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THE DEVELOPMENT OF ARTIFICIAL INTELLIGENCE IN HEALTH AND MEDICINE: A BIBLIOMETRIC ANALYSIS

VINIT SINGH[1], DR. SAIKAT GOCHHAIT[2]
Symbiosis Institute of Digital and Telecom Management, constituent of Symbiosis International (Deemed University)

Abstract: During recent decades, the growing relevance of Artificial Intelligence (AI) in the field of health and medicine has sought exceptional research interest. AI is already helping us to diagnose diseases more effectively, develop drugs, customize treatments and even edit genes. Artificial Intelligence (AI) research in the field of medicine has been rising briskly. Healthcare AI initiatives, in 2016, have received more funding than AI projects in any other field of the world economy. The goal of this article is to examine and discuss health and medicine published studies related to the area of Artificial Intelligence, published in Peer Review Journals and indexed for the period 2008-2019 in the Web of Science Core Collection. The analysis examines, how the adoption of Artificial Intelligence has opened new avenues for exploration by taking into consideration the publication volume, authors and countries that have collaborated. Also, how digitizing and unifying the medical data would lead to AI finding useful pattern. A worldwide nexus of significant techniques like, involving authors' keywords and content assessment of relevant research literature were underlined, Machine learning, Artificial Neural Network, Artificial intelligence, Deep Learning. This study takes detailed evaluation for emerging AI developments and future general usage prospects.

Keywords: artificial intelligence; health; medicine; machine learning; neural network; deep learning

Introduction

In 1955 John McCarthy first used the Artificial Intelligence (AI). This was described as "the science and engineering of making smart machinery." Concurrently, McCarty and colleagues conducted an AI conference in the U.S. in 1956 to establish a new interdisciplinary research area. Artificial Intelligence is a field of computer science dedicated to the design of intelligent computer systems. This Intelligent Computer System is a system that is comparable to human behavioural intelligence. With AI it is possible to establish similar systems of human thinking ability. Its field of applications include robotics, expert systems, automatic translation programs, and analysers for natural languages, natural language statement production, audio analysers, simulators and problem-solving theorems (Cakir & Otunctemur, 2018).

Although the increasing importance and significance of artificial intelligence (AI) is unquestionable, there is no widely accepted meaning for the term itself. The phrase broadly refers to computing techniques that resemble human cognitive ability-related processes such as reasoning, learning and adaptation, sensory understanding, and engagement. Many AI implementations are currently small, as they can only perform certain tasks or resolve predefined challenges. AI works in different ways, drawing the principles and techniques from mathematics, logic, and biology. In recent years, machine learning has been the most promising form of AI, and is the fundamental approach to several of the applications available. Machine learning allows systems to recognise patterns and deduce their own rules when presented with data, instead of implementing pre-programmed commands (Ramesh et al., 2004).

AI techniques have recently sent massive waves across healthcare, while sparking an ongoing controversy about whether AI doctors can substitute human physicians eventually. We suppose that human physicians will not be substituted in the near future by machines, but AI can absolutely help physicians make much better medical judgment or even replace human decision in certain responsive medical fields. Recent popular AI implementations in healthcare have been accomplished through the expanding collection of resources on healthcare and the massive growth of methods for big data analytics. Based on pertinent issues, groundbreaking AI approaches will uncover relevant information embedded in a broad range of data that can affect clinical decision-making (Bukowski et al., 2019).

Although AI is briskly altering the health perspective, financial aid on the subject has indeed increased significantly in current years, addressing a requirement for detailed research assessment trends and also medical AI advancements. This article addresses the use of bibliometrics analysis to identify research patterns in health and medicine related to AI, in order to identify gaps in literature and organize the concise, on-point presentation of information that would help influence government and help it to progress. Scientometrics uses published literature records to impartially assess the health-related implications of research findings, and provide substantial scientific evidence. It shows how relevant scientific articles evolve nationally and internationally, causing an increase in the count of papers written over time, and signifies the perceptual cooperation of research collaborations on various issues. This paper provides a more comprehensive understanding of literature and future scope through a detailed review, and to propose new avenues for addressing this important concern. Specifically, the paper has analysed the advancement of medical AI development worldwide, and examined trends of areas of research and correlations in this field. (Tran et al., 2019)

Objective

As we are moving on towards automation, it is important to understand how Artificial Intelligence has been transforming the medical landscape throughout the years (Yu et al., 2018). This article intends to provide a comprehensive understanding of papers and data analysis trends, and provides the potential of attempting to solve this serious challenge. In terms of context, the growth of research production in medical AI was assessed and research predictions has been analysed in this field. 5545 records were collected from the Web of Science database within the period 2008 – 2019. The keywords used for this study were ‘artificial intelligence’, ‘health’, and ‘medicine’, machine learning ’,‘ neural network and deep learning. Top 1000 papers for each keyword were selected, based on the number of citations. The database was analysed to make a qualitative and quantitative assessment on research output such as core research areas, growth of publications, productive countries, highly cited publications and authors.

Analysis and Result

Primary Research Areas:

The keywords used for this study were ‘artificial intelligence’,‘health’,‘medicine’, ‘machine learning’, ‘neural network’ and ‘deep learning’.Top 1000 records for every keyword is dependent on the count of citations, for years 2008-2019, that have these keywords in their title have been considered for the analysis. The key research areas for this study has been depicted in the table below:

Research Area	**Record Count**	**Percentage (%)**
Computer Science	*1210*	*21.821*
Engineering	*1092*	*19.693*
Science Technology Other Topics	*568*	*10.243*
Neurosciences Neurology	*557*	*10.045*
General Internal Medicine	*484*	*8.729*
Biochemistry Molecular Biology	308	*5.555*
Chemistry	*294*	*5.302*
Radiology Nuclear Medicine	*197*	*3.553*
Psychology	*192*	*3.463*
Automation Control Systems	*187*	*3.372*
Material Science	*177*	*3.192*

Table 1: *Key research area for the analysis*

Other areas included are Environmental Science Ecology, Energy Fuels, Cell Biology, Physics and 114 others and these constitute 5.032% in total.

Annual Publication Growth Output:

Out of the 5545 records collected from the Web of Science database, it was found that 72.588% (4025 records) of the data were original articles. The reviews made up 26.023% (1443 records) of the total. The collection also includes editorial materials, proceeding papers, meeting abstract, reviews, early access and book chapters.

The graph below represents the number of records published in each year from 2008-2019. The year 2009 is ranked highest with 723 records published (13.03% of the total 5545 records collected), with 2010 and 2008 following with 679 (12.24%) and 669 (12.06%) records respectively. This indicates that in formative years, more research was conducted to understand how Artificial Intelligence can be involved in applications and technologies for our day to day medicine and healthcare needs. Also, work needs to be extended in that area so that in future AI has a significant role to play in health care services and products. AI in the form of machine learning, is the principal requirement behind the advancement of precision medicine.

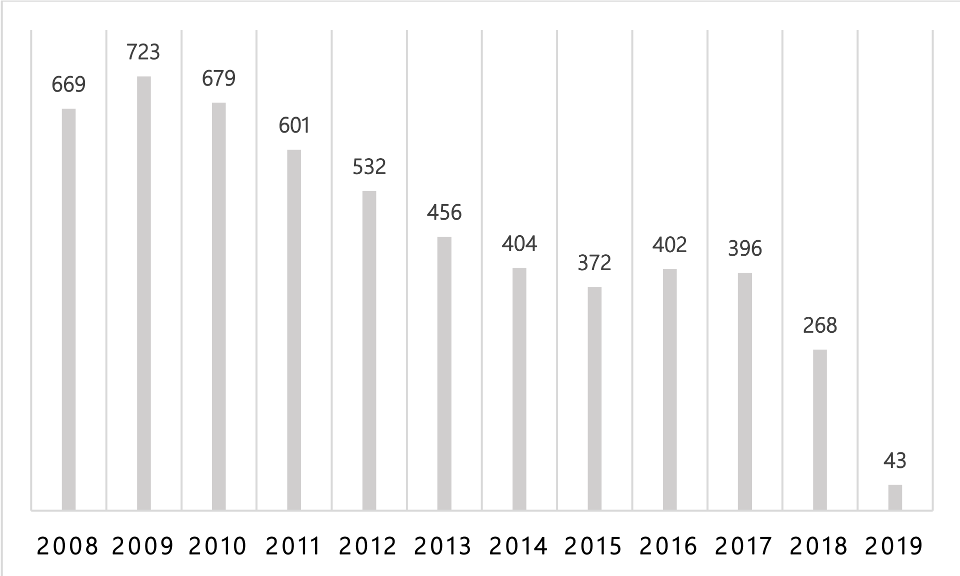

Figure 1: *Number of records published during 2008-2019*

Country-wise analysis of Publications:

The 5545 records collected for this study have been published by 152 countries. According to the analysis, the USA has the highest number of records published, which is 2762records which accounts for 49.811% of the total collected records. The USA is followed by Peoples Republic of China with 852 records (15.365%) and England with 819 records (14.77%).

H-Index: The index of 'h' indicates that a value of h records (under analysis) has been cited h number of times within the selected period (1980-2019). It is an important tool to evaluate a researcher's output in terms of its quality and consistency.

The table shows the top 20 countries with the highest publications. It also includes statistical analysis of the citations of records for each of these countries, that is, the h-index value, the count of citations (including and excluding self-citations), and total cited articles (with and without self-citations). Self-citation refers to the external citations in the record. The publication of countries not mentioned in the table below represents less than 2.522% of the total publications under analysis.

Countries	Number of Publications	Percentage (%)	H Index	Total Citation	Total Citation (Excluding Self Citation)	Count of Articles being Cited	Count of Articles Cited (Excluding Self Citation)
USA	2762	49.811	743	1764600	1760845	1356074	1354765
Peoples R China	852	15.365	280	307203	305941	247185	246769
England	819	14.77	399	597481	596931	521275	521007
Germany	548	9.883	307	337288	336907	302962	302785
Canada	514	9.27	333	455963	455560	397397	397215
Australia	390	7.033	242	269666	269392	240073	239969
France	357	6.456	244	280587	280406	256689	256599
Italy	335	6.037	240	276718	276579	255153	255078
Netherlands	311	5.605	247	245283	245122	224676	224601
Spain	286	5.154	192	185328	185144	170234	170155
Switzerland	266	4.794	206	207888	207706	191102	191023
India	174	3.136	128	123132	123004	111971	111923
Japan	166	2.992	140	159221	159080	146251	146193
Sweden	166	2.992	145	153254	153131	138806	138760
Belgium	164	2.955	142	132908	132845	123693	123658
Singapore	164	2.955	123	96318	96116	83641	83567
South Korea	156	2.811	121	94833	94700	87000	86951
Scotland	147	2.649	128	135104	135002	123969	123925
Denmark	137	2.469	127	141251	141165	128855	128816
Iran	127	2.289	78	63275	63123	55740	55679

Table 2: *Top 20 countries with the highest publications and citation details*

Most Cited Records:

The table represents the top 12 highest cited records published within the 5545 data collected. It also includes the information on the authors of the publications, the country, and the year they were published in.

Further results of the study are as follows:

- According to the analysis of 5545 records, the total number of citations (sum of citations of all records under analysis) is ***2846823***.
- The total number of citations without self-citations (external citations in paper)is 2835037.
- The total count of articles being cited, that have citationsof any records under the analysis is ***1983531.***
- The H-index of all 2495 collected record is ***856.***
- The average citation per article is ***513.4.*** This value is calculated bytotal count of times the citation has been done divided by complete count of records collected.

Articles	Authors	Country	Year	Citations
ImageNet Classification with Deep Convolutional Neural Networks	Krizhevsky, Alex; Sutskever, Ilya; Hinton, Geoffrey E.	USA	2017	23871
Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement	Moher, David; Liberati, Alessandro; Tetzlaff, Jennifer; Altman, Douglas G.	Canada, Italy, England	2010	18408
Global Cancer Statistics, 2012	Torre, Lindsey A.; Bray, Freddie; Siegel, Rebecca L.; Ferlay, Jacques; Lortet-Tieulent, Joannie; Jemal, Ahmedin	USA, France	2015	17149
LIBSVM: A Library for Support Vector Machines	Chang, Chih-Chung; Lin, Chih-Jen	Peoples R China	2011	16478
Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement	Moher, David; Liberati, Alessandro; Tetzlaff, Jennifer; Altman, Douglas G.	Canada, Italy, England	2009	14607
Deep learning	LeCun, Yann; Bengio, Yoshua; Hinton, Geoffrey	USA, Canada	2015	13244
Cancer Statistics, 2017	Siegel, Rebecca L.; Miller, Kimberly D.; Jemal, Ahmedin	USA	2017	12574
Cancer Statistics, 2016	Siegel, Rebecca L.; Miller, Kimberly D.; Jemal, Ahmedin	USA	2016	11195
Scikit-learn: Machine Learning in Python	Pedregosa, Fabian; Varoquaux, Gaeel; Gramfort, Alexandre; Michel, Vincent; Thirion, Bertrand; Grisel, Olivier; Blondel, Mathieu; Prettenhofer, Peter; Weiss, Ron; Dubourg, Vincent; Vanderplas, Jake; Passos, Alexandre; Cournapeau, David; Brucher, Matthieu; Perrot, Matthieu; Duchesnay, Edouard	France, Japan, Germany, England, USA	2011	11167
Cancer Statistics, 2012	Siegel, Rebecca; Naishadham, Deepa; Jemal, Ahmedin	USA	2012	10739
Cancer Statistics, 2010	Jemal, Ahmedin; Siegel, Rebecca; Xu, Jiaquan; Ward, Elizabeth	USA	2010	10587
Cancer statistics, 2013	Siegel, Rebecca; Naishadham, Deepa; Jemal, Ahmedin	USA	2013	10053

Table 3: *Top 12 highly cited publications with details on author, country and year*

Author

The top authors and their publication details have been tabulated and shown below. Lui Y. has the highest number of record publications with 32 record counts, which accounts for 0.577% of the total collected records. His highest cited paper is titled '*Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: a systematic analysis for the Global Burden of Disease Study 2013*'has been cited 3636 times.

Murray C. J. L has the second-highest record with 30 publications (0.541%), and his top cited paper titled '*Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010*' has 6560 citations.

Author	***Record Count***	***Percentage (%)***
Lui Y.	32	0.577
Murray C. J. L	30	0.541
Vos T.	29	0.523
Naghavi M.	26	0.469
Zhang Y.	26	0.469
Lopez A. D.	25	0.451
Huang G. B.	23	0.415
Jemal A.	23	0.415

Lozona R.	22	0.397
Altman D. G.	21	0.379

Table 4: *Authors and record count*

The Coauthor Analysis:

The majority of the papers were the outcome of more than one author's collaborative efforts. Considering that articles in this research area were mostly the products of the coauthorship, one underlying premise stands out here: performing research on medical AI frequently involves comprehensive teamwork. Such an inference further shows the cross - disciplinary linkages between authors and the field's dynamic cross connection. Among the authors in Figure 2, the greatest number of documents were by Douglas G. Altman (orange circle) followed by Yoshua Bengia (Light blue circle). Besides this, there were lesser publications by stand-alone publishers. The absence of segments is an evidence of the lack of strength of the researcher’s correlation corresponding to everyone else. The influence of such connections was assessed in published papers by the frequency with which they occurred together. Their involvement with a certain string of words was based on their cluster formation into different thematic classes. In this cluster an author's role reflects how interlinked and regular their co-occurrence was with other authors. Many scientometric studies have verified this trend, as socially relevant and efficient researchers appear to boost their coauthors' productivity (Leena and Gochhait, 2020).

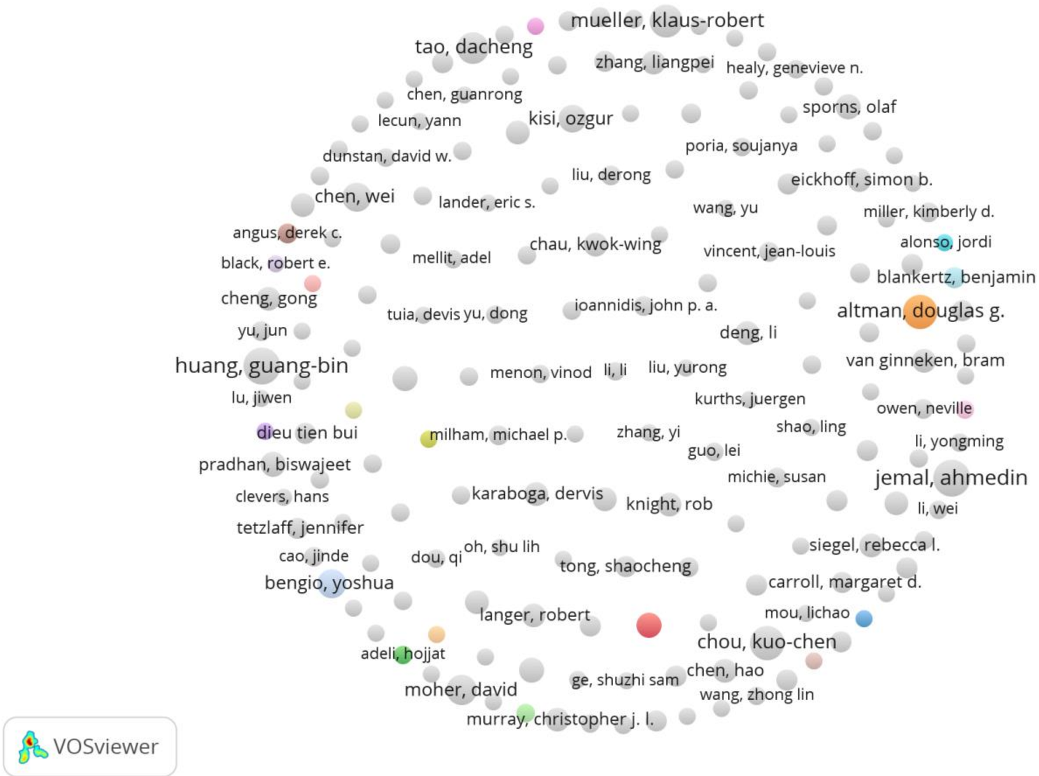

Figure 2: *The global network of coauthors*

Author Keywords:

Cluster 1 (27 items)
- adolescent
- adult
- age
- autism
- autism spectrum disord
- brain
- burden
- child
- cognition
- diabetes
- europe
- memory
- meta analysis
- neural correlate
- obesity
- physical activity
- population
- predictor
- prevalence
- regulation
- relationship
- risk factor
- schizophrenia
- sleep

Cluster 2 (23 items)
- american college
- american heart associati
- american society
- association
- cancer
- clinical application
- clinical practice guidelir
- definition
- epidemiology
- european society
- guideline
- intervention
- management
- part
- patients
- prevention
- recommendation
- report
- septic shock
- society
- therapy
- treatment
- update

Cluster 3 (23 items)
- art
- big data
- biology
- biomedical application
- challenge
- challenges
- current status
- deep learning approach
- drug delivery
- drug discovery
- future
- future direction
- human brain
- human health
- hyperspectral image cla
- lesson
- nanoparticle
- opportunity
- past
- recent advance
- regenerative medicine
- state
- synthesis

Cluster 4 (20 items)
- algorithm
- artificial bee colony
- artificial bee colony algc
- artificial neural network
- cancer statistic
- case study
- china
- class
- classification
- comparative study
- deep convolutional neu
- fault diagnosis
- feature selection
- genetic algorithm
- methodology
- neural network
- optimization
- random forest
- structure
- support vector machine

Cluster 5 (9 items)
- cause
- country
- death
- disease study
- global burden
- injury
- mortality
- systematic analysis
- year

Cluster 6 (8 items)
- convolutional neural ne
- deep
- deep neural network
- detection
- extreme learning machi
- image
- segmentation
- transfer

Figure 3: *The list of authors' keywords.*

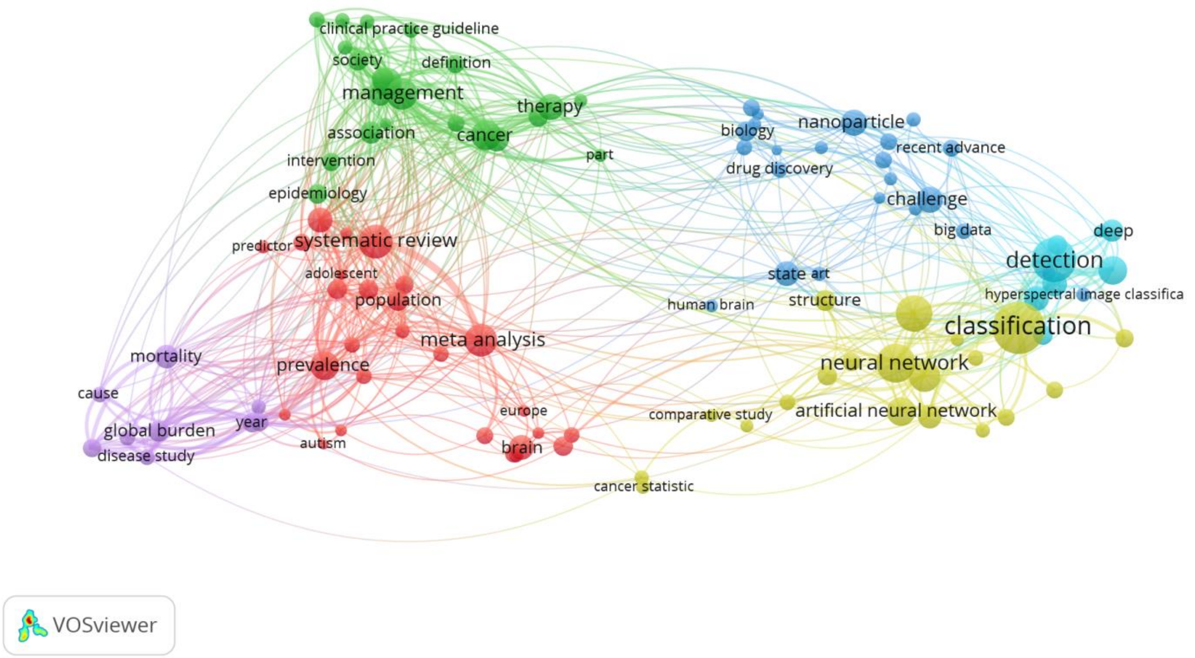

Figure 4:*The co-occurrence of authors' keywords.*

Network visualization map showing the occurrence of author keywords (i.e., keywords listed by the author). The map identified keywords with small occurrences of 25 times (Singh and Gochhait, 2020). Prevalently, keywords of similar colour were mentioned together. Physical activity, obesity, health behaviour, and weight loss, for example, have same colour indicating that these key terms are closely related and usually occur concurrently with each other.(Van Eck and Waltman, 2015)

Figure 3 shows the prominence of 110 key terms which appear on the Web of Science in our search results. The width of the line is an indicator of the relative magnitude of the association among keywords. The significance of those relationships has been determined by the frequency with which they occurred around each other in research papers. Their involvement with a certain group of words focused on clustering them into various thematic groups. Within this cluster, the keyword location signifies how correlated and recurring its complementarily with all the other terms has been.

The 110 keywords were made of 6 clusters having 27, 23, 23, 20, 9 and 8 words. The terms ‘classification’, ‘detection’, ‘meta-analysis’, ‘management’ were commonly occurring words. The visualization map also shows that among the records being analysed cancer detection related articles were quite frequent.

Conclusion

This paper has analysed the progress and various trends of AI in health and medicine over the period 2008-2019.A country-wise analysis was done which depicted that the United States had the highest number of records published with a record count of 2762 articles. The rest of the country’s count was less than 1000 publications. The USA spends a high amount in Artificial Intelligence research and development, which has evolved leading edge, revolutionary life-enhancing innovations, rising technology industry, motivating workers and boosting security interests.

Due to the rapid development of cognitive efficiency and storage capability, the progress of AI research journals has risen significantly, especially over the past 10 years. Such a growth is because of sturdy research output at reputable universities in the U.S., U.K. and Peoples R China. The trio are also responsible for significant AI research, globally. At the regional level, this research indicates that the count of Asian authors being mentioned in the citation among the top twenty papers is marginally less than that of their counterparts in North America. This can be recognized by the late entry of China on the scene. A thorough study would analyse variables impacting the discrepancy between the different sides based on the research outcome and the implications of the references.

One more inference is the factors that contribute to the medical AI research output. Evidential statistics show prominent researchers, as assessed by count of citations and count of quotes in every paper, are mostly those who still dominate a discipline and remain viable for much of their career, as well as devise a methodology that is valid in a broad range of research areas. In other reports this pattern has been witnessed, so that senior and efficient researchers would boost their collaborators' productivity. This article reflects three suggestions in context of the policy ramifications. Firstly, in recent times, increasing common approaches have included AI to collect health data to sustain cancer treatment (Table 3). This can be inferred as 11 out of the top 20 cited papers deal with the research and statistics on cancer. This means AI applications in medication are now becoming progressively instrumental in helping towards diagnosis and treatment of cancer. Secondly, emerging economies must also start investing in medical AI. Especially China and India, which have grown as the key players in the world. Thirdly, the exponential growth of AI could pose fresh problems for defined guidelines. Fourthly, subsequent AI technologies and growth prospects would further focus on machine learning analysis of information from recent treatment testing and ultra-modern imaging methods to forecast therapy feedback, particularly in parts where there is currently a lack of objective diagnostic methods. Finally, to facilitate the implementation and advancement of AI in healthcare and medication, it is crucial to establish multilateral guidelines as well as regulatory requirements to routinely evaluate and validate the credibility of medicinal products in diagnostic situations. The absence of suitable diagnostic samples for simulations of AI development is a serious issue in integrating AI to health and medicine. This is particularly true for labelled datasets, which involve annotation from doctors / medical experts and are therefore very expensive and time-consuming to gather.

In summary, AI is being implemented for a multitude of reasons, particularly in health sector. With technology advancement, AI has the potential to encourage light highlighting major health issues and might be constrained by insufficient medical data and/or the incompetence of the AI to provide some personality attributes, such as empathy. The use of AI elevates certain complications that could be resolved by means of data regulation. A major hurdle for policymakers is executing AI implementation in a manner that is readily available and aligns with public interest.

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