

Knowledge mapping of online healthcare: An interdisciplinary visual analysis using VOSviewer and CiteSpace

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Xue Ding¹, Dingming Lu¹, Ruoxi Wei² and Fangfang Zhu¹ 

Abstract

Background: Online healthcare has been regarded as a permanent component and complementation in routine worldwide healthcare. Although there have been large-scale related studies in this field, studies are scattered across disciplines. Numerous publications are needed to systematically and comprehensively identify the status quo, development, and future hotspots in this field.

Methods: Publications on online healthcare were screened from the WoS database. By using VOSviewer and CiteSpace, this study analyzed 4636 articles in this field with 60,306 associated references. First, countries/regions distributions, institutions distributions, influential journals, and productive authors were obtained. Then, co-citation analysis, co-occurrence analysis, timeline analysis, and burst detection were further conducted to sketch the panorama of online healthcare.

Results: There were 147 countries/regions participated in and contributed to this field in total. Accounting for over half of the total number of publications, the USA, England, Australia, China, and Canada played significant roles in this area. Among the 24,362 authors, Guo XT was the most influential author. The International Journal of Environmental Research and Public Health was the journal with the most publications and citations. Studies in this field have shifted from basic research to applied practice research. COVID-19, mental health, healthcare, and healthcare workers were the most common keywords, indicating that studies on the impact of online healthcare on healthcare workers, online healthcare service for COVID-19, and mental health will be promising areas in the future.

Conclusions: Research on online healthcare is booming, while worldwide cooperation is still regionalized. Cross-regional cooperation among institutions and scholars is needed to enhance in the future. Online healthcare services for specific health fields and specific groups are the current and developing topics in this field.

Keywords

Online healthcare, bibliometric analysis, VOSviewer, CiteSpace, future tendencies

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Background

In the past few decades, digital technology has undergone rapid development, thus becoming the driver of the world's scientific and technological revolution and transformation in many fields.¹ The application of digital technology in the healthcare field gave birth to online healthcare platforms and online healthcare communities. For example, the Spring Rain doctor in China (<https://>

¹School of Economics and Management, Nanjing Agricultural University, Nanjing, People's Republic of China

²School of Management, China University of Mining and Technology-Beijing, Beijing, People's Republic of China

Corresponding author:

Fangfang Zhu, School of Economics and Management, Nanjing Agricultural University, No.1 Weigang, Xuanwu District, Nanjing, Jiangsu 210095, People's Republic of China.
Email: zhuffnjau@163.com



chunyuyisheng.com), Practor in India (<https://www.practo.com>), Vantage Health in the USA (<https://www.vantagehealth.ai>), and so on. Such platforms enabled primary and regular health consultations, where patients can easily search for appropriate general practitioners and specialists. Research studies on online healthcare have manifested that by facilitating healthcare knowledge sharing with patients² and supporting self-health management,^{3,4} these platforms can help relieve many of the major challenges faced by worldwide hospitals, such as geographic inconvenience and demand exceeding supply (long queues for registration, limited capacity for hospitalization).^{5–7} Online healthcare also benefits patients because of its low-cost, convenience, flexibility and time savings.^{8,9}

The COVID-19 outbreak has accelerated the development of online healthcare. According to the 49th statistical report on the Development of the Internet in China issued by China Internet Network Information Center,¹⁰ the user scale of online healthcare in China had reached 298 million by the end of 2021 (equates to 21.09% of the entire population at that time), with a year-on-year growth of 38.7%. This shows that online healthcare is a precious resource for coping with large-scale public health emergencies.¹¹ To better deal with similar public health emergencies in the future, online healthcare will remain a permanent component and complementation in routine worldwide healthcare.¹² A report from Future Market Insights¹³ indicates that the global online health market value is estimated to be 8131.3 million dollars in 2024, the global digital health industry share is estimated to reach a value of nearly 16,603.7 million dollars by 2034, and the overall market is predicted to grow at a promising CAGR of 7.4% during the forecast period.

With the recent rapid development of online healthcare in the industry, more and more scholars have begun to pay attention to this field in academia, and the number of online healthcare related publications has risen greatly in the last several years.¹⁴ Although academic research in

this field was flourishing, it still lacks of quantitative and comprehensive reviews exclusively focused on online healthcare. Bibliometrics analysis has been widely used by researchers to evaluate academic studies in a focal field, which can probe knowledge structure and development tendencies.^{15,16} As two commonly used bibliometric software, VOSviewer and CiteSpace can not only provide researchers with effective and easily operated methods to objectively and comprehensively evaluate the distribution of countries/regions, institutions, authors, and journals in a focal research field but also identify the hotspots and development trends in a specific research field.¹⁷

This study aims to establish an in-depth picture of the status quo and development process of online healthcare research in the past decades and visualize a knowledge map by using two software named VOSviewer and CiteSpace, and then predict the future trends in the online healthcare field.

Materials and methods

Data

WoS as a high-quality and full-coverage database¹⁸ has been broadly used among worldwide researchers. The WoS contains a wide range of publications in various fields, including over 15,000 journals and 50,000,000 classified publications which belong to 251 categories and 150 research areas.¹⁹ In order to ensure the quality of publications which is used for bibliometric analysis, we collected publication information from the WoS Science Citation Index Expanded (SCI-EXPANDED) and Social Science Citation Index (SSCI). As this paper aims to clarify the research status of online healthcare in related fields of social development, we eliminated areas that are too specialized, like oncology, chemistry analytical, and so on (see website: <https://webofscience.clarivate.cn/wos/woscc/summary/47f020f9-d22a-40c5-888b-b04ddaaa47c9-f51bc6eb/relevance/1> for details).

Our study analyzed publications from 1996 to 2023, as the first publication on online healthcare was in 1996. According to Mousavi and his coauthors, online healthcare means the application of information technology to the healthcare sector, which enables physicians and patients to overcome geographical barriers and engage in online communication.²⁰ Thus, we preliminarily identified “online healthcare” and “e-healthcare” as two keywords for literature search. In the process of literature search, we found that “telemedicine” and “telehealth” often appeared together with “online healthcare” and “e-healthcare”.^{21,22} Finally, four keywords “online healthcare,” “e-healthcare,” “telemedicine,” and “telehealth” for literature search were determined. By using “online healthcare,” “e-healthcare,” “telemedicine,” and “telehealth” in the topic field, we obtained a database of 14,676 publications. After category

Table 1. Descriptive statistics of the database.

Criteria	Quantity
Publications	4636
Authors	24,362
Journals	515
Institutions	6640
Countries/regions	147
Cited references	60,306

refinement, the database was narrowed down to 5117 publications. Then, we filtered by “Languages = English” and “document types = article,” ultimately yielding 4636 results. The final database is a text file which contains information of the author, title, source, abstract, keyword, addresses, cited references and use, funding, and others. The descriptive statistics of the database are given in Table 1.

Bibliometric analysis

As a quantitative method to retrospect and describe publications, bibliometric analysis is widely used by researchers to evaluate academic studies in a focal field.^{23,24} Bibliometric analysis analyzes secondary data achieved on the online database from an objective and quantitative perspective,²⁵ which enables researchers to improve the quality and reliability of their review articles by introducing a transparent, repeatable, and systematic review process.¹⁶

According to previous research,²⁶ bibliometric analysis usually includes two procedures. The first one is performance analysis, used to evaluate the publication distributions of various aspects, such as time distribution and geographical distribution. Performance analysis usually helps identify key periods and influential countries/regions, institutions, and journals. The second one is science mapping, which is used to probe the cooperation structure and evolution of a focal field.²⁷ This study used Microsoft Excel 2021, VOSviewer, and CiteSpace software to perform the bibliometric analysis. Microsoft Excel 2021 was used to obtain the year distribution and geographical distribution of online healthcare publications. VOSviewer was used to conduct the co-occurrence analysis and realize the visualization of intellectual structure. Based on the understanding of the structure of online healthcare research, we then performed burst detection and timeline analysis using the CiteSpace software to explore the development process in this field.

Results

This section showed the following results of performance analysis and science mapping. Performance analysis provided results of the yearly and geographical distribution of publications. We also listed the most relevant journals, institutions, and authors in this field. In addition, this section also included mapping analysis. To present the results of the mapping analysis, we first conducted a co-authorship analysis to detect cooperation between countries/regions and institutions. We then conducted a series of analyses on keywords, such as co-occurrence analysis, timeline analysis, and burstiness analysis using different softwares.

Performance analysis

Time distribution of publications. This study identified 4636 publications on online healthcare from the WoS database from 1996 to 2023. Figure 1 shows the chronological distribution of publications in the online healthcare research field. Overall, the growth trend of articles on online healthcare topics is exponential, which can be divided into three stages.

The first stage is from 1996 to 2006, as the original traceable article was published in 1996, and from then on until 2006. The annual number of articles in this stage is less than 10. The second stage is from 2007 to 2017; the number of papers published in this period reaches more than tenfold of the first stage. The prosperity in this stage is mainly due to the rapid development of Internet technology commercialization and the rapid growth of worldwide individuals using the Internet; the proportion of worldwide Internet users has grown rapidly from 20% in 2007 to 45% in 2017.²⁸ The rapid popularization of the Internet has provided the technical basis for online healthcare, which made the practice of online healthcare receive academic attention. In addition, the rapid spread of the Internet has facilitated cross-border cooperation and exchange in the online healthcare research field. In the last stage, from 2018 to 2023, articles meet rapid growth, which reflects the boom in this period.

Countries/regions distribution of publications. The sample used in this study contains 6640 institutions from 147 countries/regions. Figure 2 displays the global geographical distributions of the publications, from which we can see research study on this topic mainly belongs to North America, Asia, Europe, and Oceania.

Table 2 shows the top 10 countries/regions in the online healthcare field. The USA was ranked 1 in the online healthcare area (1,515, 32.68%), then followed by England (667, 14.39%), Australia (489, 10.55%), China (400, 8.63%), and Canada (343, 7.40%). In addition to publications, the number of average citations per publication of each country/region reflects the impact of a country/region in the focal field. Among the top 10 countries/regions that had the most publications on online healthcare between 1996 and 2023, the USA, Canada, the Netherlands, Saudi Arabia, and England were the most influential countries/regions. The above data reflected that the USA, Canada, and England took the leading position in this area.

Most relevant institutions. To further explore which institution is the most outstanding in the online healthcare research field, this study also performed an analysis on institutions. As shown in Table 3, the most significant number of publications were from the University of London (173 publications), followed by the University of California System and Harvard University with 126

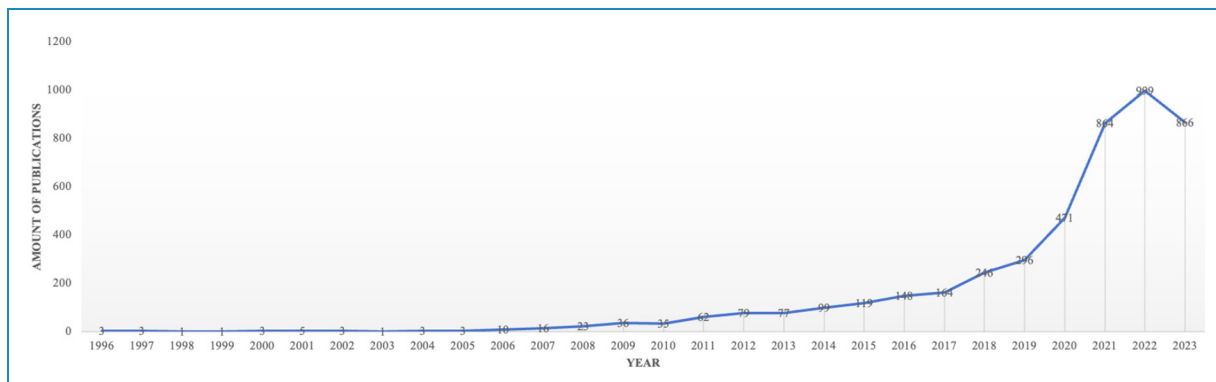


Figure 1. Distribution of publications.

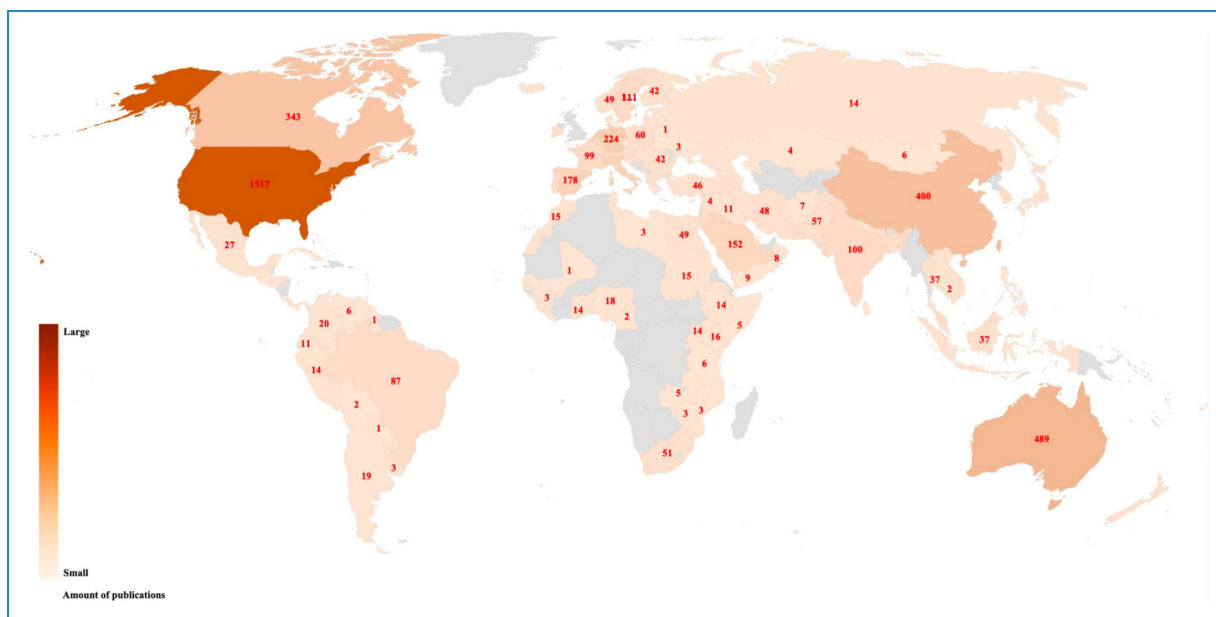


Figure 2. Global spatial distribution of online healthcare publications.

publications and 101 publications, respectively. The most infusive institutions, according to average citations per publication, were Johns Hopkins University (26.47), University College London (23.10), and the University of California System (23.03). Combining the two indicators, we found that the University of California System was both a productive and impactful institution in this field. What made Johns Hopkins University the most influential institution was that it established a website that released global statistics on COVID-19.

Most relevant journals. The amounts of publications and the amounts of citations represent the impact of a focal journal.²⁹ Thus, we identified the top 10 journals in the online healthcare research field by using these indicators.

Table 4 shows the top 10 journals (sorted by the number of publications in reverse order, 10th place is tied).

The 4636 articles were published in 515 journals, 11 journals published over 50 publications. The top five journals with more publications were *International Journal of Environmental Research and Public Health* ($n=385$, IF 5years = 4.8, Q1), *Frontiers in Public Health* ($n=237$, IF 5years = 3.6, Q2), *BMC Health Services Research* ($n=226$, IF 5years = 3.1, Q2), *Healthcare* ($n=180$, IF 5years = 839, Q2), and *BMC Public Health* ($n=132$, IF 5years = 3.9, Q2). According to “the number of citations” indicator, the top five highly cited journals were *International Journal of Environmental Research and Public Health* (5339 citations), *BMC Health Services Research* (3021 citations), *Frontiers in Public Health* (2323 citations), *BMC Public*

Table 2. Top 10 countries/regions that had the most publications on online healthcare between 1996 and 2023.

Rank	Countries/ regions	Publications	Citations	Average citations /publications
1	The USA	1515	29,325	19.36
2	England	667	11,245	16.86
3	Australia	489	6194	12.67
4	China	400	5806	14.52
5	Canada	343	6013	17.53
6	The Netherlands	252	4349	17.26
7	Germany	224	2567	11.46
8	Italy	191	3087	16.16
9	Spain	178	1760	9.89
10	Saudi Arabia	152	2596	17.08

Health (2268 citations), and *Frontiers in Psychology* (1344 citations).

Most relevant authors. Mapping analysis on authors is usually used to identify the most influential scholars in this field.³⁰ By using “the number of publications” indicator, we identified the top 10 productive authors among the 24,362 authors of these publications on online healthcare (displayed in Table 5).

Guo Xitong was the most productive author who published 12 papers from 1996 to 2023. He mainly focused on online healthcare service and physician–patient relationship from an information system perspective, such as the impact of online healthcare service on patient attitude, and the impact of interaction through online healthcare platforms on the physician–patient relationship. Lin Chung-Ying and Halwani Rabih were the second productive authors both published nine papers in our searching period. Most articles that Lin Chung-Ying published were during the COVID-19 pandemic, focusing on trust in the online healthcare system and social media use on disease cognition and mental state. While Halwani Rabih mainly researched on healthcare workers from a public environmental occupational health perspective, exploring the virtual handover by the online healthcare system, and social media use on the perceptions of healthcare workers.

Table 3. Top 10 institutions that had the most publications on online healthcare between 1996 and 2023.

Rank	Institution (countries/ regions)	Publications	Citations	Average citations /publications
1	University of London (England)	173	3230	18.67
2	University of California System (USA)	126	2902	23.03
3	Harvard University (USA)	101	1834	18.16
4	University of Toronto (Canada)	90	924	10.27
5	Monash University (Australia)	83	1054	12.70
6	University of Texas System (USA)	82	996	12.15
7	Johns Hopkins University (USA)	79	2091	26.47
8	University System of Ohio (USA)	73	1347	18.45
9	University College London (England)	71	1640	23.10
10	University of Sydney (Australia)	70	837	11.96

Mapping analysis

Cooperation between countries/regions. The network of cooperation between countries/regions means various levels of collaborations and partnerships established between countries/regions, which is crucial for scientific development.³¹ Among the various levels of collaboration between countries/regions, the partnership between researchers from

Table 4. Top 10 journals in the online healthcare research field.

Rank	Journal (country)	Publications	Citations	IF (5years)	Category quartile
1	International Journal of Environmental Research and Public Health (Switzerland)	385	5339	4.8	Q1
2	Frontiers in Public Health (Switzerland)	237	2323	3.6	Q2
3	BMC Health Services Research	226	3021	3.1	Q2
4	Healthcare (England)	180	839	2.5	Q2
5	BMC Public Health (England)	132	2268	3.9	Q2
6	Frontiers in Psychology (Switzerland)	105	1344	3.3	Q2
7	International Journal of Medical Informatics (Ireland)	76	2197	4.6	Q1
8	Patient Education and Counseling (Ireland)	74	1224	3.3	Q1
9	Digital Health (England)	61	555	3.7	Q2
10	Journal of Genetic Counseling (USA)	50	736	2.4	Q2
10	Supportive Care in Cancer (USA)	50	536	3.2	Q1

different countries/regions is the most routine and active. As co-authorship analysis includes analysis of the institutions of authors and the frequency of collaboration between specific countries/regions, it became the most common method for identifying cross-border collaboration.

To understand the inter-national/regional cooperation in online healthcare research, we conducted a co-authorship analysis. Figure 3 displays the co-authorship network map of countries/regions that had at least 10 publications in this field. There were five clusters in the countries/regions co-authorship network. The “Asia, North America, Oceania” and “Europe” clusters were the first two clusters that covered the most influential countries/regions, as shown in Table 2. Then, followed by the “Middle East” and “England and Ireland” clusters, which contained England and Saudi Arabia, two countries/regions as given in Table 2. As the smallest cluster, the “Singapore” cluster just contained one country. Clusters “Middle East” and “Singapore” have no cooperation, and the “Asia, North America, Oceania,” “Europe,” and “England and Ireland” clusters all had cooperation with the other four clusters except themselves.

Cooperation between institutions. To understand the inter-institutional cooperation in online healthcare research, we also probed the co-authorship network of institutions by using co-authorship analysis. Figure 4 displays the co-authorship network map of institutions that had over 20 publications in this field. Six clusters existed in the institution’s

co-authorship network. Except the cluster with a purple node in Figure 4, the other five clusters all show geographical proximity, which reflected the significant influence of geographical factors on academic cooperation.

Co-occurrence analysis on keywords. Keywords are generally used to summarize the research topics and core content of publications;³² the keywords analysis aims to understand the patterns and relationships between keywords. Thus, we first listed the high-frequency keywords (Table 6), which reflected the more influential and concerned keywords. As can be seen in Table 6, “Covid-19” “Mental health” “Healthcare” “Healthcare workers,” and “Depression” were the top five keywords.

In order to probe the association strength between keywords and identify clusters or themes within the online healthcare field, we then conducted a co-occurrence analysis on keywords.³³ This study analyzed keywords of publications in the online healthcare research field using the VOSviewer software (Figure 5). From Figure 5, we can see that COVID-19, healthcare, mental health, internet, social media, and telemedicine were the central nodes (also appeared in Table 6).

Co-occurrence analysis using VOSviewer generated a network consisting of “online healthcare service” “disease prevention and health privacy” “mental state” and “online healthcare practice” clusters. The red nodes in Figure 5 belonged to cluster one, which was the largest and most

Table 5. Top 10 authors in the online healthcare research field.

Rank	Authors	Publications	Citations	Interests
1	Guo XT	12	409	Online healthcare community, physician-patient relationship, online healthcare service
2	Lin CY	9	366	Trust in the online healthcare system, social media use in healthcare
3	Halwani R	9	246	Online healthcare workers, perceptions of healthcare workers
4	Haluza D	8	167	Health literacy, telemedicine, doctor-patient communication
5	Willis K	8	157	Mental health of healthcare workers, help-seeking behaviors
6	Fisher J	8	60	Online healthcare service, self-rated health
7	Al-Tawfiq J	8	244	Online healthcare education, online healthcare workers
8	Smallwood N	8	157	Online training on healthcare workers, perceptions of healthcare workers

(continued)

Table 5. Continued.

Rank	Authors	Publications	Citations	Interests
9	Pakpour A	7	276	Perceptions of healthcare workers, health literacy
10	Siewe Fodjo JN	7	119	Online healthcare education, online healthcare workers

vibrant cluster. In terms of the node amount, cluster two with a green colour and cluster three with a blue colour belonged to the second largest cluster. While considering the node size, cluster three had more associations with other clusters. Yellow nodes belonged to cluster four. We also used a table to present the clusters of keywords more visualized (Table 7).

It can be seen from the results of co-occurrence analysis on keywords that there were four themes in the online healthcare research field. Cluster one was about the “online healthcare service” theme, which is most flourishing. Cluster one mainly focused on how can online healthcare services provide convenience to both patients and doctors, for example enhancing patient satisfaction,³⁴ providing more health information³⁵ assisting in decision-making.³⁶ Cluster two was “disease prevention and health privacy,” exploring the effects of online healthcare on the prevention of infectious disease,³⁷ and health privacy concerns of online healthcare usage.³⁸ The “mental state” cluster studied the online healthcare usage in the mental health field, for example, the internet-based mental healthcare for a specific group,³⁹ and the online consultation in mental healthcare during the COVID-19 pandemic.⁴⁰ As the smallest cluster, cluster four was about the “online healthcare practice” theme, related to the healthcare practice opportunities, challenges, and transformation under online healthcare usage.⁴¹

Timeline analysis on keywords

As VOSviewer is unable to render keyword cluster visualization on year slices, this study furtherly used CiteSpace to conduct timeline analysis on keywords (Figure 6). When adding the timeline into consideration, 10 clusters were generated. Clusters except “#8 implementation” spanned more than 15 years, among which “#0 COVID-19,” “#1 health information,” “#2 health literacy,” and “#3 primary care” had longer time span. This reflected that these four clusters was perennial in the online healthcare field.

Research studied on the “#0 COVID-19” cluster were mainly interested in mental health and healthcare workers,

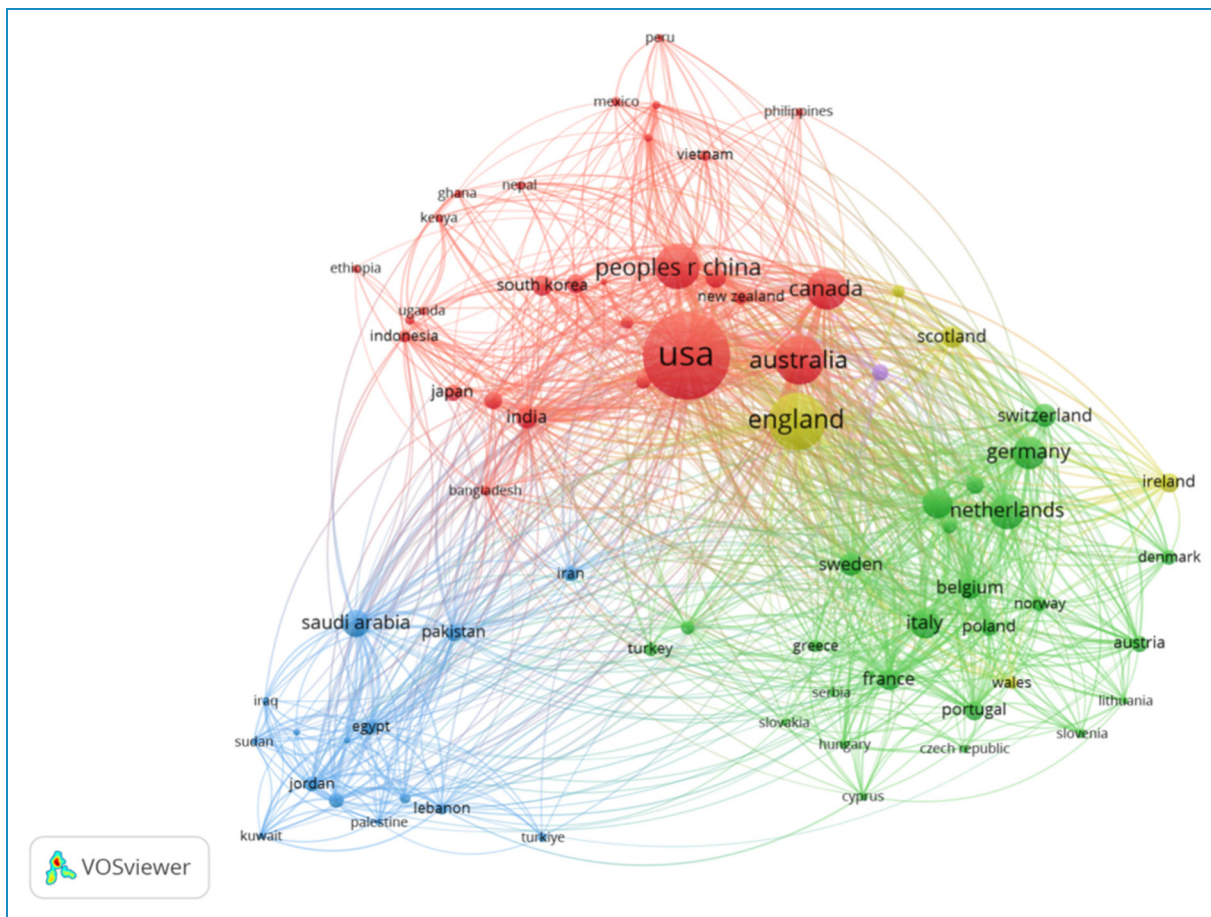


Figure 3. Co-authorship network map of countries/regions in online healthcare research.

while the interest of studies in the “#1 health information” cluster was relatively dispersed, distributed in health information, information technology, seeking behavior, online resources, and so on. Popular topics in the “#2 health literacy” cluster were public health and social support. Hot topics in “#3 primary care” were the internet and primary care health. “#4 medical students” explored online medical education and was less related to online healthcare. The principal topic in “#5 social media” was social media use in the online healthcare community. Studies on the last four clusters were relatively few; hot topics were quality of healthcare, attitudes, and knowledge translation for “#6 patient safety,” “#7 rates,” and “#8 implementation,” respectively. The high-frequency keyword of “#9 disparity” was US, which meant most studies in this cluster were in the context of the US country.

Burst detection on keywords

Burst detection is a common method to detect pivotal and emerging topics in bibliometric analysis. By using CiteSpace, this research performed a burst detection analysis on keywords in the online healthcare field and revealed the top 20 keywords with the strongest citation

bursts in our searching period (Figure 7). Internet as the technological basis of online healthcare gained sustainable attention over a long period of time. The health information, community, and system also received a long period of attention. The recent popular topics were the COVID-19 outbreak, psychological impact, healthcare workers, and so on.

As academic research is constructed on the basis of predecessors; there are time overlaps between hot topics. Similarly, stages divided by hot topics also have time overlaps. Overall, the development of this field has gone through three stages. The first stage was from 2001 to 2015; at that time, the hot topic was data statistics of online healthcare. The second stage was from 2011 to 2020; health information seeking and perception obtained prominence at this stage. The final stage witnessed the COVID-19 pandemic (from 2021 to 2023); therefore, mental health and the COVID-19 pandemic became the most popular topic.

Discussion

This study has conducted a systematic review of academic research on online healthcare by using VOSviewer and

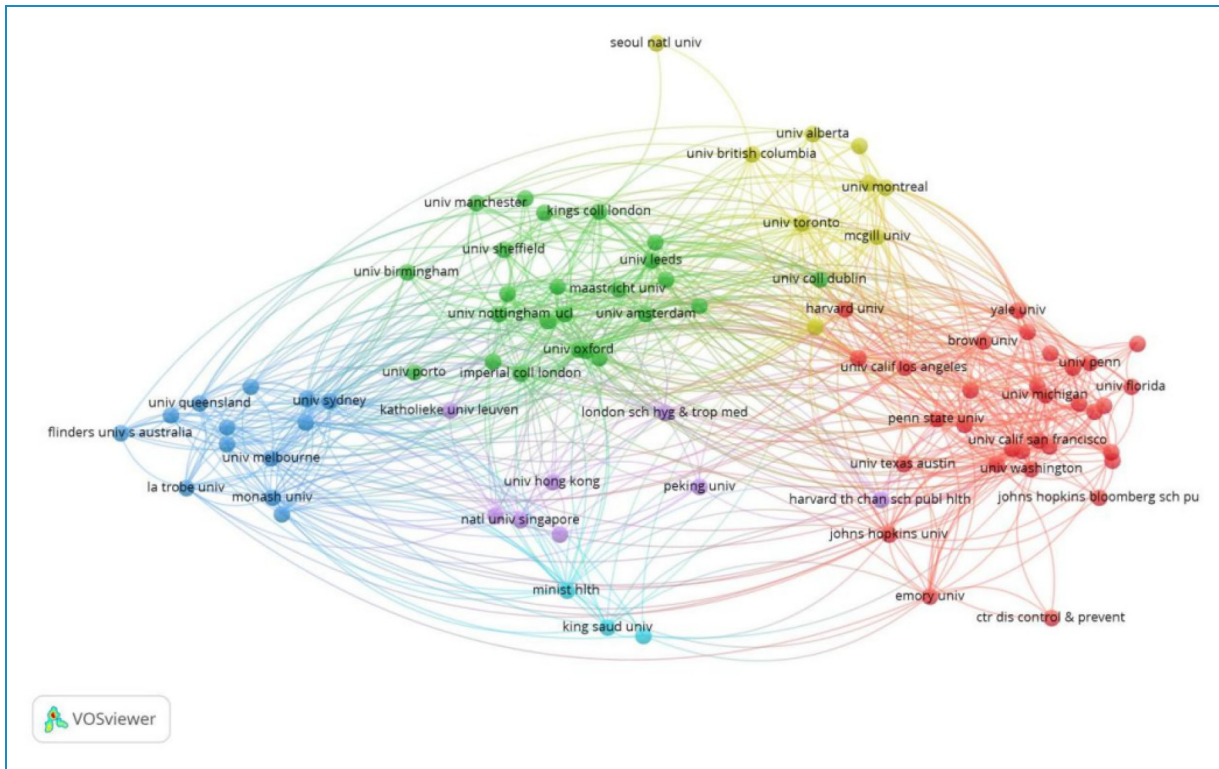


Figure 4. Co-authorship network map of institutions in online healthcare research.

Table 6. High-frequency keywords in online healthcare research.

Keywords	Frequency	Keywords	Frequency
COVID-19	758	Social media	91
Mental health	218	Healthcare professionals	88
Healthcare	199	Education	85
Healthcare workers	173	Public health	80
Depression	118	Primary care	79
Anxiety	109	Telehealth	78
Pandemic	108	Stress	74
Telemedicine	104	Communication	72
Knowledge	95	Burnout	71
Internet	91	e-health	68

CiteSpace. Through VOSviewer, we clarified the relationships of countries/regions, institutions, and keywords,

CiteSpace enabled us to explore the hot topics in different clusters and different stages.

General findings

According to the distribution of publications, there are three major stages of the research on online healthcare: the first stage is from 1996 to 2006 (36 publications), the second stage is from 2007 to 2017 (858 publications), and the last stage is from 2018 to 2023 (3742 publications). The strongest citation burst keywords in the first stage are internet and mortality, reflecting that data statistics of online healthcare has become the research hotspot since then. As with the second stage, health information seeking and perception obtained prominence, bursting keywords like health information, systems, community, and so on. The last stage witnessed the COVID-19 pandemic; therefore, mental health and the COVID-19 pandemic became the most popular topics during this period.

The distribution of countries/regions indicated that the USA was the most productive country, then followed by England, Australia, China, and Canada, 3054 out of 4636 analyzed publications were published in these five countries. This meant that the USA, England, Australia, China, and Canada played an important and dominant role in this field, probably because leading economies and information technology have facilitated the emergence and use of online

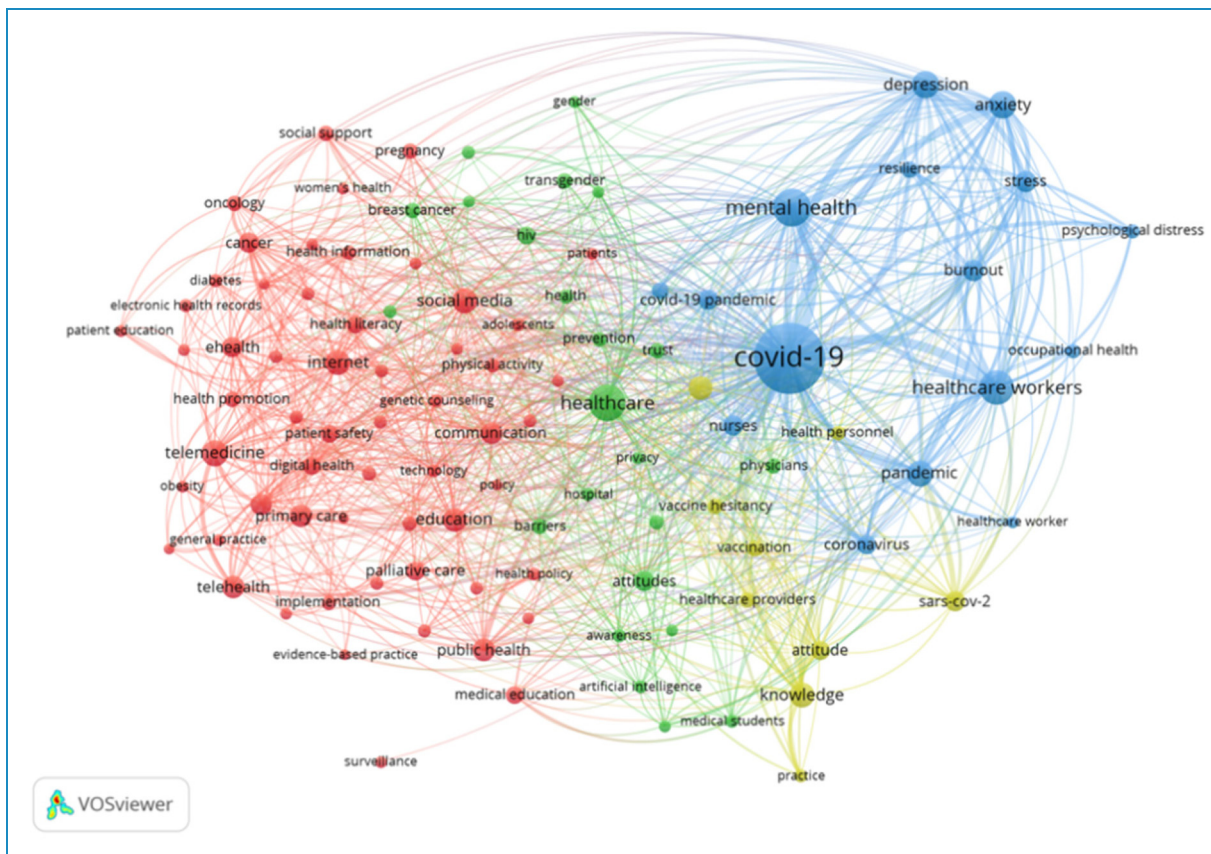


Figure 5. Co-occurrence analysis of keywords in online healthcare research.

healthcare; then, the academic research thrived in this context.^{42,43} By using the “average citations per publications” indicator, we found that the USA, Canada, Netherlands, Saudi Arabia, and England were the most influential countries in this field.

The most productive institutions were concentrated in productive countries, half of the top 10 most productive institutions were in the USA; four were in England and Australia (two per country). The last top institution was in Canada. Most top 10 institutions were near the core of each cluster in the co-authorship network map of institutions, reflecting that these institutions (excluding the University System of Ohio) were the trendsetters in this field (Figure 4). Cooperation was often in adjacent institutions. Among the 24,362 authors, 54 published over 5 articles in this field. This indicated that, different from country and institution, there were not many prolific authors in this field. We also clarified the top 10 journals in this field (as 10th place was tied, Table 4 lists 11 journals), and found all of them were located in Europe and the USA; this is because the major publishers are concentrated in those regions.

We also identified the top 10 productive authors in this area and found that Guo Xitong, Halwani Rabih and Lin Chung-Ying were the top three most productive authors.

They contributed to online healthcare by conducting research studies from different perspectives. Guo’s research studies in this field were mainly from the perspective of physician–patient relationships, focusing on how online healthcare impacts the physician–patient relationship and patient attitude. Halwani Rabih mainly studied on healthcare workers from a public environmental occupational health perspective, probing how the virtual handover by online healthcare influences the perceptions of healthcare workers. Most articles that Lin Chung-Ying published were during the COVID-19 pandemic, focusing on trust in the online healthcare system and social media use on disease cognition and mental state.

Online healthcare cooperation networks

For the past few years, academia has realized the significance of scientific collaboration, which was an important path to accelerate the diffusion of science and technology, and promote the economy and society. This study provided a holistic view of online healthcare research cooperation networks by mapping analysis. By using co-authorship analysis provided by VOSviewer, this study explored the collaboration networks of countries/regions and institutions.

Table 7. Clusters resulting from the co-occurrence analysis of keywords.

Cluster 1: Online healthcare service		Cluster 2: Disease prevention and health privacy	
Internet	Health policy	Privacy	Trust
Health literacy	Palliative care	Hospital	HIV
Health information	Technology	Attitudes	Transgender
Women's health	Education	Awareness	Gender
Social support	Digital health	Artificial intelligence	Breast cancer
Pregnancy	Patient safety	Healthcare	Barriers
Social media	Telehealth	Prevention	Physicians
Adolescents	Public health	Cluster 3: Mental state	
Physical activity	Medical education	Covid-19	Burnout
Genetic counseling	E-health	Mental health	Occupational health
Communication	Telemedicine	Depression	Healthcare workers
General practice	Obesity	Anxiety	Pandemic
Cancer	Primary care	Resilience	Coronavirus
Diabetes	Patient education	Stress	Nurses
Oncology	Surveillance	Covid-19 pandemic	Psychological distress
Electronic health records	Evidence-based practice	Cluster 4: Online healthcare practice	
Health promotion		Vaccine hesitancy	Practice
		Vaccination	Attitude
		Healthcare providers	Knowledge

There are five clusters in the countries/regions' cooperation networks. According to the geographical distributions of countries/regions, the five clusters are labeled "Asia, North America, Oceania" "Europe" "Middle East" "England and Ireland," and "Singapore." Even though cooperation between countries/regions was close in this field, existing cooperation was mainly among countries/regions within the same continent. It was worth noting that cross-regional cooperation between eastern and western countries was still relatively rare. Especially for China, due to the booming development of its internet technology and the popularization of its internet infrastructure, China has become a pioneer in the practice of online healthcare. However, there was a mismatch between the status of online healthcare practice and scientific research in China. In future online healthcare research, it is very necessary for China to further strengthen collaboration and exchanges in the same cluster, such as the USA, Australia, and Canada. Meanwhile, it is also necessary for China to expand collaboration and exchanges with influential countries/regions in other clusters, such as England, Netherlands, Germany, Italy, Spain, and Saudi Arabia.

Six clusters existed in the institution's co-authorship network. Similar to the countries/regions cooperation network, most clusters in the institution co-authorship network were in geographical proximity, which reflected the significant influence of geographical factors on academic cooperation. Institutions of England, the USA,

Canada, and Australia were the main forces in the online healthcare research field in the world. Only two Chinese universities, Peking University and the University of Hong Kong, were active in the institution's cooperative networks. In order to enhance the institution's influence, achieving the matching of practice and academics, Chinese institutions need to cooperate more extensively with institutions in England, the USA, Canada, and Australia.

Hotspots on online healthcare

As keywords are generally used to summarize the research topics and core content of publications, this research conducted a more detailed analysis on keywords. Co-occurrence analysis on keywords provides a way to clarify the distribution of numerous studies in the online healthcare research field. Timeline analysis further renders keywords cluster visualization on year slices, while burst detection assists us in probing the potential frontiers in this field.

According to co-occurrence analysis (Figure 5), there are four clusters in this field: "online healthcare service" "disease prevention and health privacy" "mental state," and "online healthcare practice." When combined with the results of timeline analysis on keywords, studies belonging to "online healthcare service," "disease prevention and health privacy," and "mental state" clusters will



Figure 6. Map of timeline view in the online healthcare research field.

obtain longer attention in this field. The timeline analysis result showed that the hotspots of online healthcare research mainly focused on “#0 COVID-19,” “#1 health information,” “#2 health literacy,” “#3 primary care,” “#4 medical students,” “#5 social media,” “#6 patient safety,” “#7 rates,” “#8 implementation,” and “#9 disparity.” According to the result of burst detection, academia focused on the internet, systems, health information, framework, adolescents, healthcare workers, psychological impact, anxiety, COVID-19 pandemic, and SARS in a chronological order. Changes of the bursting keywords reflected that the research focus in this field had shifted from basic research to applied research. A recent hotspot in online healthcare research area was online healthcare used during the COVID-19 outbreak,^{44,45} the effect of online healthcare service on psychological state,^{46,47} and the role of healthcare workers in promoting online healthcare.^{48,49}

Conclusions

Online healthcare has been studied by scholars for years, while there was still a lack of a holistic picture in this field, resulting in chaotic understandings of the current

research. By using VOSviewer and CiteSpace, this study conducted a bibliometric analysis of publications on online healthcare. The amounts of publications in this field has steadily increased year by year. The USA, England, Australia, China, Canada, Netherlands, Germany, Italy, Spain, and Saudi Arabia were the main forces in this research area, whose institutions were also more outstanding. The University of London in England was the most influential institution. The most productive author was Guo Xitong from the Harbin Institute of Technology. The cross-regional collaboration between eastern and western countries/regions was still relatively rare. During the past decade, the major research trends transformed to the online healthcare service and the mental health during the COVID-19 pandemic, which reflected that the basic research in this field has been relatively mature, studies in this field had shifted from basic research to applied practice research. Hotspots of online healthcare research mainly focused on “#0 COVID-19,” “#1 health information,” “#2 health literacy,” “#3 primary care,” “#4 medical students,” “#5 social media,” “#6 patient safety,” “#7 rates,” “#8 implementation,” and “#9 disparity.”

Using VOSviewer and CiteSpace together, this study conducted a bibliometric analysis on online health research.

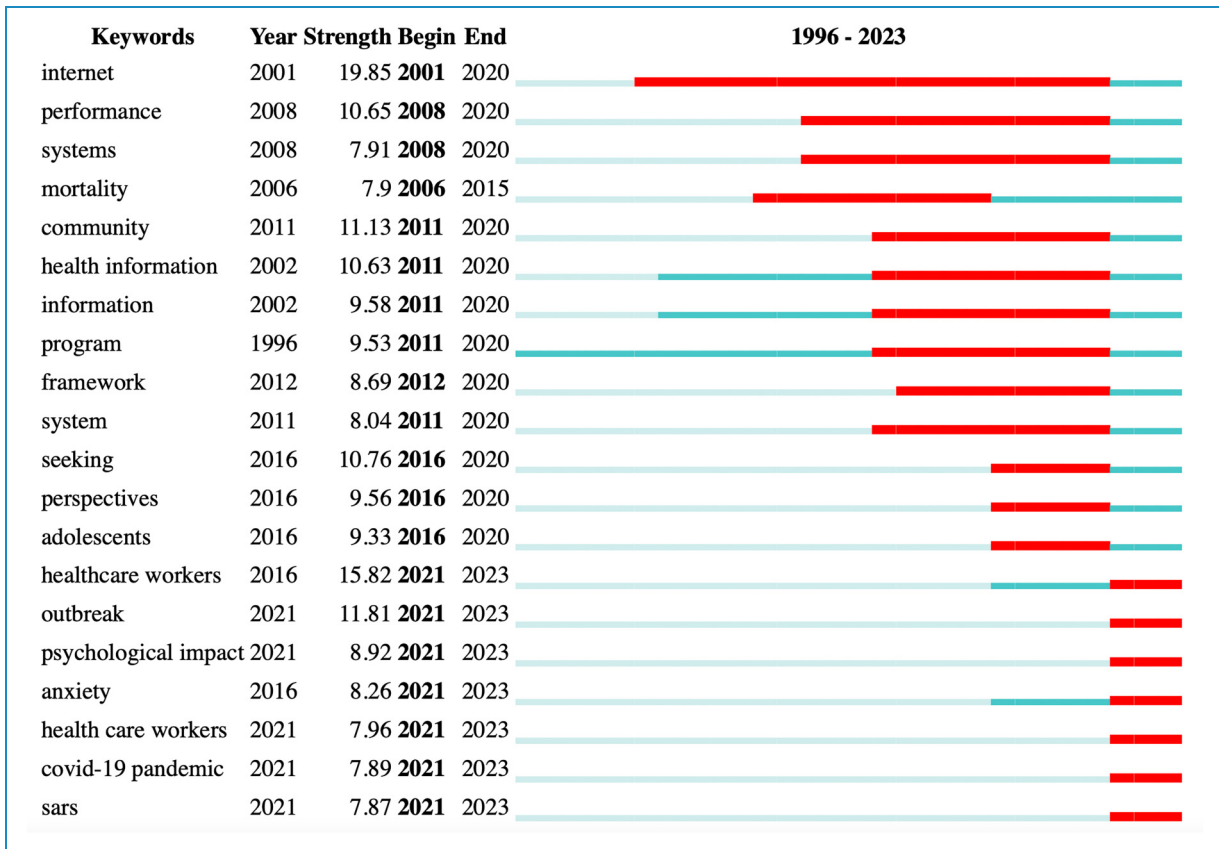


Figure 7. Top 20 keywords with the strongest citation bursts in the online healthcare field.

Compared with a traditional literature review, we provided a more holistic and explicit picture of online healthcare research. The whole landscape will help scholars who are interested in this field to quickly and thoroughly understand the development process. This study can also be used as a guidebook for scholars to identify the dominant authors, publications, journals, or institutions they want to refer. Finally, the potential frontiers predicted by bibliometric analysis can also provide inspiration and insight for future research.

This study also has some limitations. First, we collected data in only one database. Although WoS covers over 15,000 journals, some journals may still not be included. Therefore, some publications may have been missed.⁵⁰ Second, to ensure the quality of publications, we only included the article publications, excluding conference papers, working papers, and other types of publications. This may result in the loss of the latest findings and abundant perspectives. Finally, the interpretation of the bibliometric analysis results may be influenced by individual cognitions. This research tries to overcome the subjective interpretation from only one researcher, by multiple discussions between multiple authors.

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Guarantor: FFZ.

ORCID iD: Fangfang Zhu  <https://orcid.org/0009-0004-7699-2007>

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Appendix

Notation

Abbreviations

CAGR	Compound Annual Growth Rate
COVID-19	Corona Virus Disease 2019
HIV	Human Immunodeficiency Virus
USA	United States of America
WoS	Web of Science database