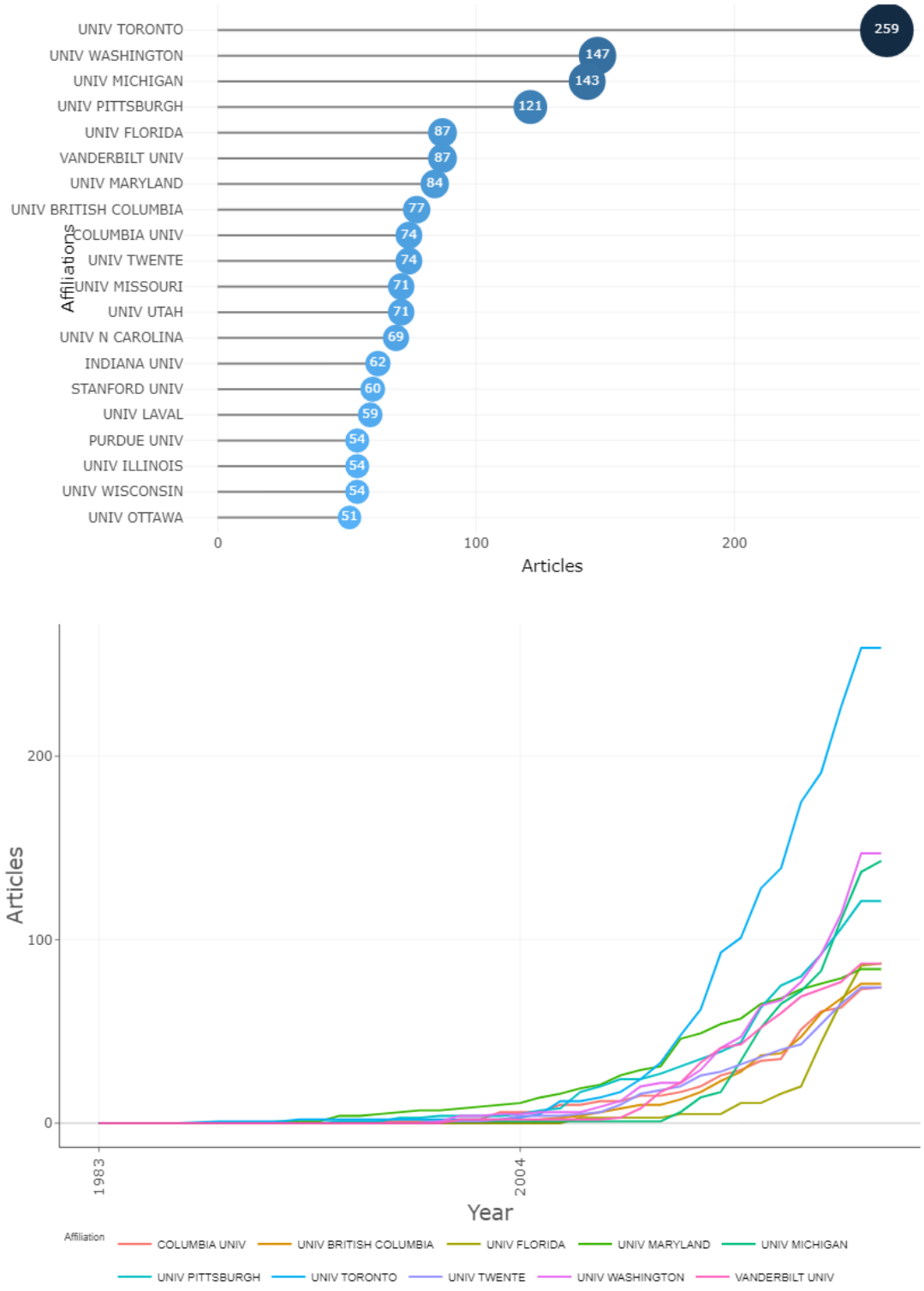


Figure 4: (a)Top 20 most active institutes in usability testing research. (b) Trend of the growth of scientific production of usability testing research.

Table 5: Top 10 most cited countriesin field of usability testing research.

Country	NP	TC	Average Article Citations
USA	5499	28412	16.55
Canada	1458	5032	15.48
United Kingdom	933	4729	14.24
Netherlands	594	3364	17.08
Italy	362	2353	15.48
China	623	2219	9.25
Germany	556	2129	9.55
Spain	407	1884	11.78
Korea	375	1290	8.66
Australia	419	1278	9.54

NP: "Number of Publications", **TC:** "Total Citations".

the most potent cocitation documents. Then James Lewis has the most robust article with 3932 total link strength.

Co-authorship countries network visualization

Figure 8 (a) shows ten main clusters of coauthorship based on authors' countries. Circle size indicates number of publications, and line thickness indicates cooperation between nations.[52] The minimum number of documents of a country, and the minimum number of citations of a document were fixed at five. In total, from 110 countries, only 69 countries met the threshold. Most countries had a cooperative relationship with the United States. Based on TLS, the top country was the USA (TLS=549). Then there were England (TLS=308), Canada (TLS=223), and Germany (TLS=213). These productive countries have strong collaborative relationships. USA, Finland, Denmark, Sweden, and England are among the oldest, and Saudi Arabia, Pakistan and Indonesia are among the newest countries in the overlay visualization by year (Figure 8 (b)).

Keywords network visualization

In network and cluster analysis, the color corresponds to a specific research cluster, whereas the circle dimension indicates how often the keywords are repeated in the analysis article. The thickness of the line connecting the circles indicates the intensity of the correlation between the keywords.[53] The occurrences map based on authors keywords presented four main recognized clusters. In Figure 9 (a), each cluster is marked with a color. The minimum number of authors' keywords occurrences was fixed at 25. Of the total 11046 keywords, only 25 keywords were plotted. Based on TLS, the top five author keywords were usability (TLS=438), user-centered design (TLS=349), usability testing (TLS=183), mhealth (TLS=177), and user experience (TLS=159). Also, the occurrences map based on keywords plus presented three main recognized clusters. The minimum number of keywords plus occurrences was fixed at 25. Of the total 4519 keywords plus, only 48 keywords plus were plotted. The top three keywords plus were care (TLS=363), design (TLS=345), technology (TLS=299), usability (TLS=237), and health and impact (TLS=228). The co-occurrence author keywords network visualization is presented in Figure 9 (b).

DISCUSSION

This research presents the current status of scientific productions and collaboration networks in usability testing. According to the findings, 5273 documents are indexed in WoS, and have been growing since 1983. Bibliometric analysis can be broadly divided into two main categories: performance analysis and science mapping.[54] Both of these analyses were performed in this study. Detailed findings are discussed below.

Overall, the results show the annual growth of usability testing published by this research community. With the development of information technology, the trend of publishing usability testing research is likely to continue to grow. The bibliometric analysis of other scientific fields also indicates the increasing growth of publications. This finding is consistent with the findings of other studies.[55-57]

According to the analysis, Khajouei R has the highest number of publications and Jaspers MWM had the highest number of citations and *h*_index. In other words, some researchers are even more influential with fewer published articles on usability testing. Performance analysis of authors is assessing an author's productivity to help identify the core authors and productive specialists. Performance analysis of authors helps to identify the core authors and productive specialists. This, in turn, can be valuable for collaboration and co-authoring future research.[30]

The United States, Canada, the United Kingdom, and the Netherlands produced the most publications among the 110

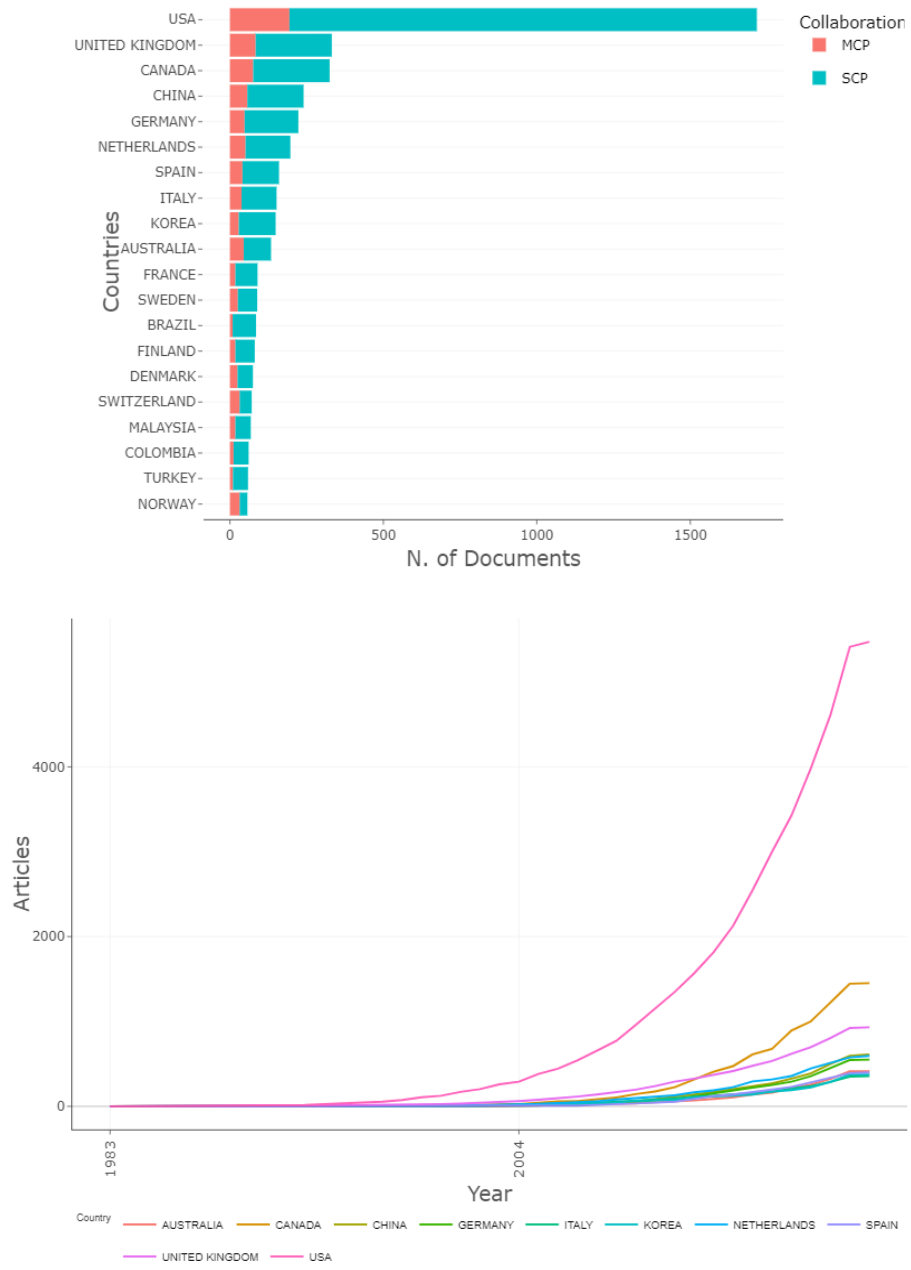


Figure 5: (a)Trend of the growth of scientific production of usability testing research in countries. (b) Most productive countries: Single Country Publications (SCP), Multiple Country Publications (MCP).

countries. The USA, by a large margin over the others, published the most papers. While, the Netherlands had the highest average article citation rate, followed by the USA. In the USA, despite the 36-year timespan from the first publication and the total document counts of 5499, the average number of citations per document appears to be low, probably because the production of robust literature in most producing countries leads to a decrease in average article citations over the years.[48] Publications with the most citations usually have a significant impact on the bibliography of the subject due to their pioneering contributions. Developing countries have the highest level of international cooperation. These countries, despite their small production, these developing countries publish papers with international cooperation. These collaborations with other countries can allow researchers to study with colleagues who speak English and to receive study opportunities in the future. Citations increase as a result of international collaboration.[58,59] Researchers from different countries participating in an international study indicate a high standard of study and can facilitate future international collaborations.[60] Collaborative research at the international level

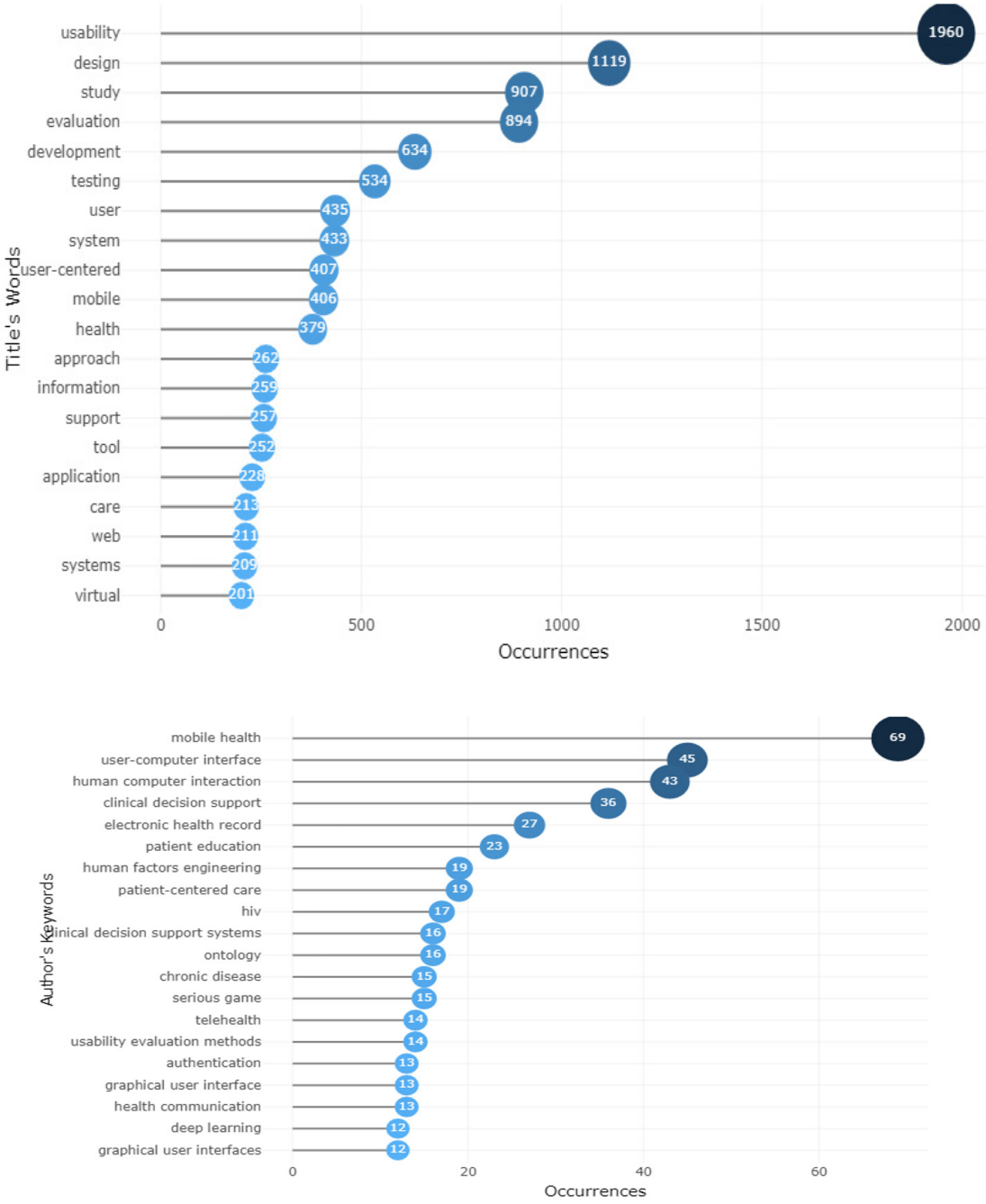


Figure 6: (a) Most frequent keywords in usability testing title. (b) Most frequent author keywords in usability testing title.

provides investigators with a new opportunity to maximize their importance and interact with other researchers.[61]

The analysis of clusters of coauthorship based on authors' countries showed that most countries had a cooperative relationship with the United States. Co-authorship clusters can reveal the structure and dynamics of scientific communities, as well as the patterns of knowledge production and diffusion.[62] Furthermore, collaborations expand and enrich a researcher's professional network, making it more extensive and interconnected.[63]

The keyword analysis highlights essential research areas and explains how they are interconnected. Thus, keyword analysis is an essential part of understanding trends in research.[64,65] In Garfield (1990), the statistical analysis of keywords was advocated for identifying research focus areas and predicting research trends within a discipline.[66] A hot spot in a discipline can be identified by counting the frequency with which keywords appear.[49,67] For the development of terminology, author keywords can be beneficial.[68] On the other hand, Keyword Plus are terms automatically derived from the titles of cited articles' references

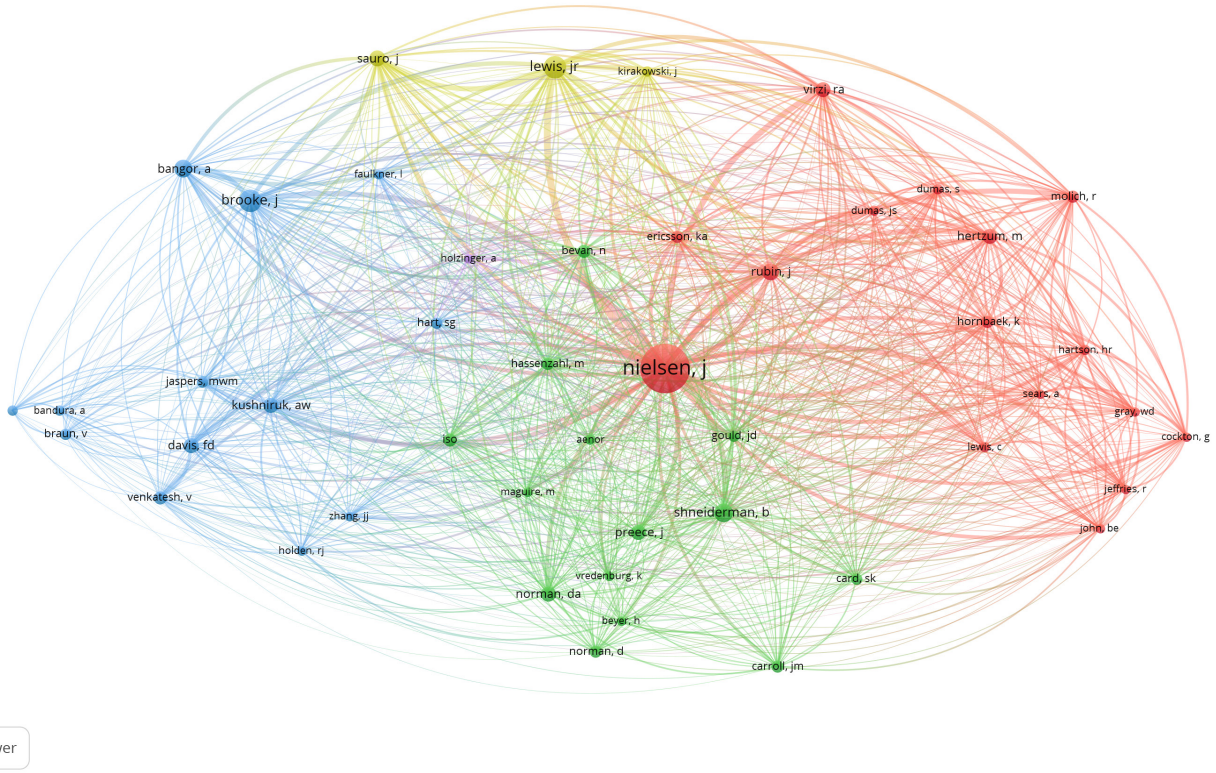
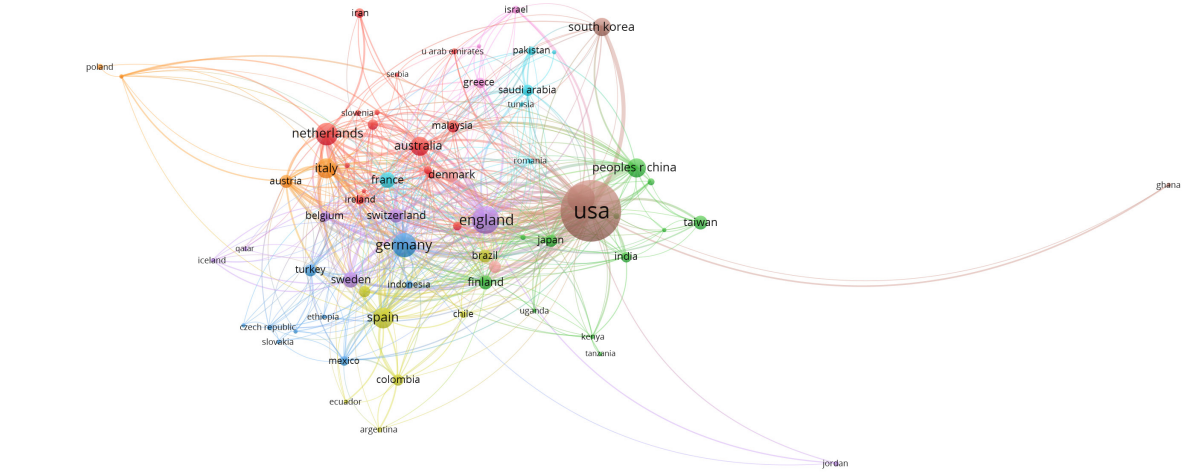


Figure 7: Cocitation authors network visualization.



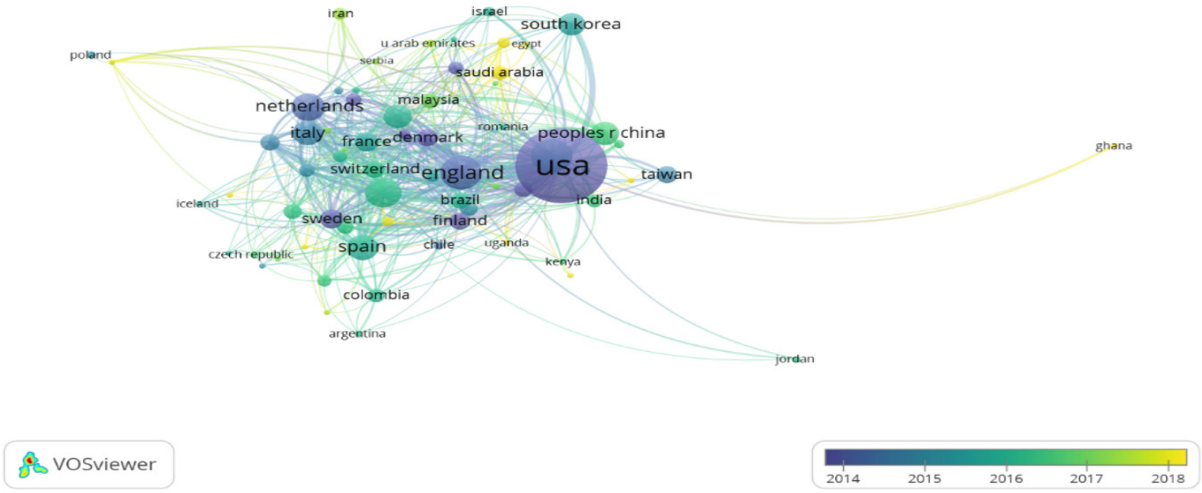


Figure 8: (a) Co-authorship countries Network visualization (b) Co-authorship countries Network visualization by time (year).

but do not appear in the article's title.[69] Keywords plus are more descriptive than author keywords. Keyword plus can express the contents of articles more concisely.[64] Keywords plus and author keywords are commonly used as analysis units regarding the bibliometric analysis of the knowledge structure of scientific fields, Keywords Plus is equally effective as Author Keywords. But it does not provide a comprehensive representation of an article's content. Although there is limited research evidence of keywords plus' effectiveness, Garfield believes that Keywords Plus terms are more effective at capturing the depth and variety of content in an article.[70] In this study, we analyzed both cases for a comprehensive review.According to the findings, the trend of keywords has changed in recent years. The usability testing studies have improved over time, and words and themes that were not previously used in the studies have begun to be considered over the years. Keywords are mainly selected based on the mesh. This is due to the special emphasis of journals on the selection of keywords and for more visibility of publications.[71,72]

Limitations

While this is the first bibliometric analysis of usability studies to our knowledge, and it does draw important conclusions from its examination of the papers in this field, it does have some limitations. Data were extracted from WOS only, and other databases were not examined. Consequently, publications only indexed in other databases may have been missed. There may also be a language bias; although there were no linguistic requirements placed on the publications in our study, however, the majority of WOS publications are written in English. In addition, this study primarily focused on journals and excluded other scientific publications (such as books, proceedings papers, and reports). Consequently, several significant studies, particularly emerging research, may have been missed. Furthermore, the quality of WOS publications varies widely. Weighted analysis of publications based on quality evaluation was beyond the scope of our investigation. Consequently, our study may have accorded equal weight to publications of varying quality.

Future Directions

According to the findings, the scope of usability testing is wide. Usability testing has a broad application in various domains, especially in health information technology and communication. Future research can explore more aspects of usability testing based on the following summary:

To get a more comprehensive view of the global state of usability testing publications, future studies could include publications in languages other than English.

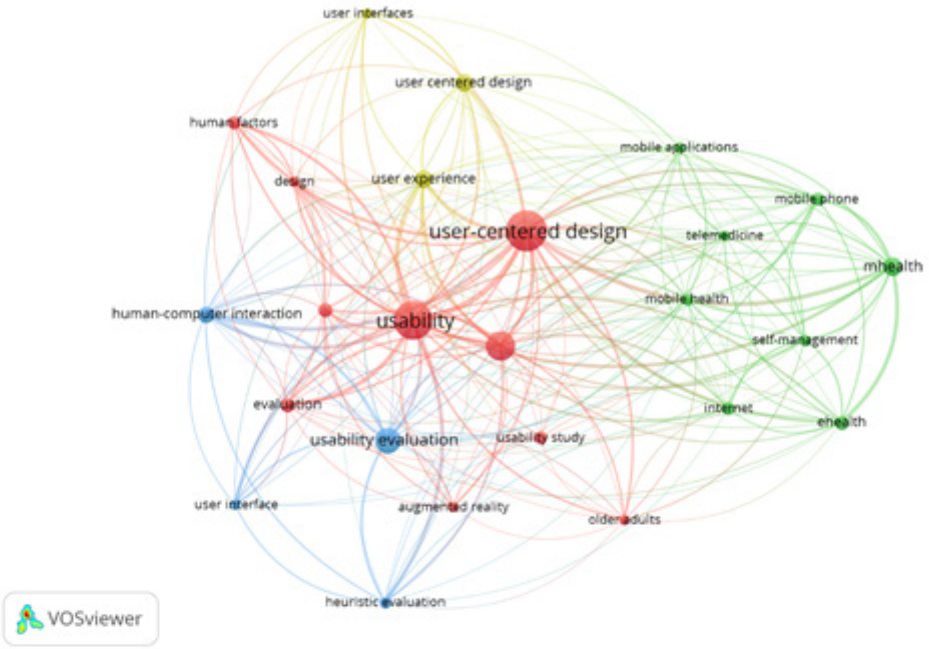
Future studies could also explore other databases as a potential avenue for further research.

Another possible direction for future research is to evaluate the quality of publications and conduct a weighted analysis of publications.

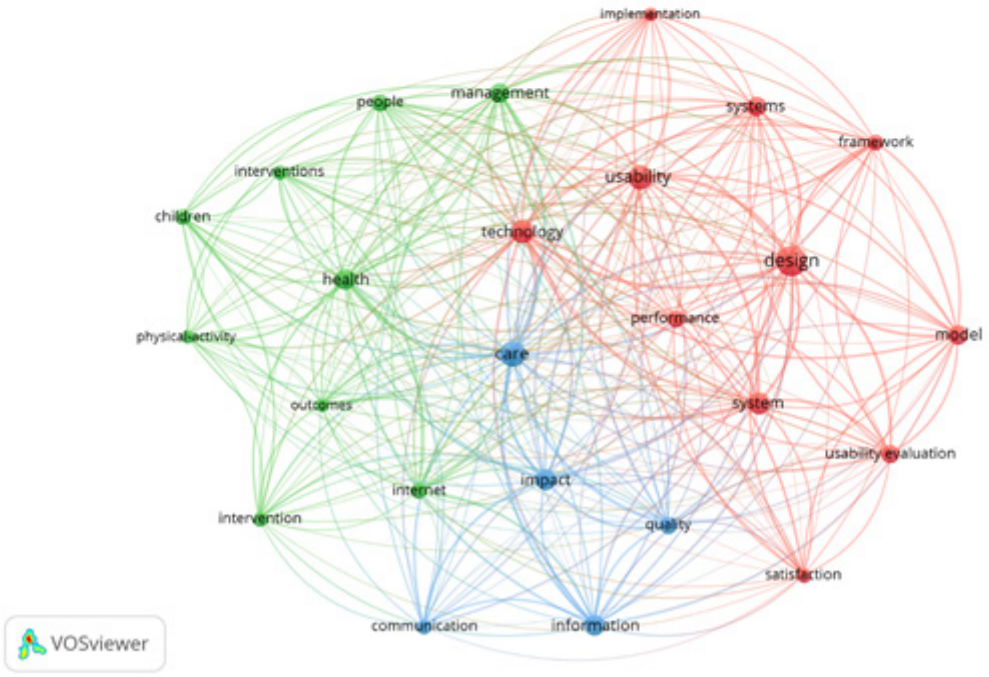
Another possible direction for future research is to explore how usability testing can enhance the benefits of health information technology.

Another possible direction for future research is to investigate the best practices and criteria for usability testing.

Exploring how usability testing can help communicate the value of HIT products or services, particularly in emerging markets, could be a significant topic for future research.



(a)



(b)

Figure 9: (a) Author keywords network visualization. (b) keywords plus network visualization.

CONCLUSION

The current study reveals the most recent hotspots and trends in research and the status of global collaboration in usability testing research. The findings identified prominent countries, institutions, journals, original articles, and authors to indicate the most influential research channels. In order to analyse both performance and citation networks, several bibliometric methods were implemented. Usability testing has become more popular in recent years, as shown by the rising number of publications on various topics related to this paper. The main driver of this trend was the development and demand for health information technology and the necessity of the interaction between humans and computers. In other words, Usability testing has recently shown promising applications in information systems research and human-computer interaction. This study's findings may prove helpful in shaping the direction of future studies on usability testing, we believe.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

AUTHORS' CONTRIBUTIONS

All of the authors have contributed to writing the article. The corresponding author performed the final proofreading.

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Cite this article: Baghini MS, Mohammadi M, Norouzkhani N. Usability Testing: A Bibliometric Analysis Based on WoS Data. J Scientometric Res. 2024;13(1):9-24.