Chapter

Detection and Characterization of E-Health Research: A Bibliometrics (2001–2016)

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Abstract

E-health is the use of ICT to improve the ability to treat patients, facilitate behavior change, and improve health. It has many benefits like healthcare cost reduction, convenience for users, and health system improvement. Several literature reviews have included one part or the other of the field, but an overall review is lacking possibly due to the field's constant evolution. An overview of E-health research is needed. We selected the related literature on E-health downloaded from Web of Science and PubMed as data source and used the visualization analysis function of CiteSpace. Literature information would be converted into precise mapping knowledge domain. Through further analysis of mappings, we explored the theoretical framework and the forefront in the field of E-health. Our study shows that over the past 15 years, the USA, England, and Australia were the top three countries that published the largest number of papers. Researches about Internet technology, telemedicine (m-health), and healthcare lay the basis of E-health research development. Particularly, m-health, health system management, and experimental intervention have emerged and formed the new study frontier in the recent 3–5 years. With the advancement of E-health projects, an increasing number of scholars have been studying the commercialization of E-health.

Keywords: E-health, bibliometrics, visualization analysis, CiteSpace

1. Background

Advances in information and communication technology (ICT) and the dissemination of network data processing created a new environment of universal access to information and globalization of communications, businesses, and services. In the health sector, a variety of new ICTs are implemented to improve the efficiency of all levels of healthcare. E-health—or digital health—is the use of ICT to improve the ability to treat patients, facilitate behavior change, and improve health. Many benefits of E-health have been presented, including cost reduction and convenience for users [1, 2], reduction of health service costs and improving health service quality [3, 4], reaching isolated or stigmatized groups, timeliness of access to the Internet [5], increasing user and supplier control of the E-health intervention [6], and changing government policy making [1]. E-health is making healthcare more efficient while allowing patients and professionals to access and manage data in ways that were previously impossible [7]. Thus, E-health does not specifically refer

to a certain subject. It is an application area where many subjects are associated such as clinical informatics, health informatics, electronic health record, consumer health informatics, and various Internet-based technologies and services [8].

According to Faber, Mitchell coined the term E-health in 1999 [9]. The study of E-health has attracted research interest after it was used by the World Health Organization (WHO) [10]. First, some researchers raise the theory that E-health communication may have immense potential to promote behavior changes through unique features such as mass customization, interactivity, and convenience. As a result, it can help improve the quality of medical care and lower the cost [11, 12]. On the basis of these theories, many researches have been conducted to confirm the advantages and benefits of E-health, such as "automatic-sleep classification program" research and "E-health intervention model designing" [13, 14], challenges in establishing a national databank of anonymized person-based records, and randomized controlled trial of web-guided approach [15–17]. Published articles in related fields are on the rise year by year (**Figure 1**), and many countries have also raised programs, Europe "e-Health Action Plan 2004–2010" and "e-Health Action Plan 2012–2020" and the USA "Federal Health IT Strategic Plan (2015–2020)," on the development of health information systems. The United Kingdom "Health and Social Care Act 2012" proposed that we need to reform healthcare and take the advantage of information technologies to improve the quality of patient care [18–20]. It informs us that combining health work with ICT is the trend of medicine development since medicine and health are the basis of stable development for a country.

As for E-health researches, there are several main topics: (1) Consensus and standardization of E-health research. (2) Evaluation methods and challenges—proper evaluation methods are needed to establish E-health quality and efficiency evaluation model [21, 22]. (3) Quality, value, and future trends—as most people

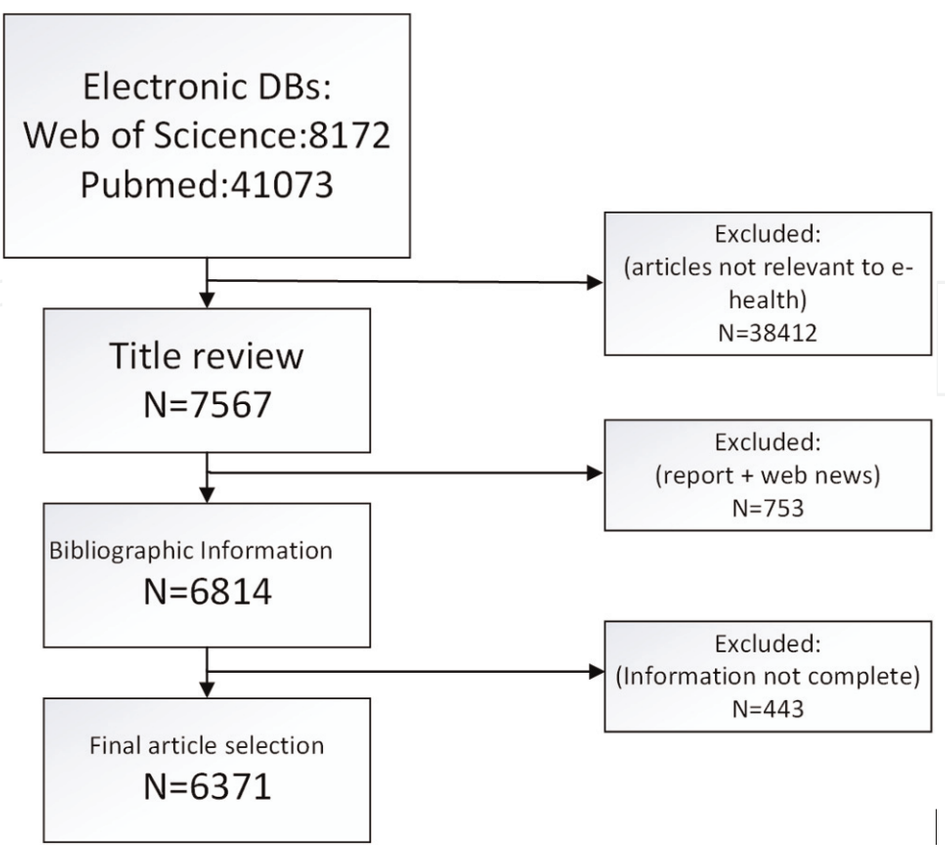

Figure 1.
Flow chart of the literature.

think, E-health application is cost-effective and efficient and will improve qualities of clinical work [23–25]. The academic literature has primarily focused on issues in the adoption and diffusion of specific E-health technologies, and only a few papers concern on the development of E-health subject [26]. This leads to the current state that although some literature reviews cover one part or the other of the field [27, 28], an overall picture is still missing which is possibly due to the field's constant evolution. Besides, coherence of these researches is poor, and the interaction between scholars is not enough, making it difficult to reach a consensus about E-health research.

We explore the law of E-health discipline development using the scientific metrology, social network analysis, and information visualization technology. Progressively synthesized co-citation networks are constructed and visualized to aid visual analytic studies of the domain's structural and dynamic patterns and trends [29]. The formation of E-health, hot topics evolution, and trend of this research field being explored is achieved.

This study aims to present an analytical review on the state of E-health research. A review framework composed of multiple research methods is developed and applied to yield a broad coverage of E-health research. We explore the distribution of E-health hot topics and probe the research frontier by bibliometric methods. The evolution of different topics is evaluated and some research directions are proposed.

2. Methods and tools

2.1 Data source

Web of Science core collection is used as data sources. We summarized the scope of E-health, and developed the following search query according to the results of literature research (**Table 1**). We selected the search term to retrieve all relevant literatures for 15 years, and 6371 documents were retrieved in total.

		Search query	Number of hits
WOS	#1	TS = (Clinical decision support system) OR TS = (Health informatics) OR TS = (Medical research using grids) OR TS = (healthcare information systems)	23,184
	#2	TS = (Clinical Informatics) AND #1	2209
	#3	TS = ((electronic health record) or EHR or cpoe or (computerized physician order entry) or e-prescribing)	18,034
	#4	TS = (CONSUMER HEALTH INFORMATICS)	409
	#5	TS = ((health knowledge management) or (decision aids for patients) or (virtual healthcare teams))	17,993
	#6	TS = (telemedicine or mhealth or m-health or wireless networks or (vr technology) or cloud-computing or (self-monitoring healthcare devices) or (health surveillance systems) or (e-mental health))	206,209
	#7	TS = cyber medicine	26
	#8	TI = (ehealth or (e-health) or (E-Health) or EHealth or EHEALTH or E-HEALTH or (electronic health))	9484
	#9	TI = health and (big data)	283
	#10	TS = health and (big data)	3558

		Search query	Number of hits
	#11	#9 and #10	283
	#12	#7 OR #6 OR #5 OR #4 OR #3 OR #2 OR #1	241,715
	#13	#12 or #11 and #8	8172
PubMed	#1	(((ehealth OR (e-health) OR (e-health) OR ehealth OR ehealth OR e-health OR (electronic health)) title/abstract)) AND ((((((((((Clinical decision support system[Title/Abstract]) OR Health informatics[Title/Abstract]) OR Medical research using grids[Title/Abstract]) OR healthcare information systems[Title/Abstract])) OR ((Clinical Informatics[Title/Abstract]) AND ((((Clinical decision support system [Title/Abstract]) OR Health informatics[Title/Abstract]) OR Medical research using grids[Title/Abstract]) OR healthcare information systems [Title/Abstract])))) OR ((clinical informatics) AND ((((Clinical decision support system[Title/Abstract]) OR Health informatics[Title/Abstract]) OR Medical research using grids[Title/Abstract]) OR healthcare information systems[Title/Abstract])))) OR (((electronic health record [Title/Abstract]) OR cpoe[Title/Abstract]) OR e-prescribing[Title/Abstract])) OR CONSUMER HEALTH INFORMATICS[Title/Abstract]) OR ((((health knowledge management[Title/Abstract]) OR decision aids for patients[Title/Abstract]) OR virtual healthcare teams[Title/Abstract])) OR ((telemedicine OR health OR m-health OR wireless networks OR (vr technology) OR cloud-computing OR (self-monitoring healthcare devices) OR (health surveillance systems) OR (e-mental health)) title/abstract))	41,073

Table 1.
Search query for this study.

2.2 Methods and tools

Information visualization is an analytical method which can realize the interactive visualization analysis on abstract data and enhance people's perception of the abstract information [30]. To some extent, information visualization offers a quick independent, scientific judgment of the objective evidences [31]. CiteSpace, UCINET, Pajek, His cite, and Ref Viez 3 are software that researchers used mostly to do information visualization analysis, among which CiteSpace is the most popular one [32, 33]. CiteSpace, a Java-based application developed by Chaomei Chen professor who is a Changjiang Scholar from Dalian University of Technology, can display the abstracted data in the visual form and facilitates further data analysis, rule discovery, and decision-making. It is easy to use and its visualization results are excellent. In this paper, we determined the discipline layout and hot spots about E-health in a specific period based on SCI and CiteSpace.

3. Results

3.1 Brief descriptions of E-health development

3.1.1 Number of articles published

As **Figure 2** shows, the histogram denoted quantity of E-health research, and the line chart shows the literature accounted to the total each year. In general, the quantity of the published literature showed an increasing trend with the average

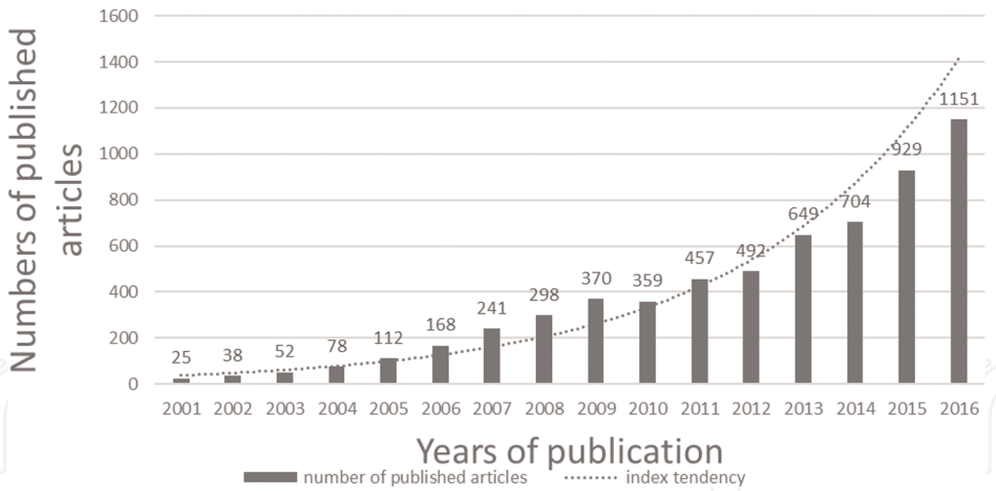

Figure 2.
The number of articles published each year.

annual growth rate of 29.93% from 2001 to 2016. In detail, we saw two inflection points in 2005 and 2010. Considering the quantity and proportion trend of the literature, we divided the whole research time into three parts which are listed as 2001–2005, 2006–2010, and 2011–2016.

Reasons for the above trend have two aspects. First, they are associated with some pivotal view point. Eysenbach, G and WEBB, TL published their important literature in 2005 and 2010. They are both authorities in E-health research [7, 34]. Therefore, the quantity of published literature began to rise in these years. Second, developing technology and government attaching importance to medical research contributed a lot. The development of E-health depended on science and technology progress. Many governments have different preferential policies for health science research and Internet communication techniques which promoted E-health research.

3.1.2 Country analysis

Figure 3 shows the published number of key nodes and the influence degree of relevant researchers concretely. Centrality is an index used to measure the

Figure 3.
Visualization map of countries.

Frequency	Centrality	Country	Rank
1158	0.28	USA	1
486	0.17	England	2
480	0.15	Australia	3
434	0.16	Canada	4
430	0.08	Netherlands	5
415	0.11	Germany	6
323	0.1	Spain	7
273	0.04	Italy	8
195	0.02	Austria	9
180	0.12	France	10
161	0.05	Sweden	11
154	0.01	People's of Republic China	12
143	0.08	Switzerland	13

Table 2.
High-frequency countries.

importance of a node in the whole network. It is more likely that the node is the key point in the network if the centrality is big. As shown in **Table 2**, USA's published quantity was the most in the top 13 countries. In detail, America published 1158 papers, which accounted for one-fifth of all literature from 2001 to 2016, whereas China was in the twelfth place. China published 154 papers, accounting for only 2.6%. Above countries had the centrality from 2002 to 2004, among which the USA have had it earlier in 2002 and CHINA in 2004. As for the centrality value, the USA, England, and Australia were the top three, and their researchers had a major influence on the field of E-health at the same time. Besides, the influence of China is quite weak because of its low-value centrality.

3.1.3 Research directions

Every article has multiple research directions, but after statistically ranking, the top 10 directions were: healthcare science and service, computer science, medical informatics, engineering, public environmental occupational health, telecommunications, psychology, general internal medicine, and information science library science. In addition, these articles also involve some elements of clinical areas such as nursing, cancer treatment, pharmacy, and science and technology development (**Table 3**). The top four research directions are healthcare science and services, computer science, medical informatics, and engineering, accounting for more than 100%, which means all the literature is concerned with the four research directions, so it is suggested that these four research directions are the theoretical basis of E-health research.

3.1.4 Authorship analysis

As for the publishing frequency of authors, their publishing situation was the same as the regarding countries'. We try to strengthen the cooperation between authors to serve the E-health and those producing more relevant output. As shown

Research directions	Frequency	Rank
Healthcare science and service	1919	1
Computer science	1904	2
Medical informatics	1439	3
Engineering	1095	4
Telecommunications	411	5
Public environmental occupational health	367	6
Psychology	242	7
General internal medicine	213	8
Information science library science	183	9
Nursing	149	10

Table 3.
Research directions.

in **Figure 4** and **Table 4**, the top five authors did not cooperate with others directly. It indicated that they focused on different topics and all of them were leaders in their research directions. Bernd Blobel was the top and he published 35 papers. He works at University Hospital Regensburg. By studying the privacy and security of some E-health system, he could analyze and design of advanced health systems properly [35–37]. Gunter Schreier concerns that using mobile devices or communication technologies provide huge opportunities for home monitoring applications [38]. He found that different types of data acquisition technologies have an important effect on patients' willingness to participate in telehealth programs in the long term [39]. JJPC Rodrigues works at the University of Beira Interior. He mainly studied the application effect of different kinds of wireless sensor networks in the

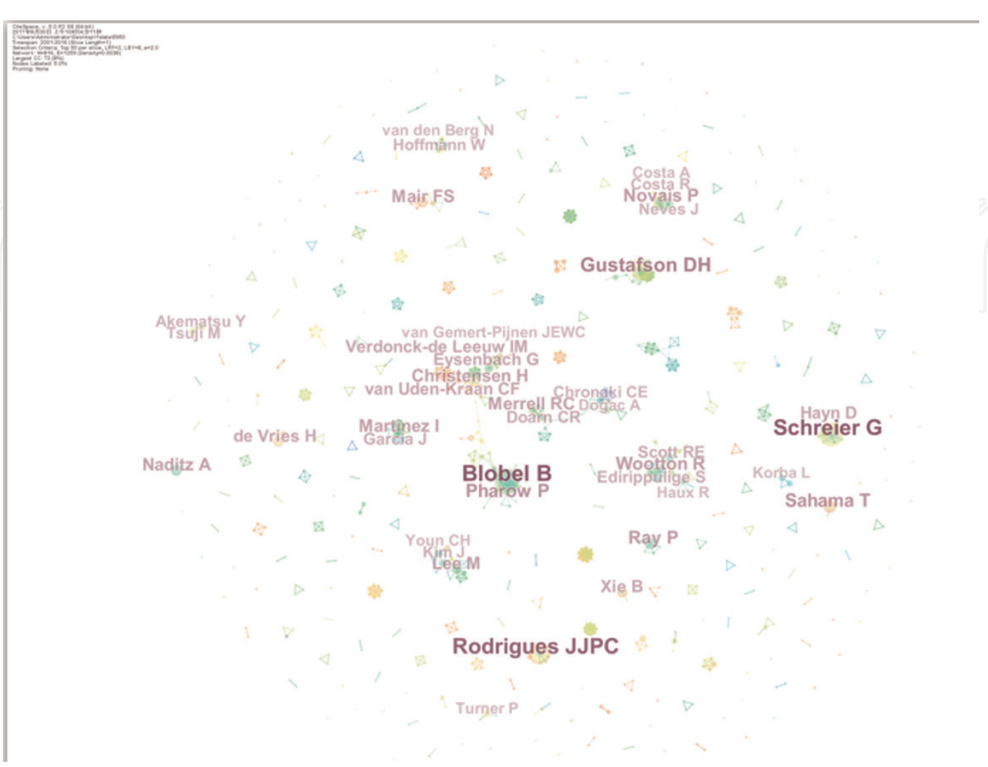

Figure 4.
Visualization map of authors.

Authors	Frequency	Rank
Blobel B	35	1
Schreier G	33	2
Rodrigues JJPC	29	3
Gustafson DH	28	4
Eysenbach G	22	5

Table 4.
High-frequency authors.

medical field. In the last 15 years, he proposed some network solutions, such as IP-based wireless sensor network, biofeedback data visualization for body sensor networks, real-time query processing optimization for wireless sensor network, and so on [40–42]. Gustafson typical papers are concerned with the research around consumer health informatics which influence on how patients or potential patients get health knowledge they need [43]. As for Eysenbach, he is the founder of E-health field, and he proposed the concept of E-health in 2002. In the subsequent time, he researched on the quality of electronic health information, Internet access to health information, and evaluation of E-health-related program [44–46]. According to the number of citations, Eysenbach is one of the most important core authors in E-health research. The focus of these five authors is not the same, but from the visualization map, their research direction all represents hot spots in this period.

3.2 Research focus analysis and frontier analysis in E-health research

3.2.1 Research focus analysis

Research hot spots are issues or special directions studied by lots of people in recent years. Keywords, a highly generalized summary, and important index of papers are the core of academic papers. Therefore, we could get the research hot spots and the main subjects of one study area by analyzing the change trend and characteristic of the keyword frequency (**Figure 5**).

Due to the function of CiteSpace, the bigger the size of node is, the more important the node in the visualization map is. It is obvious that some keywords [Internet, telemedicine (m-health), technology, randomized controlled trial, management, and system] have a quite bigger size than others. Besides, considering that our research topic belongs to medical study, we could speculate that telemedicine, randomized controlled trial, health system, health management, and applying Internet-related technology in medical field have become the research hot spots and the main subjects in the study of most scholars from 2001 to 2016.

Seeing from the frequency of keywords, we can broadly divide the E-health research into several main subjects. "Internet technology" is the first one, which is the combination of "Internet" and "technology." E-health is the ICT in the field of healthcare, so the Internet technology development is driving force of E-health [17]. "Telemedicine," the second subject, appeared 618. It refers to the provision of remote clinical services via real-time two-way communication between the patient and the healthcare provider by using electronic audio and visual means. "Telehealth," "m-health," and "communication" belong to it, which mainly concern on whether telemedicine or m-health could help improve the efficiency of individual access to medical services to solve the existing problems [47, 48]. "Randomized controlled trial," the third one, is research method and one kind of intervention. These clusters concentrate on proving the advantages and disadvantages of E-health

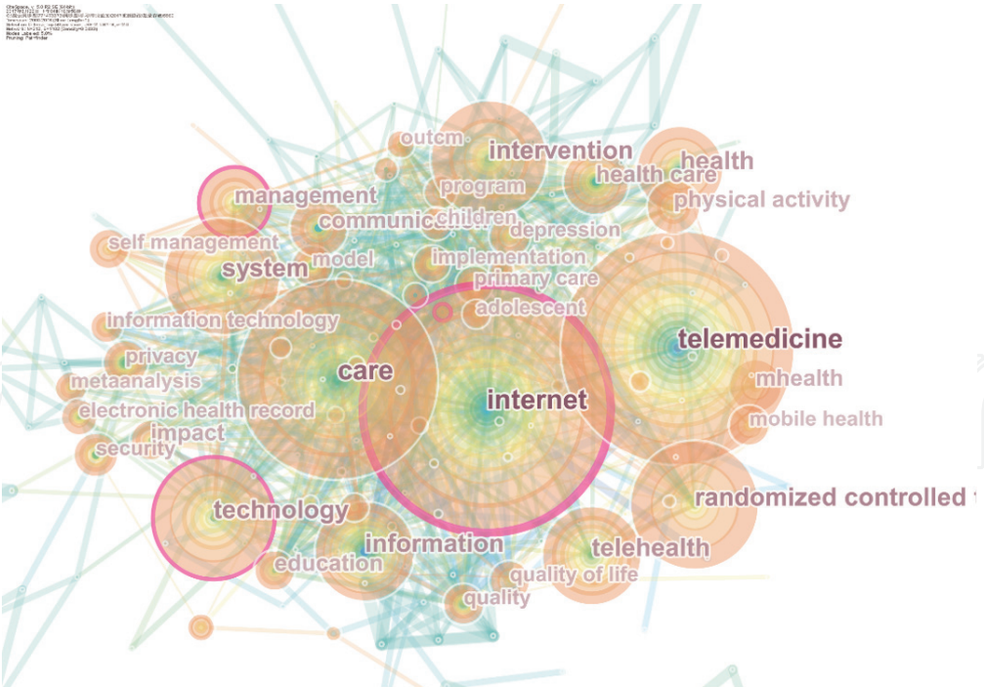

Figure 5.
Visualization of hot topics in 2001–2016.

programs. Fourthly, papers researching "healthcare field" focus on E-health application like electronic health record and attributes such as security, privacy, and interoperability [49]. With the promotion of information network technology development, the main task of the next phase is how to ensure the efficiency of E-health system data storage security, transmission, ease of use, and privacy protection. "Health management," the fifth one, is an abstract conception. Any keywords associated with management can be divided into this class such as self-management, adherence, and mental health management [17, 50, 51].

3.2.2 Visualization of hot topics evolution

To explore the degree of concern of the international E-health research, we divided it into three periods: from 2001 to 2005, 2006 to 2010, and 2011 to 2016. The frequency of keywords has been counted as shown in **Table 5**. Similar to the above method, we get the visualization maps of keywords in different times, as shown in **Figures 6–8**.

In Atlas of visualization, the three stages of topics evolution show a gradual trend of convergence. In 2001–2005, the link intensity among high-frequency keywords was low. The study of E-health was at an exploratory stage, and research direction is scattered as scholars had not yet formed a complete theoretical system. With the emergence of E-health concepts raising academic great interest, scholars considered using network communication technology can greatly improve the quality of medical service and reduce healthcare costs. However, they also doubted whether it determined the actual role, which focused them on the theoretical exploration and the possibility of assessment of E-health [45, 52–54]. In 2006–2010, with the Internet explosively developing and governments attaching more importance to E-health gradually, some medical items based on network technology entered the implementation phase. Scholars tried to evaluate implementation of these projects from visual map aspects. The formation of E-health research prototype has an important connection with the Internet, telemedicine, and care.

2001–2005		2006–2010		2011–2016	
Keywords	**Frequency**	**Keywords**	**Frequency**	**Keywords**	**Frequency**
Telemedicine	39	Telemedicine	163	Internet	440
Internet	37	Internet	151	Care	416
Information	20	Care	92	Telemedicine	416
System	18	Information	73	Randomized controlled trial	323
Care	16	System	71	Intervention	281
Health information	10	Telehealth	59	Technology	278
Quality	10	Quality	51	M-health	251
Education	9	Technology	48	System	247
Information technology	8	Health	47	Telehealth	213
Management	7	Healthcare	47	Health	204

Table 5.
Frequency of keywords in different periods.

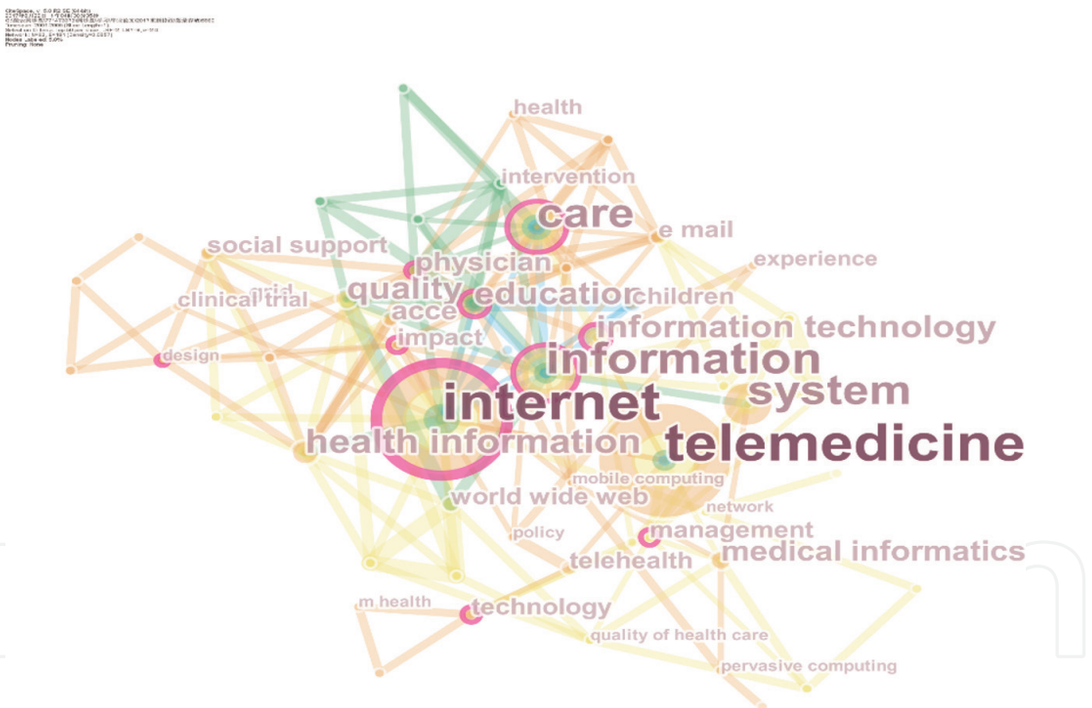

Figure 6.
Visualization of hot topics in 2001–2005.

Scholars thought that the core was the Internet, telemedicine, and care. This provided a point of reference standard for future research directions and reduced misuse and abuse of the concept [44, 55–58]. In 2011–2016, visual maps showed that the core keywords were still the Internet, telemedicine, and care. The map of central tendency is obvious but there had been significant changes. M-health, system management, and randomized controlled trial suddenly broke out, which respectively reflected three characteristics of E-health research: mobile, systematic, and precision. The popularity of mobile and wearable devices greatly accelerated the development process of E-health. Systematic management of the healthcare system can effectively improve the quality of medical services. Precision means

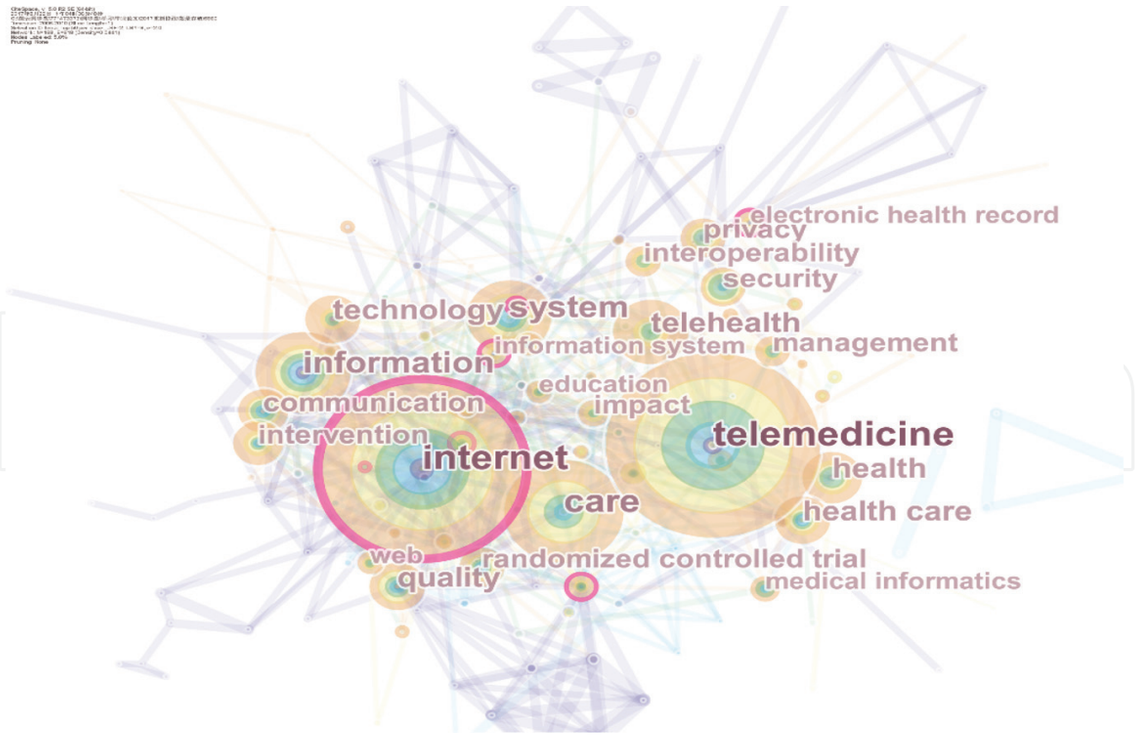

Figure 7.
Visualization of hot topics in 2006–2010.

Figure 8.
Visualization of hot topics in 2011–2016.

researchers used random control experiments and other scientific methods to assess E-health to obtain scientific outputs [59, 60]. In addition, the keyword "big data" began to appear in the knowledge map, indicating that scholars began to study the application of health data technology to promote E-health-related research projects. Application of big data technology can help solve the problem that medical field data volume, various, and grows rapidly to deal with.

The evolution of topics in **Figures 6–8** and **Table 5** can be divided into several classes: continuous topics, emerging topics, and disappearing topics.

Continuous topics: telemedicine, Internet technology, and care are continuous academic focus of research topics. From the point of view of clusters each year, telemedicine, Internet technology, and care focus on different research topics in the last decade. The main direction of telemedicine research is to determine the initial authoritative definition and unify communication standard [61].The aim of mid-term is to assess the effect of the recent literature, and the aim of recent time is to review telemedicine research from the perspective of human society. Internet technology which functioned as support of the development of E-health technology in recent years has undergone tremendous changes. Scholars began to explore the possibility of using a network to pass health information, using network storage to transfer data, and analyzing the advantages and disadvantages of doing so. Then, they gradually changed to focus on the user network information literacy and healthy relationship, which pointed out that information literacy is to enhance users' ability to understand E-health for further development [62]. Electronic health records are the most direct and most important solutions for problems such as how to build a unified specification and how to help different medical workers when they cannot communicate directly. Research focus gradually changed the use of electronic health record information, medical research, and health information so that they maximize the effectiveness of change.

Emerging topics, including health technology, information literacy, and cloud computing, have developed rapidly in a few years. Relatively speaking, mobile health technology and information literacy were at the heart of co-occurrence analysis in recent years. Improvements of the Internet and other information technologies and increasing researchers' knowledge promote the application of E-health. Earlier E-health applications and services are based on computer terminals, but portable monitor cannot do that with the advances in mobile technology in recent years. Thus, the use of mobile devices in health and disease management or monitoring the user's health condition has attracted great concern [63]. In previous studies, researchers found that different users get different abilities to accept the electronic health information, which has significant impact on the development of E-health. Therefore, some scholars have done some research in information literacy [64].

Cloud computing is an emerging technology based on Internet computing in which shared resources are provided on the Internet to other users on demand. Basically, cloud is a synonym for the Internet and composed of clusters of

Frequency	Burst	Author	Year	Title	Journal source
17	9.52	van Gemert-Pijnen JEWC	2011	"A holistic framework to improve the uptake and impact of eHealth technologies"	Journal of Medical Internet Research
15	9.40	Donkin L	2011	"A systematic review of the impact of adherence on the effectiveness of e-therapies"	Journal of Medical Internet Research
20	8.42	Mair FS	2012	"Factors that promote or inhibit the implementation of E-health system: an explanatory systematic review"	Patient Education and Counseling

Table 6.
Document bursting information.

computers working upon distributed systems that provide service in real time over a network. Cloud computing is massively scalable which provides a superior user experience and is characterized by new Internet-driven economics [65]. Once established a unified exchange standard is used to do real-time exchange; the amount of data analyzer will face is enormous, so using cloud computing technologies to process these data would be a satisfactory solution.

Nonetheless, studies regarding information security, privacy, and IT policies had decreased gradually in these three periods.

3.3 Research frontier analysis

The concept of research frontier was introduced by Price. It is used to describe a trend in the field of research. Price uses his own definition of indicators and watches the trends of the article citations according to these indicators [66]. Research frontier is a dynamic concept. The cited articles containing the contents of research front are the knowledge base, and research front is based on these articles. Emergence refers to the rate of change of cited frequency, which can be considered that the content of some emergent literature is discussed form research frontiers. To detect research frontier, we need to analyze the content of citing articles, burst words, and burst literature. CiteSpace provide us a method—Citing articles Cluster, which is the base of identifying clustering-edge [67]. By doing content analysis and clustering, according to Visual analysis results CiteSpace outputted, we can determine the forefront of research in the field of E-health research.

We do co-citation network process, get burst information of literature, and use the burstness at the right of the software to view the strength of emergent literature and emergent time distribution (**Figure 9**).

The first column in **Figure 6** indicates cited emergent literature and strength, representing emergent index. The higher the index is, the more focused cited literature is. The right place in the figure indicates the time literature emergence.

Top 100 References with the Strongest Citation Bursts

References	Year	Strength	Begin	End	2001 - 2016
EYSENBACH G, 2001, J MED INTERNET RES, V3, P, DOI	2001	18.7709	2004	2009	
NORMAN CD, 2006, J MED INTERNET RES, V8, P, DOI	2006	13.2744	2011	2014	
OH H, 2005, J MED INTERNET RES, V7, P	2005	12.8609	2009	2013	
EYSENBACH G, 2005, J MED INTERNET RES, V7, P, DOI	2005	11.7317	2010	2013	
NORMAN CD, 2006, J MED INTERNET RES, V8, P, DOI	2006	10.9302	2011	2012	
FOX S, 2009, SOCIAL LIFE HLTH INF, V, P	2009	10.5232	2010	2012	
EYSENBACH G, 2002, JAMA-J AM MED ASSOC, V287, P2691, DOI	2002	9.9558	2003	2010	
EYSENBACH G, 2008, J MED INTERNET RES, V10, P, DOI	2008	9.7305	2008	2013	
EYSENBACH G, 2011, J MED INTERNET RES, V13, P, DOI	2011	9.5221	2012	2016	
WANTLAND DEAN J, 2004, J MED INTERNET RES, V6, , DOI	2004	9.496	2009	2012	
DONKIN L, 2011, J MED INTERNET RES, V13, P, DOI	2011	9.4054	2013	2016	
BAKER L, 2003, JAMA-J AM MED ASSOC, V289, P2400, DOI	2003	9.3663	2004	2009	
BLACK AD, 2011, PLOS MED, V8, P, DOI	2011	8.6386	2011	2013	
MAIR FS, 2012, B WORLD HEALTH ORGAN, V90, P357, DOI	2012	8.4255	2014	2016	
CHAUDHRY B, 2006, ANN INTERN MED, V144, P742	2006	8.3965	2009	2012	
KREPS GL, 2010, PATIENT EDUC COUNS, V78, P329, DOI	2010	7.9926	2013	2016	
HESSE BW, 2005, ARCH INTERN MED, V165, P2618, DOI	2005	7.9049	2007	2012	
EYSENBACH G, 2002, BRIT MED J, V324, P573, DOI	2002	7.76	2003	2010	
GRIFFITHS F, 2006, J MED INTERNET RES, V8, P, DOI	2006	7.5986	2012	2014	
FOX S, 2011, SOCIAL LIFE HLTH INF, V, P	2011	7.5839	2013	2016	

Figure 9.
Document co-citation bursting statistical chart.

The red part of the document is the period when cited rate raised most rapidly. At this stage, literature based on these knowledge bases is a research frontier. Drawing keywords co-occurrence network map combined with these citing articles can help identify research frontier.

Figure 8 shows the results of literature whose mutation time has been covered at least in the past 3 years and three documents were chosen which have the highest intensity of mutation (**Table 6**). Then we retrieved Web of Science for citing articles and conducted keyword cluster analysis and word frequency statistics. Combined with automatic identification function, we drew a cluster map of article citations, interpreted three key documents' citing document clustering and word frequency comprehensively, and did qualitative analysis of E-health academic field frontier research.

"A holistic framework to improve the uptake and impact of E-health technologies" is an article published by van Gemert-Pijinen Pewc in 2011. He found that a lot of E-health technologies were not appropriate for health services, the effect of which did not match people's expectation. After careful study, he believed that it was because developers ignored the dependencies among technologies, human characteristics, and environmental impact. Thus, he proposed a frame based on many scholars' studies to improve the quality of health services. Under such unity frame's guidance, E-health technology can be combined with the health sector better, but it needs more empirical support [18].

Based on high-frequency statistics and keyword co-occurrence cluster time-zone views (**Figure 10**), we can find high-frequency keywords including "intervention," "randomized controlled trial," "technology," "framework," "physical activity," and "self-management." Researchers use different research methods to compare the actual effects of E-health and then make reasonable predictions about the future of these applications, such as Van's framework [8]. Then the cost of applying emerging technologies in the medical field is reduced. Using a reasonable evaluation

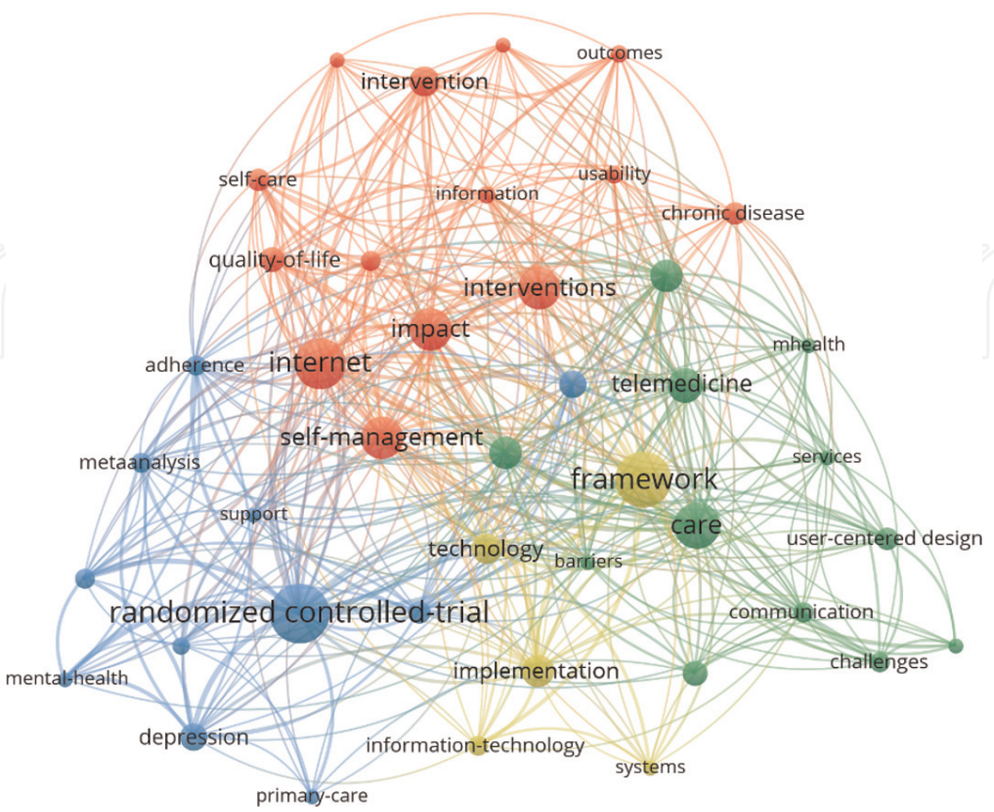

Figure 10.
Keyword-based clustering co-occurrence patterns.

framework to study the cost–benefit of Internet technology in the medical field has become a trend in the future.

Emergent literature of the cluster is "A systematic review of the impact of adherence on the effectiveness of e-therapies." This article reviewed the development of electronic treatment and the impact patient compliance has on treatment effect. It assessed factors that affect patient compliance and listed ways to improve electronic treatment and then concluded that electronic treatment was lacking in effective treatment of electronic protocols. Due to remote treatment, the patient was easier to be influenced by external factors. Further studies are needed to establish consensus compliance measurement program and understand the factors affected by compliance.

According to the high-frequency keywords and keyword co-occurrence clustering results (**Figure 11**), we can find high-frequency keywords named "randomized controlled trial," "adherence," "Internet," "depression," "intervention," "mental health," and "stress management." Scholars have studied methods to enhance patient attachment and loyalty to E-health technologies, including the use of network health technologies and mobile technology to manage the patient's physical and mental health, by increasing the degree of interaction between patients and electronic health technology to improve the patient's sense of e-therapy. In other words, making patients trust in e-therapy is a problem that needed to be solved.

"Factors that promote or inhibit the implementation of E-health system: an explanatory systematic review" is an article aimed to review the literature on the implementation of E-health to identify barriers and facilitators to E-health implementation and outstanding gaps in research on the subject. Mair published this review, and he found some interesting results: (1) work directed at making sense of E-health systems, specifying their purposes and benefits, establishing their value to users, and planning their implementation, (2) factors promoting or inhibiting engagement and participation, (3) effects on roles and responsibilities, (4) risk management, and (5) ways in which implementation processes might be reconfigured by user-produced knowledge [68]. He thought the published literature

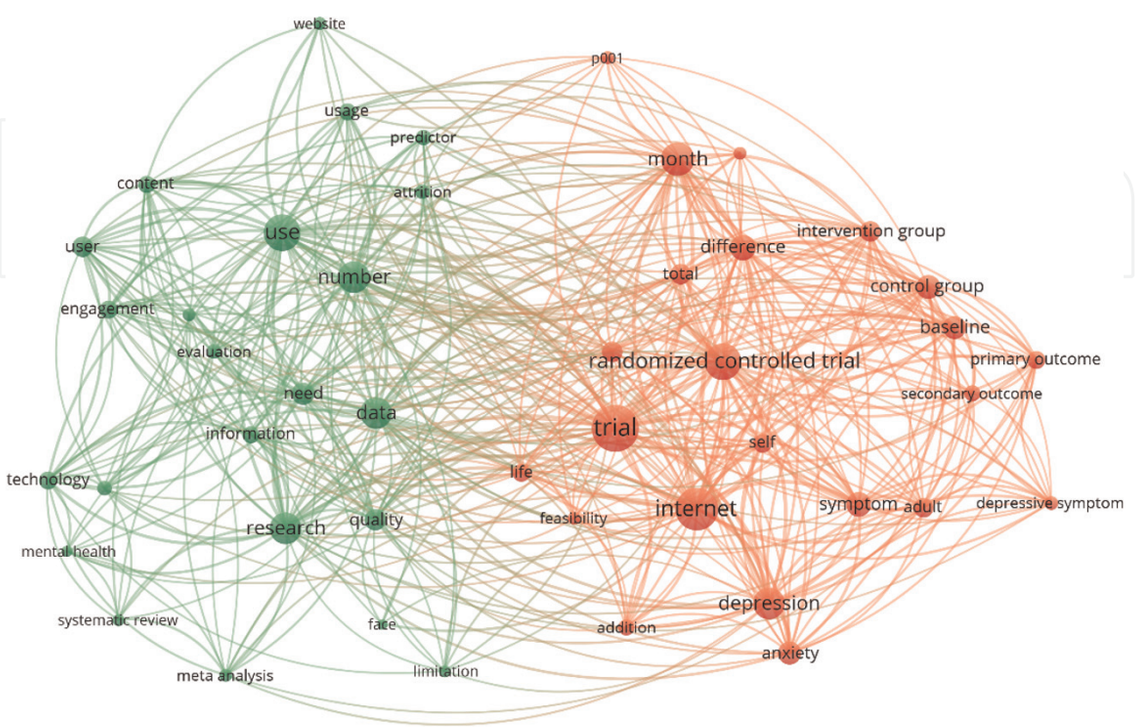

Figure 11.
Keyword-based clustering co-occurrence patterns.

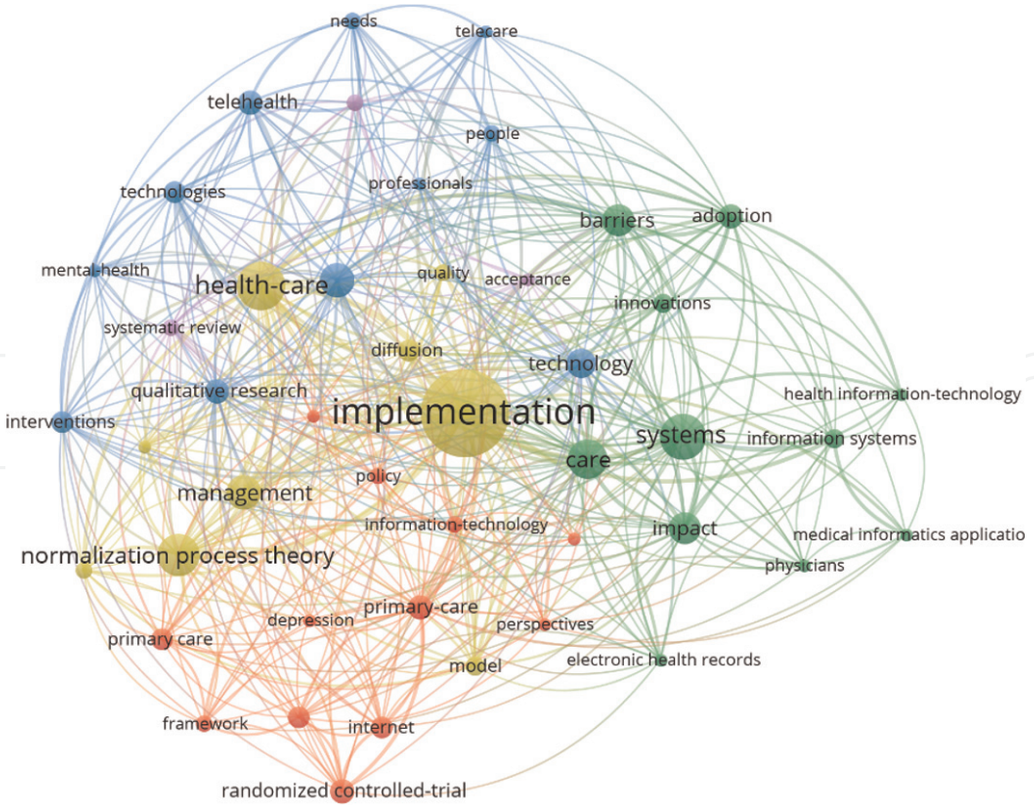

Figure 12.
Keyword-based clustering co-occurrence patterns.

focused on organizational issues and neglected the wider social framework which must be considered when introducing modern technologies.

Implementation, system, healthcare, normalization process theory, qualitative research, meaningful use, and impact are high-frequency keywords. The scholars who cite the article are concerned about the role and responsibility of electronic health in the medical process, risk management, ways to engage with professions, and how to ensure the potential benefits of new technologies (**Figure 12**). Mcevoy Rachel studies using the normalization process theory to research implementation process [69]. Deborah studies the role of digital technologies in self-management [70]. Jane does an organizational analysis of the implementation of telehealth in view of whole systems [71]. Scholars are also concerned about factors having impact on E-health applications, whether they are positive factors or obstacles [72–74]. With the increase of E-health project numbers, these areas deserved more empirical investigation and have been research frontiers, such as the ways to identify and anticipate how E-health services will impact everyday clinical practice, how new E-health services will affect clinical interactions and performance of clinical work, and the effects of different methods of engaging with professionals before and during the implementation of E-health.

3.4 Themes that develop quickly and need to be focused

Combined with literature review, among the research frontiers, E-health business is the core which is based on other articles concerned on commercialization of E-health which is experiencing explosive growth. As it goes, scholars proposed a lot of interesting and innovative project, attracting attention from the government and some companies. It seems that E-health is more cost-effective, efficient, and more convenient, which will substitute the face-to-face treatment in the future. However,

although many of us think E-health is better than traditional treatment methods, governments operating E-health system decreased in number [75]. In view of that, we seek evidence that could help us find the reason. Since research about E-health has come into a new stage, technologies have already reached the demand, and governments are also positive that designing a complete E-health system is a top priority. Unfortunately, no one has satisfied the requirement [76]. A sustainable system need to be operated for a long time, so we need to take cost and profit into consideration. But we found that most of the research or surveys neglected these and they just concentrated on realizing E-health system [77–79]. On this occasion, how to reduce cost and profit will be the center of most scholars' study.

4. Discussion and conclusion

The E-health has been one of continued research focuses on the study of many academics, and the majority of scholars tended to publish papers to show their achievements. Annually published papers have reached 900 in 2015 and 2016, which is a pretty substantial number.

There was a gap between China and some developed countries in the researches of E-health. For instance, the USA, the UK, and Australia were the top three countries that published many articles. The impact of the UK was bigger than the USA according to the centrality index. The published quantity of references in China was not up to 1/6 of the USA and 1/3 of the UK. The time when China became to have centrality was 2004 which was later than most developed countries.

There were many institutions and authors working on this field. Among them, the number of authors who published at least one paper was 3770. On the one hand, it indicated that many scholars paid attention to E-health research from 2001 to 2016. On the other hand, there was great potential to improve the cooperation of authors, because the present relationships were not close which was revealed from the visualization map. Therefore, it is important to improve the allocation ability of resources and form cooperation network, so that we can deepen and improve the development of E-health.

Global E-health research focused on five topics ("Internet technology," "telemedicine," "E-health intervention on healthcare," "health system," and "personal health management"). With the development of information technology, E-health has been absorbing and applying emerging information technologies and applications. Among them, the application of the sophisticated cloud computing technology and big data are typical examples. Cloud computing is an emerging technology for Internet and composed of cluster of computers working upon distributed system that provide service in real time over a network. According to the definition by NIST, cloud computing is "a model that can provide distributed, rapidly provisioned and configurable computing resources" [78, 79]. Big Data in healthcare is concerned with meaningful datasets that are too large, too fast, and too complex for healthcare providers to process and interpret with existing tools. The application of big data technology can help solve the problem that medical field data is volume, various, and it grows too rapidly to deal with.

In addition, E-health has been a research focus of many counties over the world early in the twenty-first century. In detail, Internet, telemedicine, and health care became the focus in 2006. However, m-health, system management, and experimental intervention began to form the new study hot-spots, especially the commercialization of E-health from 2011. Therefore, scholars tended to set up a new E-health system so that we can improve the efficiency of health care and monitor people's health level in the distance and profit by developing E-health business.

This book chapter provides a reference for scholars working on this field and lays a foundation for further research on health IT policy.

5. Limitations

Although findings are based on the above analysis, there are still several potential limitations that may encourage further research efforts. First, this study only focuses on literature indexed by WoS and PubMed. Although WoS emphases paper quality to ensure accurate and meaningful data, it leads to some articles related to E-health not being covered. These will have some impact on the accuracy of research output on E-health.

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