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A scientometric analysis on coronaviruses research (1900–2020): Time for a continuous, cooperative and global approach

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ABSTRACT

Infectious diseases remain a complex, recurring, and challenging public health hazard. Coronaviruses have led to multidimensional consequences on health, mobility, and socio-economic conditions. Despite the significance and magnitude of impact from epidemics to the pandemic, literature is sparse on comprehensive coronaviruses related research performance over time. This study aimed at a scientometric evaluation of coronaviruses related literature including COVID-19. Data related to Coronavirus research was extracted from the Web of Science (WoS). All types of publications (28,846) were included and retrieved. To measure the quantity and quality of the publications, “R-Bibliometrix” package was used for detailed analysis exploring a wide range of indicators. Generally, an increasing trend was observed over time led by the USA and China followed by the United Kingdom, Europe, and few other developed countries. The last two decades contributed around 39.5% of documents while only 06 months of 2020 additionally contributed around 46.5% of total documents. Earlier shorter spikes of increased post epidemic publications followed by decreased productivity were detected in the last 2 decades and showed a lack of continuity-‘a research epidemic following a disease epidemic’. Articles (53.4%) were the most common publication type. Journal of Virology, British Medical Journal (BMJ), and Virology were leading sources while BMJ, and Lancet showed increased contributions recently. Overall, similar trends of top authors were observed in terms of productivity, impact, collaborations, funding sources, and affiliations with few exceptions mainly from affected regions. Top 20 countries contributed >89% of documents suggesting a lack of global efforts. Networking was found to be mainly among developed nations with limited contributions from resource-limited countries perhaps requiring more cooperation. Recent post-COVID publications rise is highest, unprecedented, and rapidly growing. Authors strongly recommend recent COVID-19 pandemic as a call for continuous, more cooperative, and collective global research.

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Introduction

Infectious diseases with accompanying morbidity and mortality remain a major and recurring public health hazard. The growing local, regional, and global health systems might have been accredited to promote and protect the health, but repeated confrontations by existing and emerging infectious diseases is another counter

reality. Among many sources of infection, viruses have evolved with hostile attributes like hard to be identified, diverse ways of transmission, and potential to create epidemics [1,2]. This phenomenon is becoming more obvious in the last two decades throughout the world with threats like; Zika, dengue, Ebola, influenza, Middle East respiratory syndrome (MERS), and severe acute respiratory syndrome (SARS), along with increasing antimicrobial resistance (AMR) [3–6]. Increasing travel and other global connections have added another challenge in preventing these epidemics from converting to pandemics [7].

Coronaviruses (CoVs) are the largest known RNA viruses and until recently, there were six known human coronaviruses [4,8]. A novel coronavirus (SARS-CoV-2/COVID-19), was identified as

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7th in the series in late December 2019 [9,10]. World Health Organization (WHO) declared it as a “public health emergency of international concern” on 30 January 2020 [10]. New coronaviruses seem to appear intermittently in humans, largely due to wide-ranging distribution, high prevalence, genetic diversity, and increasing human-animal links [9,11]. In contrast to previous variants, this new coronavirus pandemic is escalating rapidly [12]. It has encompassed more than 215 countries and territories while its global morbidity and mortality numbers are continuously increasing with >4,893,186 confirmed cases and 323,256 deaths [13,14]. Regardless of extended research efforts, its epidemiological aspects are still showing substantial limitations and this issue may persist in the future [15,16].

Public health outbreaks are becoming even more complex and challenging. Coronaviruses are known threats but recent COVID-19 has caused extraordinary multidimensional consequences on health, mobility, and socio-economic conditions to further complex the situation [3,17]. Planning, systems, and resources have been intensely challenged throughout the world. The consequential outcomes in developed settings are under clouds of uncertainty and even more adverse circumstances can be expected to happen in low- and middle-income countries. The health systems, which are considered as the central defense have also faced severe challenges. Importantly, the diverse transmissibility of coronaviruses, particularly, the recent COVID-19 has led to much higher numbers of health providers being suffered [18,19]. Over the past few years, World Health Organization (WHO) has published blueprint lists of priority diseases that need to be considered as a great public health risk with epidemic potential and need to be prioritized for research and development attention. These lists have also been updated few times and according to the most recent list, coronavirus variants (MERS, SARS, and COVID-19) are amongst the leading and consistent challenges in the last two decades [20].

Any epidemic or pandemic, require verdicts that are usually made with limited understandings, quickly changing, and uncertain circumstances [21]. Arguably, need assessment, planning, and preparedness are vital but context is usually not that simple [22]. A significant role of scientific research in disease control and prevention particularly for viral and other infectious disease epidemics and pandemics is well known and established. Research output and trends lay the solid foundation for virus identification, vaccine development, prevention and control measures, and development of specific drugs [23]. Bibliometrics is a gateway to identify research trends and comprehensively evaluate proceedings and performance indicators widely used for mapping knowledge in different scientific disciplines [24,25]. It identifies the prolific authors, institutions, countries, and other salient indicators involved in research, and examines the evolution of key knowledge areas within related literature. Although few coronaviruses related bibliometric studies have been conducted in the previous decade but mainly on MERS-CoV [26,27], yet there is a lack of enough research on many aspects [28,29]. However, the recent global challenge has led to exceptional, speedy, and growing interests with more contributions focusing only on COVID-19 and the last 2 decades publications [23,30,31]. It is assumed that the issue relates to many regional and global strategic dimensions. Perhaps, it is essential to understand the evolution of scientific knowledge on coronaviruses including COVID-19 to assist in need-based and better-informed decision making [30,32]. More importantly, despite coronaviruses' significance and its magnitude of impact from epidemics to a pandemic, in the last many decades, literature is sparse on comprehensive coronaviruses picture over time in terms of relevant research performance and trends [28]. To fill this knowledge gap, this bibliometric study aimed to evaluate the literature on coronaviruses including COVID-19 using a comprehensive range of indicators.

Materials and methods

Several databases such as; Scopus, EBSCO, Science Direct, ProQuest, PubMed, etc., are accessible for researchers to explore. For this study, Web of Science (WoS) was selected which is generally considered as relatively consistent, standardized [33], and one of the extensively used source for bibliometric analysis in various fields of study [34–37]. Additionally, WoS, a Clarivate Analytics (Formerly Thomson Reuters) maintained platform, is considered as the most precise and comprehensive source for scientific exploration and appraisal with the highest quality indexing [38]. It is also assumed to be more appropriate to the study scope and evaluate the research output of different regions, authors, or organizations [39,40] along with analysis of its results. It encompasses search across salient search databases, disciplines, and document types along with more than one billion searchable cited references [41]. According to the study objective, appropriate criteria, search topics, and keywords were identified from the literature, to retrieve relevant documents.

This study planned to use a wide range of indicators that measure the quantity and quality of the publications and provide a critical picture of national and international contributions to literature related to coronavirus. King Abdul Aziz University (KAU) online library and digital resources were used to access information. This research was conducted using scientometric techniques with efforts made to assure the quality of data at both initial extraction and later processing phases. The research analyzed all published documents specifically focusing on coronavirus. Considering the study scope, to cover all relevant literature and ensuring the sensitivity, the title search was used as carried out in other bibliometric studies [42–45]. The following search strategy was used: TI=(Coronavirus OR Corona virus OR Coronavirus OR COVID OR CoV OR nCoV OR SARS OR severe acute respiratory syndrome OR MERS OR Middle East respiratory syndrome) To avoid bias due to frequent database renewal, all the documents and data were retrieved in a single day on 3rd July 2020. All types of publications (total = 28,846) with no time restriction starting in 1900, were included and retrieved. Further detailed analysis was conducted on all documents with no language limitation. Data was extracted from WoS in plain text files and WoS metrics and data analyzer were also used for few variables including; open-access documents, research areas, and web of science categories. Later bibliometric analysis at the author, source, and document levels were performed using “R-Bibliometrix” package [46]. In Scientometrics, this tool is explicitly used for quantitative and qualitative evaluation of research performance using a comprehensive range of indicators.

The information of retrieved documents was analyzed by various bibliometric matrices such as; journals, publication year, authors, citation reports, countries, institutions, and sources, among the few. Collaborative networks were observed among the top contributors. Top keywords were identified, and a factorial analysis was conducted to explore conceptual and hierarchical relations. Two researchers (AAM and NSB) independently searched and extracted the required information to verify the process.

Results

The total number of documents focused on coronavirus and indexed in WoS was 28,846 (Table 1) from 4821 sources and 140 countries with the USA, China, Italy, and United Kingdom representing around; 20.9%, 18.7%, 6.8% & 5.5% respectively. Around 1/4th of documents reported funding source. Near to 69% of total documents were in the open-access category. The single-authored documents were 19.9%. Regarding the type of publications, the most common publication type in the field of coronavirus research

Table 1
Summary table.

Description	1900–1999	2000–2019	2020 ^a	1900–2020
Documents	4009	11,403	13,434	28,846
Sources (Journals, Books, etc.)	983	2479	2493	4821
Keywords Plus (ID)	3054	12,205	4886	16,402
Author's Keywords (DE)	1257	11,618	10,506	20,888
Average citations per documents	22.31	23.12	4.35	14.27
Authors	6504	30,289	45,332	76,016
Author Appearances	11,642	66,896	67,544	146,082
Authors of single-authored documents	928	1089	2067	4013
Authors of multi-authored documents	5576	29,200	43,265	72,003
Single-authored documents	1190	1621	2927	5738
Documents per Author	0.62	0.38	0.30	0.38
Authors per Document	1.62	2.66	3.37	2.64
Co-Authors per Documents	2.9	5.87	5.03	5.06
Authors' countries	64	115	131	140
Group Authors	–	194	564	710
Research Areas	120	146	141	152
Web of Science categories	171	232	217	249
Organizations	1356	5534	12,225	15,410
Funding Sources	22 (9.8%)	3685 (36.3%)	3987 (22.1%)	7125 (25.8%)
Open access	1121 (27.9%)	7145 (62.6%)	11,611 (86.4%)	19,877 (68.9%)
Collaboration Index	1.98	2.99	4.12	3.12
Document types				
Article	2838 (70.8%)	7790 (68.3%)	4774 (35.5%)	15,402 (53.4%)
Editorial	33 (0.8%)	589 (5.2%)	3683 (27.4%)	4305 (14.9%)
Letter/Correspondence	80 (2%)	493 (4.3%)	3052 (22.7%)	3625 (12.6%)
Reviews	324 (8%)	727 (6.4%)	1167 (8.7%)	2218 (7.7%)
Others	734 (18.3%)	1804 (15.8%)	758 (5.6%)	3296 (11.4%)

^a Data retrieved on 3rd July 2020.

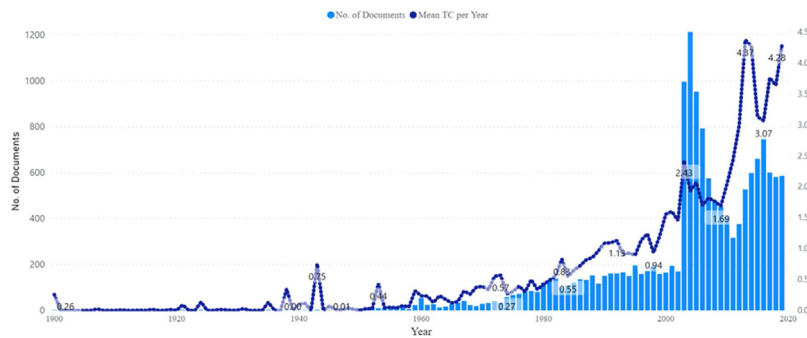


Fig. 1. Year-wise distribution of publications and Mean total citation per year (1900–2019).

was articles representing around 53.4% followed by editorials (14.9%), letters/correspondence (12.6%), and reviews (7.7%).

Fig. 1 shows year wise publications and total citations (except 2020). Maximum documents were found in 2020 (13,434) followed by 2004 (1213). The last two decades (2000–2019) contributed 39.5% of documents while only 6 months of the year 2020 additionally contributed around 46.5% of total documents. Two spikes (2003–2006 and 2013–2016) were observed. Mean citation per year showed an increase in the last 2 decades and an exponential rise from 2009.

Table 2 shows the 20 most productive authors with authors' impact. In total, 35 authors were having ≥ 70 publications while 6 authors having ≥ 130 publications namely; Yuen KY (177), Perlman S (160), Wang Y (154), Drosten C (144), Enjuanes L (131), and Li Y (130). Four authors (Yuen KY, Drosten C, Chan KH, and Peiris JSM) were found to have $\geq 10,000$ total citations (TC). Among these 20 most productive authors; 9 authors showed H-index of ≥ 40 and 13 authors had the starting publication year in the last 20 years (2000–2004) as shown in Table 2.

Most of the articles showed multi authors. In terms of corresponding authors, the top 20 and top 10 countries contributed around 89.7% and 75.1% respectively, led by the USA, China,

Italy, the United Kingdom, and Canada (Table 3). Mostly similar trends were observed for total citations per country. Saudi Arabia, Switzerland, the Netherlands, Belgium, and Australia showed relatively more multi-country publications. Only Saudi Arabia showed more multi-country publications than single country publications.

Fig. 2a shows three field plot for the top 20 most productive countries, authors, and affiliations from 1900 to 2019. Among countries, China, the USA, Germany, Netherlands, and Saudi Arabia showed relatively major author contributions. University of Hong Kong, Chinese Univ Hong Kong, University of Iowa, The University of North Carolina, and Utrecht University were the major contributing affiliations. In the year 2020, China dominated among countries followed by the USA while Huazhong Univ Sci and Technol and Wuhan Univ were the major contributing affiliations as shown in Fig. 2b.

Amongst funding sources, the USA organizations (United States Department of Health Human Services & National Institutes of Health NIH) were leading followed by Chinese and European sources. General Internal Medicine, Virology, and Infectious Diseases were the most common research areas and a similar trend was observed in WoS categories. Top 20 cited documents are shown in Table 4 with global and internal citations. All of these 20 doc-

Table 2
Top 20 most productive Authors and their impact (1900–2020).

Author	Start Year	No. of Publications	No. of Publications as Corresponding Aurthor	No. of Publication as First Author	h-index	TC
PERLMAN S	1987	143	69	12	40	4541
YUEN KY	2003	136	57	0	54	11817
ENJUANES L	1988	130	56	8	46	5328
DROSTEN C	2003	124	38	7	45	10410
BARIC RS	1985	121	53	8	45	5515
WEISS SR	1982	101	50	11	38	3628
ROTTIER PJM	1986	99	30	5	44	6190
MEMISH ZA	2012	91	62	22	36	4928
JIANG SB	2004	85	42	7	33	3025
LIU DX	1991	84	59	10	30	2031
WANG Y	1992	81	23	15	16	841
MAKINO S	1985	79	43	12	39	3648
WOO PCY	2004	79	23	26	36	5660
HOLMES KV	1977	77	27	8	38	4545
CHAN KH	2003	75	1	5	46	8546
HAAGMANS BL	1997	75	29	7	33	4298
LAI MMC	1982	75	13	12	44	5063
SAIF LJ	1986	73	35	10	32	2299
TALBOT PJ	1985	73	31	7	29	1936
LAU SKP	2004	70	10	23	34	5057

Table 3
Top 20 countries with Corresponding authors.

Country	Documents	% Contribution	SCP	MCP	MCP Ratio	Country Appearances
USA	5581	23.30	4573	1008	0.1806	32,716
China	4931	20.60	4035	896	0.1817	33,415
Italy	1557	6.50	1266	291	0.1869	10,602
United Kingdom	1436	6.00	1043	393	0.2737	8604
Canada	932	3.89	710	222	0.2382	6510
Germany	886	3.70	600	286	0.3228	6104
France	828	3.46	642	186	0.2246	6347
Japan	676	2.82	583	93	0.1376	3897
India	603	2.52	500	103	0.1708	3092
Korea	559	2.33	489	70	0.1252	4061
Australia	461	1.93	298	163	0.3536	3302
Singapore	456	1.90	385	71	0.1557	2700
Spain	411	1.72	327	84	0.2044	2854
Netherlands	400	1.67	254	146	0.365	2669
Brazil	374	1.56	310	64	0.1711	2422
Saudi Arabia	350	1.46	168	182	0.52	3541
Iran	325	1.36	266	59	0.1815	2254
Turkey	262	1.09	239	23	0.0878	1396
Switzerland	231	0.97	135	96	0.4156	1929
Belgium	219	0.92	141	78	0.3562	1207

CA-Corresponding author, SCP: Single or Intra-country publication, MCP: Multiple or Inter-country publication.

uments were published in the last 2 decades (2003–2020) while among them 6 (30%) in the year 2020. Sources; ‘New Engl J Med’ followed by ‘Lancet’, and ‘Science’ were major contributors to these highly cited documents.

Twenty-eight (28) sources showed ≥ 100 publications with ‘Journal of Virology’ as the leading source having 832 documents followed by ‘British Medical Journal (BMJ)’ and ‘Virology’ with 516 and 353 documents respectively. Fig. 3a shows the year-wise growth of the top 10 productive sources mostly with increased contributions in recent decades. In total, 20,888 Author’s Keywords and 16,402 Keywords Plus (ID) were used. COVID 19, Coronavirus,

SARS COV2, SARS, Pandemic, MERS COV, and SARS COV, and were the most frequent keywords.

Fig. 3b shows the Conceptual structure word map of keywords, using a multi-dimensional scaling approach among leading 25 key terms and a minimum of 20 documents with three possible clusters. The upper (green) cluster is a combination of 06 keywords related to China, novel coronavirus, and public health-related terms. The upper cluster (blue) 05 words are mainly related to MERS, spike protein, and transmission. The lower cluster (pink) embodies 14 keywords with pandemic, infection, pneumonia, treatment, and mainly SARS and COVID-19 related terms.

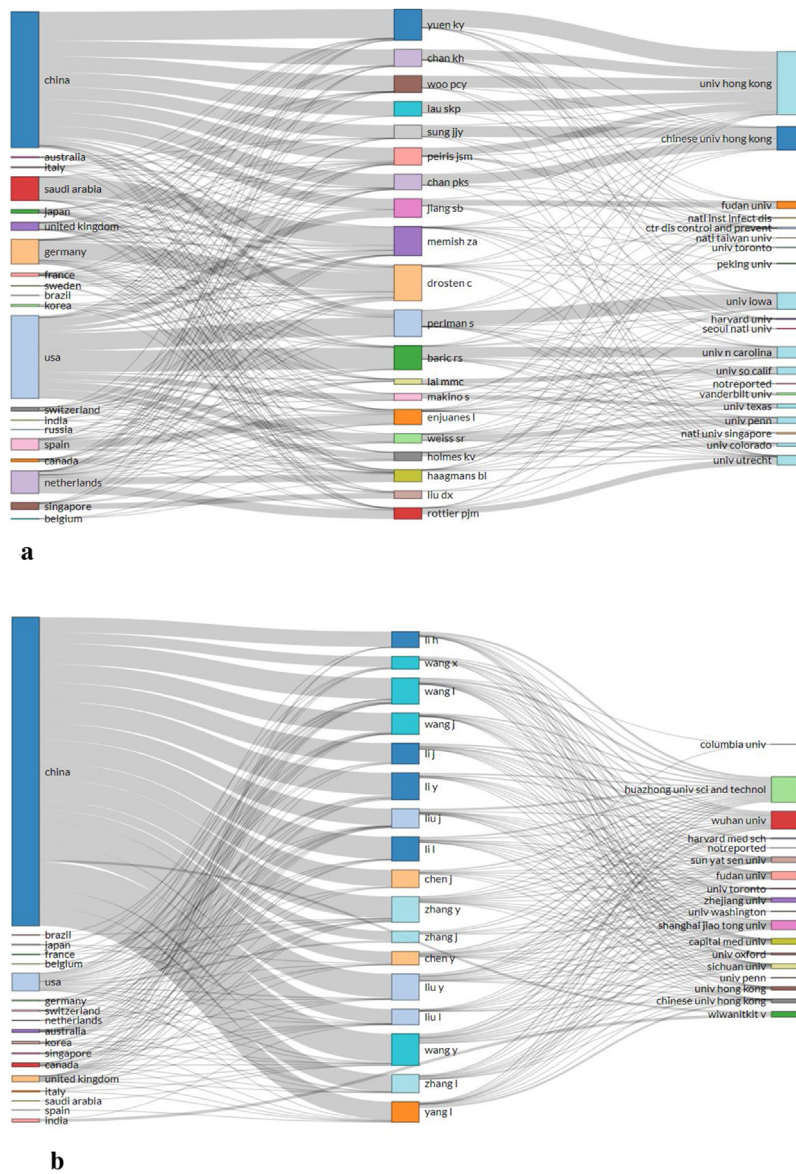


Fig. 2. (a) Three Field Plot for the top 20 most productive countries, authors and affiliations (1900–2019). (b) Three Field Plot for the top 20 most productive countries, authors and affiliations (2020).

Discussion

The evidence generated by quality research in health care and its publications has provided solid support over the last few decades to combat health and disease-related challenges. Considering the needed comprehensive exploration of Coronaviruses over time, this study provides a reference and a summarized macroscopic overview on Coronavirus related research output using WoS as a source of data and bibliometrics platform.

This study reported, generally increasing trend of productivity over the years, starting in 1900 with the start of an initial rising trend in the late 1960s that possibly followed the initial phase of human coronavirus encounter [47]. The first many decades were relatively less productive as more than 85% of documents were published in the last 2 decades (2000–2020) with three sudden spikes showing increased research productivity. The number of documents started to suddenly, increase from 2003 to 2006 followed by a decrease till the second rise from 2013 to 2016 which also followed a decline in numbers until 2019. This finding was also observed in other relevant studies that found spikes in the same;

post SARS and post MERS (2012–2014) time in the last 2 decades [26,27,31] along with the recent post-COVID-19 rise [23,30] which is relatively much higher than previous spikes that reflects its overall impact on researchers around the world [28,31]. It was reported that the first 6 months of 2020 have already contributed around 46.5% of the total publications and this trend is still likely to expand rapidly. This study finding suggests more, timely and credible evidence-based support but also highlights the reactionary research trend with short and above normal reaction in productivity that may be portrayed as ‘a research epidemic following a disease epidemic’. Considering the evidence and history, it might be vital to make relevant research a continuous priority, and plan to allocate the required resources to better prepare for the future.

In general, articles were the leading type representing more than half of the total documents followed by editorials, letters/correspondence, and reviews. To date, articles are less in proportion during the recent post-COVID-19 period but not in numbers. This trend can be expected to rise soon with the potentially highest number of articles in a single year and early access options. Editorials, on the other hand, were of relatively higher numbers

Table 4
Top 20 highly cited documents.

Document	Year	Internal citations ^a	Global citations ^a	TC per Year
Huang CL, 2020, Lancet	2020	2132	2191	2190
Ksiazek TG, 2003, New Engl J Med	2003	1532	2009	112
Drosten C, 2003, New Engl J Med	2003	1506	1911	106
Zaki AM, 2012, New Engl J Med	2012	1231	1539	171
Peiris JSM, 2003, Lancet-a	2003	1252	1534	85
Rota PA, 2003, Science	2003	1239	1523	85
Marra MA, 2003, Science	2003	1056	1313	73
Wang DW, 2020, Jama-J Am Med Assoc	2020	1270	1302	1300
Chen NS, 2020, Lancet	2020	1183	1205	1200
Li WH, 2003, Nature	2003	903	1200	67
Guan W, 2020, New Engl J Med	2020	1167	1188	1190
Zhu N, 2020, New Engl J Med	2020	1125	1158	1160
Lee N, 2003, New Engl J Med	2003	861	1079	60
Koren S, 2017, Genome Res	2017	2	1053	263
Guerin C, 2013, New Engl J Med	2013	72	1048	131
Guan Y, 2003, Science	2003	673	978	54
Peiris JSM, 2003, Lancet	2003	790	961	53
Li WD, 2005, Science	2005	504	926	58
Marçais G, 2011, Bioinformatics	2011	74	866	87
Zhou P, 2020, Nature	2020	811	846	846

^a TC: Total Citations, Internal Citations (within selected documents), Global Citations (in Web of Science).

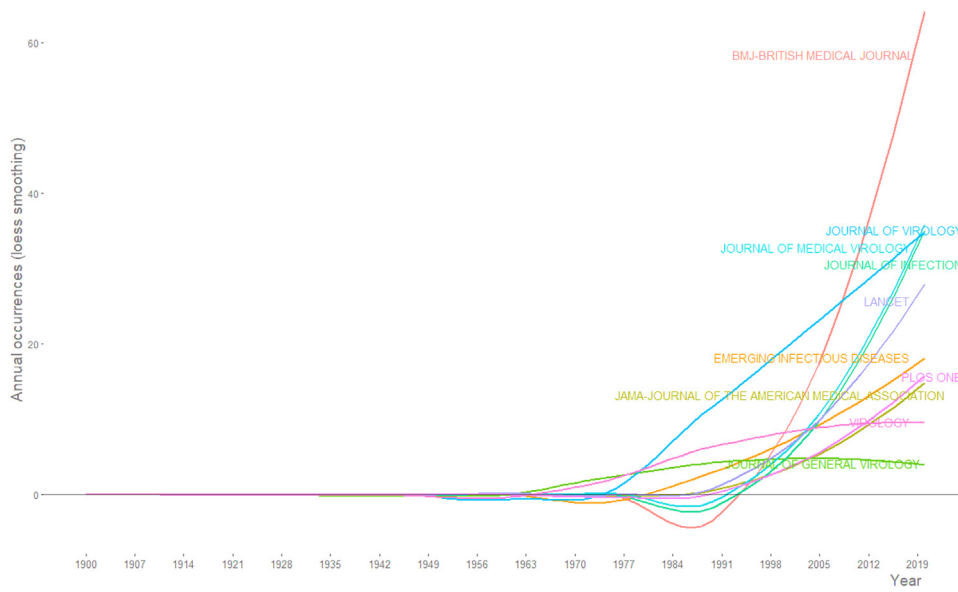
recently, which shows experts' interests and contributions. English was the single most dominating language. Open access documents were around 69% of the total and generally an increasing trend over time with a maximum in the last two decades. Notably, post-COVID-19 documents showed around 86% of documents in the open-access category. Interestingly, news items were found to be relatively much higher in post-COVID-19 times. These findings show the priority and significance of research along with its appropriate dissemination and accessibility. More documents reported any funding support in the last two decades than any other period. This trend is still not obvious in post-COVID (22%) but needs to be considered and followed. Documents were found to be related to a wide range of research areas and WOSC that show scientific contributions from basic and observational to interventional dimensions. General Internal Medicine, Virology, and Infectious Diseases were the most common research areas and a similar trend was observed in WoS categories. Besides, relatively higher contributions from 'Medicine General Internal', 'Public Environmental Occupational Health', and 'Infectious Diseases' were found in 2020 (post-COVID-19) possibly indicating the recent more efforts at preventive and clinical dimensions. However, Veterinary Sciences, Biochemistry Molecular Biology, Immunology, and Microbiology showed a decline in recent decades.

Among countries, the USA & China were the main contributors collectively around 40% of global productivity. This finding was also observed in relevant studies focusing on coronaviruses; MERS [26], last 2 decades [31], and recent COVID-19 [23,30]. A similar trend was found in terms of leading funding sources that can be the additional associated aspect of dominance along with other resourceful settings factors. Other main contributing countries were the United Kingdom, European countries, Canada, and Australia. Moreover, Saudi Arabia, Japan, India, Korea, Iran, and Brazil were also found to be decent contributors from their respective regions. Interestingly, study findings suggest that the top 10 and 20 countries were contributing 75.1% and 89.7% respectively in terms of correspondences. Most of the countries outside the USA and Europe showed a rise in publication numbers in the last 2 decades and were among the affected areas, that possibly led to a reaction from researchers. China was a dominant contributor in the recent short post COVID-19 phase.

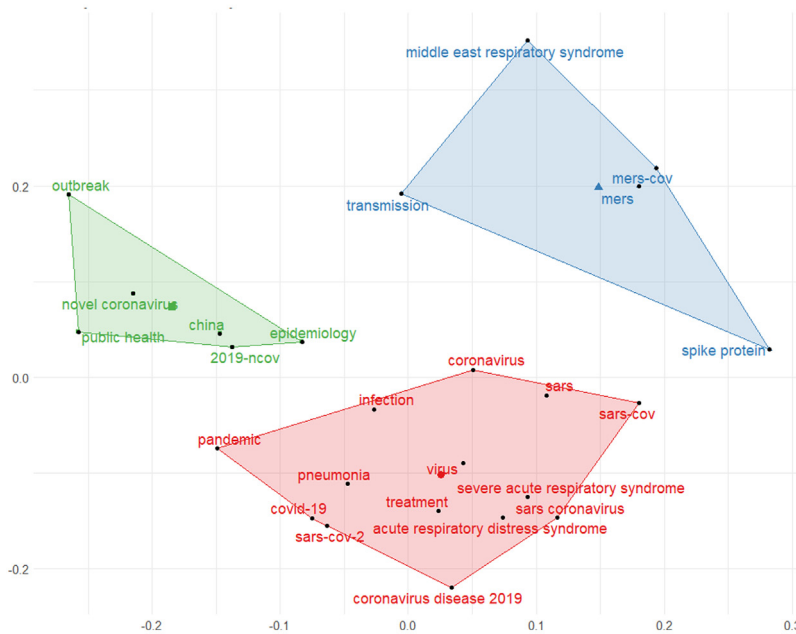
Similar trends were observed in topmost productive authors and their collaborative network, corresponding authors, and total citations per country. Yuen KY (China), Perlman S (USA), Wang Y

(China), Drosten C (Germany), and Enjuanes L (Spain) were the most productive authors. However, authors from China (Yuen KY), and European countries (Drosten C/Germany and Enjuanes L/Spain) were relatively better performers in terms of authors' impact. Saudi Arabia, Japan, India, Korea, were also decent contributors for corresponding authors other than the USA, China, and European countries. Another finding was related to the authors' starting year of relevant publications, that showed 13 out of 20 top productive authors started their publications in the last 2 decades and were mostly from the USA, China, and Europe. Few authors like Yuen KY, Perlman S, Enjuanes L, and Drosten C, remain consistent, established, and leading contributors over the decades, a finding also acknowledged in relevant literature [31]. On the other hand, most of the top authors from China started publications during 2000–2004 and contributed more in the last 2 decades while 'Memish ZA' from Saudi Arabia was also found to be a consistent contributor with decent impact. In 2020 (post-COVID-19), trends were similar except more contributions were found from China than the USA. Additionally, it can be assumed that the emerging authors in the recent decade may continue to lead in the coming decades and might also be considered for continuous support in the future. This finding might change in the near future with more contributions from other parts of the world considering the recent pandemic being started in China and then effecting other countries around the world. Surprisingly, among the top 20 authors, the proportion of documents as corresponding or first author was mostly < 50% except for a few authors. Surprisingly, Yuen KY (China) showed no publication as the first author while 'Memish ZA' (Saudi Arabia) and WOO PCY (China), showed relatively more contributions as a corresponding and/or a first author.

The number of authors, as well as co-authors per document, showed a generally increasing trend over time. Single authored documents were also showing a similar increasing trend. Remarkably, only a few months of post-COVID-19 time has already contributed more than half of the total single-author documents, also showing the possible higher contributive interests of experts. The proportion of multi-country publications generally showed a decline in the last two decades. Notably, Saudi Arabia was the only country with more multi-country publications than single country publications. Other European countries also showed relatively more multi-country publications than the leaders USA and China. Leading authors were found to be representing leading affiliations from leading countries and among them, interconnections



a



b

Fig. 3. (a) Year-wise growth of 10 most productive sources. (b) Conceptual structure word map of keywords.

and collaborative links were also observed. Mostly intra-country collaborations were observed. The University of Hong Kong was found to be the leading affiliation followed by the University of Iowa, The University of North Carolina, and Utrecht University.

This study findings suggest the trend of research and publication contributions from resourceful as well as few affected countries over time. It showed an obvious increase in research output growth from China in the post-COVID-19 time and the last 2 decades. Contributions from effected countries of low- and middle-income settings were relatively less at both numbers and impact levels. Probably, this insufficient cooperation between resourceful and

resource-limited settings has the potential to deal with local to regional epidemics but might face limitations with the pandemic challenges. Ignoring the urgency of needed support of research and evidence-based data generation in resource-limited settings might lead to a heavy collective burden and impact uncertainties in the future. Perhaps these research trends of pandemic issues suggest relevant stakeholders prioritize and deal in a continuous, collective, and global way. Providing platforms using this approach might better prepare to deal with existing and possibly future such challenges.

The Journal of Virology was the leading source followed by BMJ and Virology. Besides, the Journal of Virology, Virology, and Journal of General Virology were relatively consistent contributors over decades but with relatively declining trends in the last 2 decades. Most of the sources showed increased post-COVID-19 productivity. However, among those few top-ranked/high IF journals such as 'BMJ' 'Lancet' along with 'Journal of Infection' and 'Journal of Medical Virology' showed marked increasing contributions. Top 20 highly cited documents were published in the last 2 decades from 2003 to 2020 and were published in mainly top-ranked journals including New Engl. J Med, Lancet, and Science among a few others. Probably, these findings imply that future developments in the field may be published in the journals. Similar trends were also found in another relevant study focusing on the last 2 decades [31]. Interestingly, 6 documents (30%) of these highly cited documents were from 2020 and were not led by top authors. This finding suggests that probably new authors and groups, as well as certain post-COVID-19 publications, show the potential to have more impact in future coronavirus related research.

Coronavirus, COVID 19, MERS COV, SARS COV, and SARS were the most frequent keywords. This finding also validates the comprehensive search strategy. Study findings showed credible research efforts over the years with diverse and complex coverage of topics from basics and observational to interventional and therapeutics, also observed in another study [48]. The conceptual structure word map of keywords showed three possible clusters not only supports this finding but also possibly aligns with reactional research findings after epidemics as well as the prioritized research areas identified by WHO [20].

Though the study aimed to explore literature and purposefully 'WoS' was selected as a source yet relying on one database (WoS) can be considered as one of the study limitations. Consequently, considering the dynamic and rapidly changing data and other limitations of the data source might have affected some findings. Additionally, only top performers in a few categories were explored for networking due to limited technical and equipment resources, but the exhaustive investigation in the future is recommended.

Conclusion

This study provides a comprehensive reference and a summarized macroscopic overview of coronavirus related scholarly research evolution and performance over time. Generally, an increasing trend in terms of numbers of publications was observed over the years, led by the USA, China, United Kingdom, Europe, and a few other developed countries and the majority published in the last 2 decades. Around 6 months of 2020 has already contributed more than 46% of total documents and this trend is still expanding. Notably, reactionary shorter spikes of increased post epidemic publications followed by decreased productivity in the last 2 decades were detected, showing a lack of continuity. The recent post-COVID rise is highest and unprecedented. Overall, similar trends of top authors were observed in terms of productivity, impact, total citations, international collaborations, organizational affiliations, and funding sources with few exceptions. Top 20 countries contributed >89% of documents suggesting the lack of global efforts. Networking was found to be mainly among developed nations perhaps requiring more cooperation with low- and middle-income countries. Authors strongly recommend recent COVID-19 pandemic as a call for continuous, more cooperative, and collective global research.

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Ethical approval

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Competing interests

None declared.

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Appendix A. Supplementary data

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