Current and Future Trends of Cloud-based Solutions for Healthcare

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1 Introduction

The adoption of cloud-based computing and accompanying business models has had quite a significant impact on not only the computer economy but also a multitude of other areas. Around 80% of today's industries are estimated to switch to the cloud in the subsequent years, according to [20]. Organizations' that have resource constraints to invest in and stick up in platforms to implement their applications can even use the cloud approach to satisfy their stringent guidelines. IT resources are constantly being applied in various areas of the healthcare industry in today's modern environment [17]. They aid in the improvement of service quality, medical education, and data analysis.

We are entering the era of next-generation healthcare, which encompasses networked, intelligent, and content- aware smart devices, smart homes, and also smart hospitals, among other things [30]. For example, IBM has launched the Smarter Planet initiative, in which companies and ubiquitous, pervasive technology are urged to work across industries to address technological challenges. Personalized management techniques that suit patients' requirements by allowing them to take

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responsibility for their own advanced health informatics and enable collaborative treatment via the innovative use of technologies must also be established to transition to smart healthcare [37]. The cloud compatible system can promote smart healthcare in a variety of ways, including improved emergency response, because cloud interoperable systems enable instant access to patients' lab test data, allowing clinicians to review them right away. Cloud computing in the context of public health enables smart healthcare systems to track e-records that supports medical practices and research such as bio-surveillance, rapid response to medical issues, biological or chemical assaults, and enhanced monitoring of adverse medication effects [19].

The healthcare industry is distinct from other industries in several ways, which can be categorized as discussed here. To begin with, these industries are heavily controlled by government law, which includes patient safety laws. Second, compared to any other industry, the cost of high-risk errors in healthcare is exceptionally expensive, and finally, this manufacturing contributes to the formation of different units, such as hospital administration, labs, and patients. The exceptional privacy of healthcare and the integrity of patients' data makes the data itself sensitive, and any deceptive criteria will have had a big impact, which could result in life or death in some situations. As little more than a result, the implementation of technology can result in this sensitivity of information storage being unhurried [22] [14]. Healthcare is still being structured across the boards, and reform is enabling healthcare information innovation (HIT) to be globalized, and cloud computing, without certain, is a key element of this transformation, [27].

Infrastructure in order to improve quality healthcare and even the innovative impact it will have on other industries, [22]. Cloud businesses usually make every effort to make sure that they are extremely available and scalable. Organizations like those in the healthcare field can also benefit. Further sections of this work are providing a glimpse of the current and future trends of cloud-based solutions for the Healthcare sector. The followed section is focusing upon the research trends based upon the detailed survey of documents published during the last ten year i.e. 2011-2020 on cloud healthcare solutions from the Scopus database. The very next section is focusing on the future trends in this area and the last section is describing the conclusion.

2 Methodology

The data for this study has been collected from the Scopus database. Types of documents, the significance of publishing, subject categories of documents, popular journals, country contributions, most cited papers, title analysis, keyword analysis, and abstract analysis are all part of the study. The AGR (Annual Growth Rate), CAGR (Compound Annual Growth Rate) for documents published over the last ten year i.e., 2011-2020 has also been computed. To illustrate the more common and significant terms, word clouds were generated for the top 100 words in the title, keyword, and abstract from the 4294 published documents during the last ten years. The magnitude of the terms in this word cloud is related to how frequently they appear. The larger the word in the cloud, the higher the frequency of the term. In last, the future trends of cloud computing for healthcare sector are also covered.

3 Results and Trends Analysis

3.1 Year Wise Documents' Publishing Trends

Table 1 depicts the trend in document publishing, addressing the ideas and applications of cloud computing in healthcare over the last ten years, from 2011 to 2020. It can be shown that the number of documents on cloud-based healthcare solutions has steadily increased over the years, rising from 90 documents in 2011 to 801 documents in 2020. There has been an 88.7% growth in the number of documents' publications during this span of years. The average annual number of papers was discovered to be 429.4. This exponential growth of publications' trends in the field of cloud-based solutions for healthcare has a trend line that may be mathematically described as a graph as shown in Fig. 1. The black line in the graph with markers is representing the number of published documents for a specific year. The increasing order of this trend line is representing continuous increase of interest among researchers for e-cloud solutions in medical field.

The number of published documents in this field is represented here, along with the year of release, AGR as annual growth rate, and CAGR as compound annual growth rate. The computed average AGR and CAGR are 18.51 and 27.02, respectively. All of these indicators point to an increasing interest among researchers in using cloud-based solutions for healthcare

3.2 Types of Published Documents

According to the Scopus database, 4294 documents on cloud for healthcare have been published in the previous ten years, from 2011 to July 2020, as shown in Fig. 2. The majority of the articles published in 2011 (46.83 percent) were exclusively published at conferences. Articles type have been submitted to the remaining 37.09 percent of papers. With 5.82 percent of publications, conference-based

Table 1 Year wise publications' trend

Year	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
NOP	90	158	212	305	381	394	489	665	799	801
AGR	–	43%	25%	30%	20%	3%	19%	26%	17%	0%
CAGR	–	32%	33%	36%	33%	28%	27%	28%	27%	24%

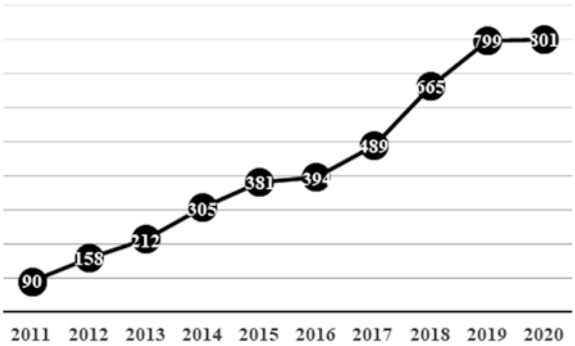

Fig. 1 Year wise publications' growth

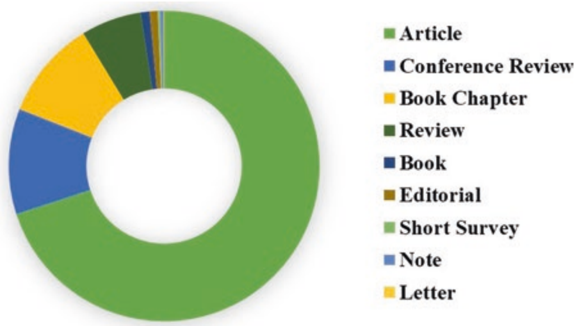

Fig. 2 Document Type on Cloud for Healthcare

reviews are next in line. Book chapters and other review papers account for 5.47 percent of all publications and 3.33 percent, respectively. Books, editorials, note, short surveys, and letters are at the bottom of the list, with a minimum proportion of documents published of 0.48 percent, 0.44 percent, 0.18, 0.11 percent, and 0.046 percent, respectively.

3.3 Countries contributing documents on Cloud in healthcare sector

The Table 2 presented shows top 20 countries which have published documents related to cloud in health care. The data presented in table considers documents published from 2011 to 2020, total count of documents is 4294. From Asia continent, 9 countries are present in the table. India is at the top most position with 1067 number of publications. China has also a significant count of research papers in the field. South Korea and Taiwan has number of publications from 150-200 range. Malaysia, Pakistan, Japan, Egypt and UAE have number of publications in the range of 50-100. From Europe continent, 7 countries are present in the table. United Kingdom has highest number of publications in the Europe continent i.e. 224. Italy

Table 2 Country based classification of documents on cloud in healthcare

Country/Territory	Number of Publications (NOP)
India	1067
United States	680
China	439
United Kingdom	224
Australia	179
South Korea	169
Canada	160
Taiwan	153
Italy	142
Greece	121
Malaysia	99
Germany	98
Pakistan	96
Spain	86
Egypt	74
Japan	72
France	61
Portugal	61
United Arab Emirates	61
Brazil	60

and Greece have number of publications in the range of 100-150. Germany, Spain, France and Portugal have number of publications in the range of 50-100. North America has two countries in the table United States and Canada. Unites States has second highest number of publications i.e. 680 in the table. Canada has number of publications in the range of 150-200. From continent Oceania, Australia is present in the table with number of publications in the range of 150-200. From South America continent Brazil is the part of table with number of publications in the range of 50-100. No country in the is having publications in the range of 0-50.

3.4 Funding Agencies Contributing Documents on Cloud in Healthcare

Funding agencies play a vital role in motivating researchers for bringing innovation and introducing new techniques for enhancing the quality and stability of research work. The table shows the top 20 funding agencies in the field of cloud in healthcare. The highest number of documents are funded by China's 'National Natural Science Foundation'. 'European Commission', 'National Science Foundation, King Saud University', and 'Horizon 2020 Framework Programme' have a number of documents in the range of 50-100. ‘Deanship of Scientific Research’, ‘King Saud University’, ‘National Research Foundation of Korea’, ‘National Institutes of Health’, ‘U.S. Depart- ment of Health and Human Services’, ‘Ministry of Science, ICT and Future Planning’ and ‘Fundamental Research (Table 2)

Funds for the Central Universities’ have a number of documents in the range of 30-40. ‘Ministry of Science and Technology of the People’s Republic of China’, ‘Ministry of Education of the People’s Republic of China’, ‘European Regional Development Fund’, ‘MinistA˜©rio da CiA˜ªncia’, ‘Tecnologia e InovaA˜§A˜£o’ and ‘Engineering and Physical Sciences Research Council’ has a number of documents in the range of 20-29. ‘Conselho Nacional de Desenvolvimento Cientı́fico e Tecnoĺogico’, ‘Ministry of Finance’, ‘Institute for Information and Communications Technology Promotion’ and ‘Government of Canada’ 10-19.

3.5 Top Institutes Contributing Research on Cloud Health Applications

In the previous ten years, a total of 160 institutes around the world have worked and published extensively in the topic of cloud application in health care. Based upon the Scopus database publications the top twenty institutes have been shortlisted are listed in table. it has been observed that out of the top twenty institutes seven of them from India, three from China, two from Saudi Arabia and Greece, along with one from each country of SPAIN, Italy, Morocco, South Korea, Romania, and Qatar. In terms of continents, Asia has fourteen institutes, Europe has five, and Africa has one. According to the ranking of QS World University 2021, four of the top twenty universities, namely King Saud University, Huazhong University of Science and Technology, Qatar University, Kyung Hee University, and King Abdulaziz University, have a ranking of less than 400. With 99 papers, the ‘King Saud University’ of Saudi Arabia took first place in cloud research in health care. India’s Vellore Institute of Technology is next on the list, with 78 publications. University of Piraeus, Anna University, and Instituto de Telecomunicacoes come in third, fourth, and fifth, with 44, 40, and 31 articles, respectively. The remaining universities not published more than 30 papers from last 10 year as per Scopus database (Tables 3 and 4).

3.6 Author Wise Publications’ Trend

Cloud computing for healthcare is a boon that is making its way into every aspect of life to make human jobs easier and faster. Many academicians have concentrated on this topic in the previous 10 years. The top 20 writers on the subject of implementing cloud computing for healthcare applications are listed in Table 5 in descending

Table 3 Top 20 funding agencies contributing documents on cloud in healthcare

Funding Agency	Number of Documents (ND)
“National Natural Science Foundation of China”	157
“European Commission”	83
“National Science Foundation”	69
“King Saud University”	53
“Horizon 2020 Framework Programme”	52
“Deanship of Scientific Research, King Saud University”	43
“National Research Foundation of Korea”	39
“National Institutes of Health”	38
“U.S. Department of Health and Human Services”	35
“Ministry of Science, ICT and Future Planning”	32
“Fundamental Research Funds for the Central Universities”	30
“Ministry of Science and Technology of the People’s Republic of China”	29
“Ministry of Education of the People’s Republic of China”	25
“European Regional Development Fund”	23
“MinistA˜©rio da CiA˜ªncia, Tecnologia e InovaA˜§A˜£o”	22
“Engineering and Physical Sciences Research Council”	20
“Conselho Nacional de Desenvolvimento Cient’ıfico e Tecnol’ogico”	19
“Ministry of Finance”	18
“Institute for Information and Communications Technology” Promotion	17
“Government of Canada”	16

order of their number of publications. The table also contains the h-index, the h-index including self, the total number of documents by the author in Scopus, and total citations of the author. The “h-index,” which refers to the number of publications with the largest number of citations, is an essential factor to examine in the table. The following column, “H-index excluding self,” displays the author’s h-index without the citations made by the author back to their research publications. An author’s total number of publications is always more than or equal to his or her h-index. The number of research articles in the Scopus database related to the author is listed under “Documents in Scopus.” The “Total citation” column shows the total number of citations made by other authors as well as the number of citations made by the author to their own study (also known as self-citation).

Vassilacopoulos, G. from the University of Piraeus, Piraeus, Greece has the highest number of research articles published in this field, his h- index is 14. However, the author in second place Malamateniou, F. with the same affiliation as the first author has an almost similar number of research publications. The author Marwan, M. is third in the list with the lowest H-index as 7. The author with the highest

Table 4 Top 20 Institutes Contributing research on Cloud Healthcare

Institutions	Country	Number of Publications	Rank
"King Saud University"	saudi arabia	99	287
"Vellore Institute of Technology"	india	78	–
"University of Piraeus"	Greece	44	–
"Anna University"	india	40	–
"Instituto de Telecomunicacoes"	SPAIN	31	–
"Chinese Academy of Sciences"	China	30	–
"Huazhong University of Science and Technology"	China	30	396
"Xidian University"	China	28	–
"Guru Nanak Dev University"	india	27	–
"Amity University"	india	27	–
"K L Deemed to be University"	india	27	–
"Qatar University"	Qatar	26	245
"University Politehnica of Bucharest"	Romania	24	–
"Thapar Institute of Engineering & Technology"	india	23	–
"Kyung Hee University"	South Korea	23	236
"King Abdulaziz University"	saudi arabia	23	143
"Universite Chouaib Doukkali"	Morocco	23	–
"Vellore Institute of Technology, Chennai"	india	23	–
"Universit'a degli Studi di Messina"	Italy	22	–
"National Technical University of Athens"	Greece	21	–

H-index of 70, the highest H-index of 68 excluding self, and also the highest citation count of 18417 is Chen, M. ranked fourteenth in the list with 14 published documents in this field. The last author among the list of top 20 authors has published 13 documents in this field. The author with the highest number of documents as 967 in the Scopus is Rodrigues, J.J.P.C. ranked at the tenth place in the list with a total of 18 documents published in this field over the last 10 years.

3.7 Top 100 Title Words' Analysis

Any academic document's major goals are classified by its title. The right title can pique the curiosity of other researchers while also presenting the research aims, breadth, and trials. As a result, the author's vision and the appeal must be reflected in the title. For popular trends and standards, this section evaluates the top 100 most commonly used words in titles of the 4294 research publications recorded in the Scopus database over the last ten years. The 100 most useable terms were determined after extensive filtering and pre-processing, and the Fig. 3 illustrates a word cloud produced based on the frequency of selected words. After deleting duplicate terms from the abstract analysis, title analysis is performed based on the remaining

Table 5 Author Wise Publications' Trend

Author Name	NP	University/Organization	H-index	H-index excluding self	Documents in Scopus	Total citation
Vassilacopoulos, G.	26	"University of Piraeus, Piraeus, Greece"	14	13	102	685
Malamateniou, F.	25	"University of Piraeus, Piraeus, Greece"	10	10	83	467
Marwan, M.	22	"Universite Chouaib Doukkali, El Jadida, Morocco"	7	5	31	118
Sood, S.K.	21	"NationalInstituteofTechnologyKurukshetra, Kurukshetra, India"	23	23	130	2240
Hossain, M.S.	20	"King Saud University, Chair of Smart Cities Technology and Department of Software Engineering, Riyadh, Saudi Arabia"	47	42	318	8530
Kartit, A.	20	"Ecole Nationale des Sciences Appliqúees d'El Jadida, El Jadida, Morocco"	8	7	55	212
Muhammad, G.	20	"King Saud University, Department of Computer Engineering, Riyadh, Saudi Arabi- aKing Saud University, Center of Smart Robotics Research, Riyadh, Saudi Arabia"	44	39	280	5845
Ouahmane, H.	20	"Ecole Nationale des Sciences Appliqúees d'El Jadida, Laboratory of Information Technologies, El Jadida, Morocco"	8	7	49	215
Hassan, M.M.	18	"King Saud University, Department of Information Systems, Riyadh, Saudi Arabia"	38	37	310	5980
Rodrigues, J.J.P.C.	18	"Universidade Federal do Piau'ı, Teresina, Brazil"	63	61	967	16,037
Villari, M.	17	"Universit'adegliStudidiMessina,DipartimentodiScienzeMatematicheeInformatiche, Messina, Italy"	27	25	248	3282

(continued)

Table 5 (continued)

Author Name	NP	University/Organization	H-index	H-index excluding self	Documents in Sco- pus	Total citation
Kumar, N.	15	"ThaparInstituteofEngineering&Technology, Department of Computer Science and Engineering, Patiala, India"	66	60	575	14,588
Celesti, A.	14	"Universit'a degli Studi di Messina, Messina, Italy"	23	20	165	2258
Chen, M.	14	"Huazhong University of Science and Technology, Wuhan, China"	70	68	407	18,417
Costa, C.	14	"Universidade de Aveiro, Aveiro, Portugal"	13	10	131	721
Alamri, A.	13	"King Saud University, Department of Software Engineering, Riyadh, Saudi Arabia"	33	33	184	4284
Deters, R.	13	"University of Saskatchewan, Saskatoon, Canada"	20	19	162	1689
Fazio, M.	13	"Istituto Nazionale di Alta Matematica "F. Severi" (INdAM), Rome, ItalyUniversit'a degli Studi di Messina, Messina, Italy"	22	20	159	1906
Khalil, I.	13	"RMITUniversity,DepartmentofComputer Science and Software Engineering, Melbourne, Australia"	28	25	211	3409
Poulymenopoulou,	13	"European Commission Joint Research Centre, European Commission, Brussels, Belgium"	7	7	29	179

words. According to research, the world of cloud environment deals with the interactive transition from "owning and managing the Information Technology system" to 'accessing and outsourcing Information Technology systems as a service". The main factors that contribute to the evolution of cloud computing are distributed systems and their peripherals, virtualization, web, and utility computing, etc. Clouds can be adapted and utilized for different needs. Therefore, three different service models are available for cloud computing, each of which satisfies a specific business requirement i.e., platform as a Service (SaaS), Infrastructure as a Service (IaaS),

Fig. 3 Title words analysis

and Software as a Service (SaaS). Numerous cloud applications are available in various sectors such as image processing, education activities and assessments, media and entertainment industry, multimedia services, telecommunication, engineering, healthcare, etc. To provide security various cryptographic algorithms, techniques, 7schemes such as certificate-less authenticated encryption with keyword search are used in cloud computing. In the cloud computing arena, fully homomorphic encryption provides the best client data security.

Machine learning is playing a significant role in cloud technology as by incorporating cloud technology; it is possible to gain access to intelligence without requiring advanced knowledge of artificial intelligence or data science. Integrating machine learning into the cloud is called cloud-based machine learning. Although the cloud is used mainly for computing, networking, and storage, through cloud-based machine learning architecture. In the healthcare sector, machine learning has virtually unlimited applications. Machine learning algorithms like classification, regression, etc. on various platforms like Hadoop, Map Reduce are used to analyze and predict diseases.

Healthcare is undergoing a digital transformation and the cloud acts as a middleware for handling dynamic heavily loaded healthcare demands. Healthcare in context of cloud computing refers to the practice of storing, managing, analyzing, monitoring, and processing hospital as well as health clinic-related data on remote servers via the Internet. It is far different from installing a data center with a server's on-site or hosting data on personal devices. Emerging developments in cloud computing technology have big potential and opportunities to improve healthcare services and the living style of humans, according to experts and researchers. Remote healthcare service system comprised of various latest innovations such as Portable medical devices, Cloudlets (cluster of computers that can provide cloud computing services), intelligent terminals (smart mobiles, tablets, etc.), cloud services platform, real-time sensors such as GPS receivers, accelerometer, ECG, body temperature sensor). Severe problems such as Epilepsy seizures (a fatal neurological disorder), hypertension (HTN), etc. can lead to severe complications. With the advancement of the internet of things and machine learning techniques, combined with cloud computing services, healthcare has become a trustworthy sector with powerful verifiable technology to solve many issues. Professionals are also exchanging genetic and medical records through a federated ecosystem, which has resulted in the early interpretation and development of therapies for uncommon diseases.

A pandemic like Covid-19 has undoubtedly thrust cloud computing into the spotlight in healthcare. There are ramifications on all aspects of society due to the pervasive coronavirus disease of the 2019 (COVID-19) pandemic, including the physical, social, and mental well-being of a human. During pandemic times, healthcare simulation software enables transformational healthcare. They also provide fine-grained data verification, authentication, and authorization control over multiple cloud server-based Healthcare Applications.

3.8 Top 100 Abstract Words' Analysis

The authors specify and limit their study goals in the form of an abstract. The abstract summarises and describes the overall flow of the work. Other scholars can recollect and follow the essential techniques of a whole paper from the abstract. To determine current recommendations and trends, this section looked at the top 100 most often used words recovered after pre-processing from abstracts used by various researchers during the last 10 years from the Scopus database. In Figure 4, you can see a cloud of words based on the frequency of matched phrases. According to the studies, the popular term cloud computing deals with the delivery of services that includes databases, networking, software, analytics, prototyping, and intelligence over the internet. Utilizing the technology, the cloud enables the deployment, sharing, and use of data, applications, and resources and eases the lives of users in rural as well as urban locations.

Cloud computing plays a crucial and significant role in various sectors with special interest built around the healthcare sector which helps to increase efficiency. The vast amount of data can be accessed from a multitude of internal sources and can be generated by healthcare providers, including electronic health records (EHRs), pharmacy sales, lab tests, patient treatment, and interaction data. The

Fig. 4 Abstract words analysis

ability to maintain, centralize and manage patient information in digital form has been made possible by advancements in IT in the healthcare sector. According to the research statistics, the traditional paper-based system has been transferred to a digital healthcare system which cannot be possible without the cloud computing platform. Doctors can connect with patients through remote consultations via phone calls or video conferencing. Hence cloud computing is the primary choice for futuristic healthcare professionals.

3.9 Top 100 Keywords' Analysis

Keywords define the overall focus of the research. This section analyses the rest of the words chosen from the top 100 keywords after filtering duplicate words from the top 100 title and top 100 abstract words. The Fig. 5 for top 100 filtered words based on their frequency

The trends show that introduction of new technologies such as Artificial intelligence (AI) robotics and cloud computing is transforming the healthcare practises. Information technology has proved several applications in the field of healthcare such as ECG analysis telemedicine interfaces SaaS (Software as a service) Azure Healthcare

APIs, cloud-based medical image visualization, biometric security, etc. Cloud computing allows these applications to be operated from anywhere. The prediction of clinical disease can be performed using machine learning and AI-based models i.e. smart random forest classifier, SVM, and Naive Bayes. In cloud computing, medical records are typically stored online through an Electronic medical record (EMR system). The Internet of things (IoT) and No SQL database technologies have been implemented to support a new generation of cloud-based PHR(Personal Health Record) services. The use of Software-defined networks is a major contributor to the adoption of IoT as they support efficient resource utilization. Preserving Anonymity in Cloud Environment is an important task because preventive control components make the cloud environment more resilient to attacks by eliminating

Fig. 5 Keywords analysis

vulnerabilities. HIPAA (Health Insurance Portability and Accountability Act) compliance becomes a major issue for healthcare businesses when it comes to security and data breaches. Data security can also be enhanced by using a digital signature and encrypting of ciphertext. In order to develop effective and efficient cloud-based healthcare applications, Hadoop-based healthcare security communication, ECC (Elliptic Curve Cryptography) can be used.

3.10 Most Cited Publications for Cloud in Health Care

Any research study may rely on the work of other researchers and the author must acknowledge the contributions of other authors by citing their work. To ensure academic integrity, research ethics necessitates appropriate citation. The use of systematic citations demonstrates that the work is genuine and reliable. During the last 10 years, the first 20 most cited published papers in cloud for healthcare sector have been presented in this section. Table 6 below shows the list in decreasing order of the matching citation index.

Rahmani et al. [29] suggested a fog computing-based architecture explore the IoT-based healthcare system by building an intelligence intermediate layer in the middle of the cloud and sensor node [29]. It can deal with numerous issues in ubiquitous computing of the distant healthcare center. The gateways of Smart e-Health can support the widespread distribution of healthcare monitoring equipment if these are implemented well. The authors also show UT-GATE, a Smart e-Health Gateway prototype that incorporates some of the higher-level capabilities addressed. This IoT-based healthcare system is also known as Early Warning Score (EWS). Zhang et al. [41] proposed a cloud cyber-system that depends upon big data analytics technologies for a patient- centric healthcare system [41]. The findings of this work suggested that cloud and big data-based technologies data helps to improve the healthcare system performance, allowing users to get benefit from a variety of smart healthcare tools and services. Hossain et al. [18] introduced a HealthIIoT-enabled monitoring system in which data is captured from ECG and other devices used for healthcare systems by using sensors and mobiles [18]. This captured data is accessed with security in order to easy access by healthcare experts from the cloud. The augmentation, watermarking systems are used to avoid the risk of individuality theft or any error related to the clinic from providers of the healthcare system. By installing an ECG health monitoring system that is based upon IoT technology in the cloud environment, the suitability and validity of the system are approved by experiment and simulation results.

Xu et al. [38] suggested a data model for keeping and understanding the IoT data [38]. To maximize the utilization of IoT data, a resource-based IoT data access technique known as UDA-IoT is devised to cap- ture and analyze the IoT data on a global scale. The results reveal that in a dispersed heterogeneous envi- ronment, the resource-based IoT approach is beneficial for data access quickly in the cloud and mobile-based approaches. Farahani et al. [9] described a comprehensive IoT

Table 6 Most cited documents on cloud in healthcare

SN	Authors	Title	Year	Cited by
1	Rahmani A.M. et al.	"Exploiting smart e-Health gateways at the edge of healthcare Internet-of-Things: A fog computing approach"	2018	475
2	Zhang Y. et al.	"Health-CPS: Healthcare cyber-physical system assisted by cloud and big data"	2017	401
3	Hossain M.S. et al.	"Cloud-assisted Industrial Internet of Things (IIoT) - Enabled framework for health monitoring"	2016	391
4	Xu B. et al.	"Ubiquitous data accessing method in iot-based information system for emergency medical services"	2014	374
5	Farahani B. et al.	"Towards fog-driven IoT eHealth: Promises and challenges of IoT in medicine and healthcare"	2018	360
6	Alamri A. et al.	"A survey on sensor-cloud: Architecture, applications, and approaches"	2013	299
7	Esposito C. et al.	"Blockchain: A Panacea for Healthcare Cloud-Based Data Security and Privacy?"	2018	279
8	Doukas C. et al.	"Bringing IoT and cloud computing towards pervasive healthcare"	2012	265
9	Flores M. et al.	"P4 medicine: How systems medicine will transform the healthcare sector and society"	2013	238
10	Chen M. et al.	"Smart Clothing: Connecting Human with Clouds and Big Data for Sustainable Health Monitoring"	2016	230
11	Gia T.N. et al.	"Fog computing in healthcare Internet of Things: A case study on ECG feature extraction"	2015	230
12	Wan J. et al.	"Cloud-Enabled wireless body area networks for pervasive healthcare"	2013	221
13	Yang Z. et al.	"An IoT-cloud Based Wearable ECG Monitoring System for Smart Healthcare"	2016	212
14	Mutlag A.A. et al.	"Enabling technologies for fog computing in healthcare IoT systems"	2019	210
15	Gu L. et al.	"Cost efficient resource management in fog computing supported medical cyber-physical system"	2017	205
16	Aazam M. et al.	"Fog computing micro datacenter based dynamic resource estimation and pricing model for IoT"	2015	203
17	Abbas A. et al.	"A review on the state-of-the-art privacy-preserving approaches in the e-Health clouds"	2014	199
18	Minelli M. et al.	"Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today's Businesses"	2013	197
19	Sultan N. et al.	"Making use of cloud computing for healthcare provision: Opportunities and challenges"	2014	193
20	Liang X. et al.	"Integrating blockchain for data sharing and collaboration in mobile healthcare applications"	2018	185

e-health design that necessitates a shift from clinic to the patient-centric healthcare system in which everyone i.e. hospital, patient, and its services seamlessly connected to one another [9]. To enable the processing of complicated data related to category, potential, and latency and implementation of various tools and applications for healthcare systems, this patient-centric IoT e-health ecosystem requires a device, fog computing, and cloud. Alamri et al. [3] offered a detailed review of sample infrastructure for sensor-cloud works, which provides an understanding of the sensor and cloud platform like the concept, design, and its applications [3]. In recent years the Sensor and Cloud infrastructure has grown in popularity as it provides an open-source, adaptable, and customized platform to execute a variety of intensive care applications. In this study research problems, existing methodologies, as well as prospective research directions are also thoroughly discussed. Esposito et al. [8] also demonstrate the aspects of using Block chain technology to secure the data stored in the cloud for the healthcare system [8]. The authors also discussed the challenges and directions of future work related to the confidentiality of data stored in the healthcare system. Doukas et al. [7] demonstrated a platform based upon Cloud Computing for managing mobile devices and sensors used in healthcare, illustrating how the IoT paradigm may be applied to pervasive healthcare in this fashion [7].

Flores et al. [10] described how systems biology and medicine are now starting to give individualized information based upon the experience of individual's health and disease at cellular, and structure levels to patients, consumers, and clinicians [10]. By tailoring therapy to each person's individual biology and reasons of disease instead of symptoms, this information will drastically reduce the cost of disease care. It will also serve as a springboard for customers to take tangible steps to enhance their health as they notice the effects of their lifestyle choices. Chen et al. [5] presented smart clothing system designs, technologies, and realistic implementation methodologies [5]. Smart clothing collects electrocardiograph impulses, which are utilized for mood monitoring and emotion recognition. The authors also point out some of the design problems and unresolved concerns that must be addressed in order for smart clothing to become ubiquitous for a variety of applications. Gia et al. [12] presented an improved healthcare monitoring framework by utilizing fog computing with smart gateways and data services like mining of data, storage in the distributed system, and services of notification at edge level of networks [12]. The findings show that fog computing has capability to reach over 90% bandwidth utilization with minimum latency at the network's edge. Wan et al., [36] presented a WBAN model and its services for healthcare schemes [36]. This model focused on the efficient routing techniques which save energy, efficient provisioning of resources, and security of the information processed in transferring data over the cloud.

Yang et al. [39] offered an Internet of Things (IoT) a based novel method for ECG monitoring. The data is collected by ECG devices through the monitoring edge and transferred to the IoT cloud [39]. The experimental results demonstrated that the suggested system is reliable in collecting ECG data. Mutlag et al. [26] conducted a thorough review of the impact of fog computing in the realm of IoT-based healthcare systems [26]. Providing inspiration, addressing research limits, and making recommendations to analysts for enhancing this important field of study. All of the research investigated fog computing in the healthcare industry in a systematic manner. All of these experiments show that resource sharing improves fog infrastructure by providing minimum latency, higher scalability, distributed manner processing, improved privacy, fault tolerance. Gu et al. [13] embedded fog technology with medical systems to create a fog computing-enabled Medical cyber-physical system [13]. Medical cyber-physical systems (MCPSs) are an emerging trend in healthcare that enable the interaction between computing elements and medical equipment intelligently. Cloud capitals are frequently used to process the captured data from medical equipment in order to support MCPSs. The proposed system delivers an optimal solution with efficient cost and outperforms a greedy algorithm. Aazam et al. [1] suggested a model that addresses the prediction of resources, customized based prediction of resources, reservation, its cost predictions for new and existing IoT clients [1].

Abbas et al. intend to cover the most up-to-date privacy conserving methods used in e-Health cloud systems [2]. In addition, the privacy-conserving methods are divided into cryptographic and non-cryptographic methods. In addition, the strengths and weaknesses of the proposed methodologies are discussed, as well as certain unresolved difficulties. Minelli et al., [25] reviewed the impact of bid data and analytics related to the business world [25]. This work focused on the strategies to collect the varieties of structured and unstructured data sets for analytic purposes, and data security and its visualization as per business needs. Sultan et al. [34] focused on the evolution of cloud computing and investigate its prospective areas which enhanced the healthcare delivery systems [34]. Liang et al. [21] suggested a novel data sharing healthcare system based on blockchain technology that protects data through a channel-formation scheme which further enhances the identity management characteristics by using membership service of blockchain technology [21]. To manage massive data sets collected and uploaded via mobile devices, a tree-based data processing and the batching mechanism were developed. By utilizing the concept of fog computing, Verma et al. [35] presented a monitoring system that observes the health conditions of patients at remote locations [35]. The services offered by the model are distributed storage access, notification and data mining etc. To process the real-time information of any patient an event-triggered approach is used at the fog layer. The proposed system's utility is boosted by implementing smart decisions on real-time healthcare data.

4 Future Trends of Cloud Computing in Healthcare

Healthcare providers can use cloud computing to cut costs while providing better, more personalized care. It also aids in the development of efficient workflows, resulting in improved service. Parallel to this, cloud computing enables patients to receive faster replies from the healthcare business and to maintain a better track of their health thanks to cloud-based healthcare data [16]. Cloud computing is increasingly being used by healthcare professionals and hospitals around the world to solve problems such as care coordination, data security, and population health [15]. Advanced cloud computing enables medical research innovation by allowing researchers secure access to critical data sets [6]. Cloud computing has also shown to be an effective tool in hospital settings [17]. Artificial intelligence and machine learning techniques, paired with advanced computation, storage, and database capabilities, assist the healthcare business in developing solutions and offering services to patients [40].

Innovative cloud computing technology will help to give fair access to care, allow healthcare providers to make the best decisions, and provide access to important medical research. Following are the latest industry trends of healthcare utilising cloud computing.

Cloud Adoption to Cloud Optimization The focus will shift away from cloud adoption and toward cloud optimization in the future [32]. Almost all healthcare providers are now using a cloud host, and they are now looking for more from their supplier [24]. Cost reductions, multi-cloud management, and data optimization are some of the areas where improvements will be made [33]. Healthcare businesses are expanding vertically and horizontally, and they require a technology partner who can help them outline their requirements. Data that must be stored to comply with governing rules but isn't accessed on a regular basis can be handled differently than data that is constantly aggregated to produce public health trends or research statistics [28]. Based on pricing, term lengths, and access restrictions, a range of cloud-based providers can suit a single healthcare organization's application demands. As companies grow, they will aim to open source all areas of their technology in order to prevent becoming reliant on a single developer.

Data access to Patient's Patients can take charge of their own health via cloud computing [17]. Patients may access their data via the cloud, which motivates patients to actively keep track of their own health decisions.

Telemedicine Capabilities Information and communication technology have recently exploded in popularity as a way to support and provide patient care services outside of medical establishments [31]. Telemedicine technology such as telesurgery, audio/video conferencing, and teleradiology offer a new way for healthcare stake- holders to collaborate and communicate. Telehealth care services allow patients to receive clinical treatment with- out having to leave their homes, and they also allow medical specialists to give their expert opinions in order to cope with complex medical issues [4]. Doctor-patient and doctor-doctor interaction, as well as the transmission and preservation of medical pictures, might all be made possible with cloud-based software.

Drug discovery Drug discovery is the process of finding new therapies and validating their efficacy as well as any potential negative effects. To find prospective medicinal molecules from a trillion conceivable chemical compositions, the method necessitates vast computing capacity. Clouds against Disease, a collaboration between Molplex, Newcastle University, and Microsoft Research, uses cloud technologies to help with medication discovery [11]. Pharmacists may now use the IaaS cloud to acquire computing infrastructure to analyse complex biological datasets. This ground-breaking method has substantially reduced the time and resources required for drug development.

Digital Libraries Medical students, scholars, and doctors rely heavily on libraries to expand their expertise. Furthermore, due to its cost constraints, paper-based medical libraries, especially in undeveloped nations, are unable to fulfill community demand. Cloud-based collections have been viewed as a promising prospect. Libraries can use cloud platform for a variety of services, including storing files, archiving, scripting languages, web hosting, and resource operational processes [16]. The individuals benefit from cloud based educational resources in the following ways:

- The access is provided on demand to both organizations and people.
- The material can be read by multiple people at the same time.
- Scholars don't have to comb through a heap of documents, thus data is available instantly.
- A conceptual query simplifies the search procedure.
- Physicians could become more informed of present healthcare developments and, as a result, enhance their work practices.

Virtual Medical Universities Because of its adaptability and pay-as-you-go nature, cloud computing has also found a home in academia. Amazon, Google, Microsoft, IBM, and HP are among the IT giants that have developed software for both on-campus and off-campus support [23]. This methodology can be used by medical universities to offer online courses, hold seminars, and improve collaboration among academics all around the world. It can assist medical institutions in reaching a larger number of learners at a lower cost and with less effort, particularly in underdeveloped nations. Models of cloud computing service can be used efficiently for academic purposes.

5 Conclusion and Future Aspects

The primary idea of proposed work is to review and to highlight the key component of cloud computing in healthcare sector. Total 4294 Scopus indexed papers on cloud in the health sector from 2001 to 2020 have been reviewed. In this study, a total of 10 different types of documents were reviewed, including 2011 conference publications (48.8%), 1593 articles (37.9%), and 250 conference Review reports (5.82%), which were further classified into 26 core disciplines, with computer science (75.36%) being the most significant contribution discipline in the area of cloud in healthcare. The engineering discipline has (40.63 percent), medicine has (17.07 percent), mathematics has (14.01 percent), and decision sciences with (8.57 percent). are the key contributor fields in the cloud in healthcare. The publication statistics suggest that cloud had the most increase in 2017, with 174 publications, and least in 2020, with only two papers relating to health care will be published. In the previous ten years, cloud research has been conducted in around 112 nations. India has the most publications (1067), while Bhutan, Armenia, Nepal, and other countries have done no research in this subject. The study identifies and analyses the contributions of the top 20 universities, sponsored agencies, and writers in the subject of cloud in the health sector. The current study focused on the core topic of healthcare, but it might be improved by delving deeper into other cloud application areas. The survey only looked at Scopus-indexed databases, but this effort could expand to include other databases in the future, as well as uncovering research opportunities in the cloud.

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