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Literature Review

Coronavirus Research in Pre-Pandemic- A Scientometric View

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Abstract

Coronaviruses are a kind of common virus that causes an infection in the nose, sinuses, or upper throat. Most coronaviruses aren't dangerous. Coronaviruses are a group of viruses that have a halo, or crown-like (corona) appearance when viewed under an electron microscope. The new coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus and doctors call it as a respiratory tract infection. Though Coronavirus is the hot topic of the day, it has been in prevalence long back in 1940's and has seven versions till today. This investigation is a scientometric analysis of literature on coronavirus using the data downloaded from SCOPUS. The results of the study show that the trend of research in Coronavirus from 1972 to 2000 productivity is very low and there is no significant growth in the research publications. The previous versions of corona virus did not have much impact on the publishing activity before the pandemic (Covid-19). After 2019, there is sudden hike and as on May 2020, the total publications in this field is 1269 (1014 - Open access; 255 - Others) which is more than 5 times as that of 2019.

Keywords: *Coronavirus Research; COVID-19*

Introduction

Coronaviruses are a kind of common virus that causes an infection in the nose, sinuses, or upper throat. Most coronaviruses aren't dangerous. Coronaviruses are a group of viruses that have a halo, or crown-like (corona) appearance when viewed under an electron microscope. Coronaviruses are named for their crown-like appearance due to surface spikes and are categorized into four major groups, Alphacoronavirus, Betacoronavirus, Gammacoronavirus and Deltacoronavirus [1]. The new coronavirus disease (COVID-19) is an infectious disease caused by a newly discovered coronavirus and doctors call it as a respiratory tract infection. It can affect the upper respiratory tract (sinuses, nose, and throat) or lower respiratory tract (windpipe and lungs). It spreads the same way like other coronaviruse, mainly through person-to-person contact. Infections range from mild to serious. Though Coronavirus is the hot topic of the day, it has been in prevalence long back in 1940's and has seven versions till today.

Name	Year Discovered	HCoV Genera	Natural Host
HCoV-229E	1966	α-Coronaviruses	Bats
HCoV-OC43	1967	β-Coronaviruses	Cattle
SARS-CoV	2003	β-Coronaviruses	Palm civets
HCoV-NL63	2004	α- Coronaviruses	Palm civets, bats
HCoV-HKU1	2005	β-Coronaviruses	Mice
MERS-CoV	2012	β-Coronaviruses	Bats, camels
SARS-CoV2	2019	β-Coronaviruses	Bats

During the prevalence of each version of coronavirus, there had been researches conducted to find out a cure for it, This paper is a scientometric analysis of literature on coronavirus using the data downloaded from SCOPUS.

Literature Review

J Lou S., *et al*. [2] analysed the coronavirus research literature available in Pubmed database during the period from 2020 January 14 to 2020 February 29. It was found that China is the main contributor (123 out of 183 papers analysed). Chahrour M., *et al*. [3] analysed publications and found that the articles came from 39 different countries, constituting 24% of all affected countries. China produced the greatest number of publications with 377 publications (67%). With respect to continental research activity, Asian countries had the highest research activity with 434 original publications (77%). In terms of publications per million persons (PPMPs), Singapore had the highest number of publications with 1.069 PPMPs

Shri Ram [4] analysed the biliographic data obtained from the SCOPUS database using the keyword "Coronavirus" in the article title, abstract, or keywords. During the period 1970 - 2019, a total of 18,003 publications were retrieved. The results of the study showed that USA was the highest productive country followed by China.

A search in the SCOPUS database using a keyword in the article title, abstract, or keywords will result in many publications that are included in many subject areas. Hence it is felt that a study on data downloaded with author assigned keyword limiting the result to bio-medical subject areas will be more appropriate.

Methods

Data for the study was downloaded from SCOPUS database using author assigned key words limiting the resulting dataset to bio-medical subjects alone. To make the study more comprehensive, those papers published in 2020 were excluded. The search string is "AUTHKEY(coronavirus) AND (EXCLUDE (PUBYEAR,2020)) AND (EXCLUDE (SUBJAREA,"CHEM") OR EXCLUDE (SUBJAREA,"ENVI") OR EXCLUDE (SUBJAREA,"MULT") OR EXCLUDE (SUBJAREA,"ENGI") OR EXCLUDE (SUBJAREA,"CENG") OR EXCLUDE (SUBJAREA,"MATH") OR EXCLUDE (SUBJAREA,"PHYS") OR EXCLUDE (SUBJAREA,"COMP") OR EXCLUDE (SUBJAREA,"MATE") OR EXCLUDE (SUBJAREA,"NURS") OR EXCLUDE (SUBJAREA,"HEAL") OR EXCLUDE (SUBJAREA,"ARTS") OR EXCLUDE (SUBJAREA,"SOCI") OR EXCLUDE (SUBJAREA,"DENT") OR EXCLUDE (SUBJAREA,"EART") OR EXCLUDE (SUBJAREA,"ENER") OR EXCLUDE (SUBJAREA,"PSYC") OR EXCLUDE (SUBJAREA,"BUSI"))".

The downloaded data in the RIS format is converted into MS Access database and necessary tables are generated using query language.

Objectives

This investigation is a pioneering effort to answer the following research questions:

- RQ1: What is the trend of coronavirus research from the date of its identification.
- RQ2: What is the authorship pattern in coronavirus research in open access and other publications.
- RQ3: What are the countries involved in coronavirus research.
- RQ4: Is there any relationship exist between the referencing pattern and citation pattern of open access publications and other publications.
- RQ5: Is there any underlying policy in research productivity by various countries of the world.

Analysis and Discussion

Year	Publications	Percent	Relative Growth Rate
1970	1	0.33	
1972	1	0.33	0.00
1975	1	0.33	0.00
1976	1	0.33	0.00
1978	3	0.98	2.00
1979	3	0.98	0.00
1980	4	1.31	0.33
1981	3	0.98	-0.25
1982	1	0.33	-0.67
1983	4	1.31	3.00
1984	4	1.31	0.00
1985	9	2.95	1.25
1986	13	4.26	0.44
1987	16	5.25	0.23
1988	13	4.26	-0.19
1989	18	5.90	0.38
1990	18	5.90	0.00
1991	13	4.26	-0.28
1992	10	3.28	-0.23
1993	11	3.61	0.10
1994	15	4.92	0.36
1995	15	4.92	0.00
1996	25	8.20	0.67
1997	25	8.20	0.00
1998	22	7.21	-0.12
1999	28	9.18	0.27
2000	28	9.18	0.00
	305	100.00	9.89

Table 1: *Trend of coronavirus research before millennium.*

The milestones in the identification of Coronavirus are

1. Identified in 1940's and first reported in 1960's
2. Second type of coV reported in 1970's
3. Third type of COV, SARS COV was reported in China in 2002
4. The fourth COV was reported in 2003
5. The fifth COV (HCOU1) was reported in 2005
6. Sixth COV (MERS-COV) was reported in 2012
7. Now the seventh one is identified as COVID-19 in 2019.

Cheever., *et al*. (1949) and Bailey., *et al*. (1949) identified the prevalence of Coronavirus in 1940s, the presence of the virus was reported in 1960's. It took nearly 40 years to identify the third type of corona virus in 2002. This is being attested by the trend of research in Coronavirus from 1972 to 2000. Here it is observed that the research productivity is very low and there is no significant growth in the research publications.

Year	Publications	Percent	Relative growth rate
2001	32	1.33	
2002	25	1.04	-0.22
2003	93	3.86	2.72
2004	135	5.60	0.45
2005	150	6.22	0.11
2006	113	4.69	-0.25
2007	128	5.31	0.13
2008	132	5.47	0.03
2009	87	3.61	-0.34
2010	90	3.73	0.03
2011	77	3.19	-0.14
2012	97	4.02	0.26
2013	129	5.35	0.33
2014	175	7.26	0.36
2015	188	7.80	0.07
2016	177	7.34	-0.06
2017	194	8.05	0.10
2018	179	7.42	-0.08
2019	210	8.71	0.17
	2411	100.00	10.48

Table 2: *Trend of coronavirus research after millennium.*

Within two years i.e. 2001 and 2002 the third and fourth type of coronavirus was identified. This is an evidence of the prevalence of coronavirus during this period and this may be the reason why there is a sudden growth in research productivity in 2003 and 2004. This growth continues till the year 2005. The significance of this growth is that, till 2004 the growth rate is more while it is less in the year 2007. The reason may be that the cure for the third and fourth type of coronavirus might have been found out in 2005. Immediately, this virus has taken another form COV (HCOU1) in 2005 and this evidences the fact that there is decline in research in 2006 and had gained momentum in 2007 and 2008. Till 2012 there is no considerable variation in coronavirus research and again the year 2012 marks the identification of sixth type of coronavirus (MERS-COV). From 2013 onwards, till 2017 there is a gradual growth in publication and there is decline in 2018. Now the year 2019 is remarkable since the seventh type of Corona virus is identified as CoV-19. As on May 2020, the total publications in this field is 1269 (1014 - Open access; 255 - Others) which is more than 5 times as that of 2019. The inference is that there is a correlation between the time of identification of a virus and the research on that specific virus.

Type of Publications	No of Papers	Percent
Open Access	1802	66.35
Others	914	33.65
	2716	100.00

Table 3: *Type of publications covered.*

With Elsevier's partnership with Impactstory [5], a nonprofit that creates online tools to make science more open and reusable, researchers are now able to discover millions of peer-reviewed open access (OA) articles with ease. Among the total publications downloaded 66.35 per cent are open access papers and the rest are categorized as others by SCOPUSs.

	Others		Open Access publications	
No of authors	Publications	Percent	Publications	Percent
Anonymous	0	0	1	0.06
1	93	10.18	83	4.61
2	132	14.44	193	10.71
3	145	15.86	218	12.10
4	136	14.88	194	10.77
5	105	11.49	212	11.76
6	81	8.86	176	9.77
7	66	7.22	159	8.82
8	37	4.05	119	6.60
9	37	4.05	115	6.38
10	29	3.17	86	4.77
More than 10 authors	53	5.80	246	13.65
	914	100.00	1802	100.00

Table 4: *Authorship pattern.*

The results of Björk B and Solomon D [6] indicate that OA journals indexed in Web of Science and/or Scopus are approaching the same scientific impact and quality as subscription journals, particularly in biomedicine and for journals funded by article processing charges. Table 4 shows the pattern of authorship in coronavirus related publications. It is found that the percentage of single authored and joint authored publications in open access publications is 4.61 and 10.71 while it is 10.18 and 14.44 respectively in other publications. That is, those research papers with four and less than four authors is less in open access papers than that of other publications. Similarly, the percentage of publications with more than four authors is 61.75 while it is 44.64 in case of other publications. That is, the number of authors per paper is more in case of open access publications than the category of others. This contradicts the views of Björk B and Solomon D (2012).

	Open Access publications		Others	
No of References	**Publications**	**Percent**	**Publications**	**Percent**
0	31	1.72	27	2.95
1	1	0.06	4	0.44
2	3	0.17	1	0.11
3	2	0.11	4	0.44
4	4	0.22	10	1.09
5	10	0.55	3	0.33
6	6	0.33	12	1.31
7	12	0.67	12	1.31
8	14	0.78	11	1.20
9	14	0.78	17	1.86
10	27	1.50	16	1.75
11-20	303	16.81	219	23.96
21-30	348	19.31	208	22.76
31-40	306	16.98	127	13.89
41-50	216	11.99	71	7.77
51-60	144	7.99	49	5.36
61-70	84	4.66	22	2.41
71-80	74	4.11	22	2.41
81-90	39	2.16	11	1.20
91-100	39	2.16	8	0.88
100 ++	125	6.94	60	6.56
	1802	100.00	914	100.00

Table 5: *Distribution by no of references.*

In open access publications, the highest per cent of publications (19.31%) have 21 - 30 references while the highest per cent (23.96%) of publications in other papers have 11 - 20 references. Here, it is to be noted that 87.20 per cent of the other publications have more than 10 references while this category is 93.12 per cent in case of open access publications. This shows that the per capita of references per paper is higher in case of open access publications.

	Others		Open Access	
No of Citations	Publications	Percent	Publications	Percent
0	171	18.71	121	6.71
1	68	7.44	120	6.66
2	48	5.25	94	5.22
3	47	5.14	85	4.72
4	39	4.27	83	4.61
5	26	2.84	70	3.88
6	32	3.50	60	3.33
7	33	3.61	67	3.72
8	21	2.30	71	3.94
9	23	2.52	64	3.55
10	14	1.53	46	2.55
10-20	158	17.29	381	21.14
21-30	81	8.86	201	11.15
31-40	46	5.03	104	5.77
41-50	33	3.61	73	4.05
51-60	17	1.86	49	2.72
61-70	11	1.20	39	2.16
71-80	7	0.77	21	1.17
81-90	8	0.88	15	0.83
91-100	1	0.11	10	0.55
100++	30	3.28	28	1.55
	914	100.00	1802	100.00

Table 6: *Distribution by no of citations.*

Table 6 shows that 6.71 per cent of open access publications do not have any citation at all while this is more in case of others (18.71%). Also 51.09 per cent of the open access publications have more than 10 citations while this is 42.89 per cent in case of other publications. This shows that open access publications more citation count than other publications. Perhaps, the reason may be that open access publications have more visibility than other publications.

S. No	Journal	Publications	Country
1.	*Virology*	151	Netherlands
2.	*Virus Research*	137	Netherlands
3.	*Journal of Virological Methods*	82	Netherlands
4.	*Viruses*	79	Switzerland
5.	*Veterinary Microbiology*	74	Netherlands
6.	*Journal of Virology*	66	United States
7.	*Avian Diseases*	48	United States
8.	*Antiviral Research*	47	Netherlands
9.	*Journal of Medical Virology*	47	United States
10.	*Biochemical and Biophysical Research Communications*	38	Netherlands

Table 7: *High productive journals (Top 10 ranked).*

Literature on coronavirus research are published in 679 journals that are indexed in SCOPUS database. The top 10 journals are listed in table 7. Virology is the highly preferred journal followed by Virus research. Among the top ten ranked journal in coronavirus research, six are from Netherlands and the remaining four are from United States of America,

	Open Access		Subscription based		Overall	
Zone	**No of Journals**	**No of Publications**	**No of Journals**	**No of Publications**	**No of Journals**	**No of Publications**
Zone 1	9	598	18	305	14	909
Zone 2	48	597	89	306	90	904
Zone 3	360	607	279	305	505	903
	417	1802	386	916	609	2716

Table 8: *Validation of Bradford's law.*

Bradford (1948) stated that if scientific journals are arranged in order of their decreasing productivity of articles on a given subject, they may be divided into a nucleus of periodicals more particularly devoted to the subject, and several 'groups' or 'zones' containing the same number of articles as the nucleus, where the number of periodicals in the nucleus and succeeding zones will be 1:n:n2 where 'n' is amultiplier [7]. This law when applied to the literature on coronavirus research shows that the overall journals listing is in the ratio of 14:90:505=1:6.43:36.07 which is more or less similar to $1:n:n^2$ and hence confines with Bradford's law. This law when applied to the open access publications show that the ratio is 9:48:360=1:5.33:40. When applied to others, the ratio is 18:89:279=1:4.94:15.5. The data do not confine with Bradford's law when applied to open access and publications belonging to the category others.

S. No	Country	Publications	Percent
1.	United States	664	24.45
2.	China	305	11.23
3.	Japan	125	4.60
4.	United Kingdom	122	4.49
5.	South Korea	116	4.27
6.	Germany	114	4.20
7.	Hong Kong	114	4.20
8.	France	112	4.12
9.	Italy	99	3.65
10.	Canada	88	3.24
11.	Taiwan	85	3.13
12.	Saudi Arabia	83	3.06
13.	Netherlands	77	2.84
14.	Brazil	71	2.61
15.	Spain	65	2.39
16.	Singapore	45	1.66
17.	Australia	43	1.58
18.	India	40	1.47
19.	Sweden	28	1.03

Table 9: *High productive countries.*

The publications on coronavirus are published by scholars from 71 countries, of which, USA (24.45%) ranks first followed by China (11.23%) and Japan (4.60%). India is in the 18th place. 11.78 percent of the publications are by scholars from 53 countries.

Author Name	Total Count	Country
Buonavoglia, C.	40	Italy
Enjuanes, L.	39	Spain
Al-Tawfiq, J.A.	37	Saudi Arabia
Decaro, N.	37	Italy
Memish, Z.A.	36	Saudi Arabia
Elia, G.	29	Italy
Martella, V.	29	Italy
Talbot, P.J.	29	Canada
Britton, P.	27	United Kingdom
Wang, H.	27	China
Wang, Y.	27	China

Table 10: *High prolific authors.*

Table 10 lists the high productive authors. Buonavoglia, C from Italy ranks first followed by Enjuanes, L from Spain and Al-Tawfiq, J.A from Saudi Arabia. Here it is to be noted that most of the high productive authors are from Italy.

Author	Count	Positional Share	Rank	PI
Al-Tawfiq, J.A.	37	15.06	3	0.41
Pratelli, A.	20	7.49	30	0.37
Decaro, N.	37	6.96	4	0.19
Memish, Z.A.	36	6.30	5	0.18
Takano, T.	18	5.71	37	0.32
BrandÃ£o, P.E.	25	5.37	16	0.21
Saif, L.J.	23	5.11	20	0.22
Fung, T.S.	11	4.62	98	0.42
Lau, S.K.P.	24	4.25	19	0.18
Liu, D.X.	25	3.97	17	0.16
Li, Y.	25	3.95	15	0.16
Elia, G.	29	3.89	6	0.13

Table 11: *Ranking of authors by positional share method.*

Kumaravel (2012) [8] has proposed a method for ranking of authors according to their positional value in the naming of authors. The formula is

PV (Positional value) = PV = (n - p +1) / n∑ where n∑ = 1+2+3+ … n and PV ≤ 1

Prepotency index PI = PV/N where N is the number of publications by an author. The PI ranges from 0 to 1. A PI value for an author which is nearer to 1 shows that he is very much involved in research productivity. Al-Tawfiq, J.A. has published 37 papers while Fung, T.S. has published 11 papers. Their prepotence index are 0.41 and 0.42 respectively showing that Fung has more involvement in the research than Al-Tawfiq.

S. No	Country/Territory	Publications	Affected*	Mortality**
	China	440	84 464	4 644
	United States	280	1 340 098	80695
	Italy	146	222 104	33 106
	United Kingdom	82	229 709	33 186
	India	53	78 003	2 549
	Canada	47	71 486	5209
	France	40	138 609	27 029
	Germany	40	172 239	7 723
	Australia	39	6 975	98
	Iran	37	112 725	6783
	Spain	35	228 691	27 104
	South Korea	34	10 991	260
	Hong Kong	33	NA	Na
	Brazil	30	177 589	12 400
	Japan	27	16 079	687
	Switzerland	27	30 330	1 563
	Singapore	24	25 346	21
	Saudi Arabia	23	44 830	273
	Sweden	19	27 909	3 460
	Colombia	18	12 272	493
	Turkey	17	143 114	3 952
	Belgium	14	53 981	8 843
	Mexico	14	38 324	3 926
	Taiwan	14	NA	NA
	Greece	13	2 760	155
	Netherlands	13	43 211	5 562
	Denmark	12	10 667	533
	Pakistan	11	35 298	761

	Austria	10	15 964	624
	Israel	10	16 539	262
	Thailand	10	3 018	56
	Norway	9	8 158	229
	Russian Federation	9	252 245	2 305
	Egypt	8	10 431	556
	United Arab Emirates	8	20 386	206
	Argentina	7	6 563	321
	Indonesia	7	15 438	1028
	Ireland	7	23 401	1 497
	Portugal	7	28 132	1 175
	South Africa	7	12 074	219
	Chile	6	34 381	346
	Jordan	6	582	9
	Nepal	5	246	0
	Peru	5	72 059	2 057
	Poland	5	17 204	861
	Macao	4		
	Malaysia	4	6 779	111
	Venezuela	4	440	10
	Viet Nam	4	288	0
	Bangladesh	3	17 822	269
	Bolivia	3	2964	128
	Kenya	3	737	40
	Morocco	3	6 512	188
	New Zealand	3	1 147	21
	Nigeria	3	4971	164
	Oman	3	4 341	17
	Qatar	3	26 539	14
	Romania	3	16 002	1 016
	Cameroon	2	2800	136
	Croatia	2	2213	94
	Ethiopia	2	263	5
	Finland	2	6054	284

	Ghana	2	5408	24
	Honduras	2	2080	121
	Iraq	2	3032	115
	Kuwait	2	11028	82
	Lebanon	2	878	26
	Mali	2	758	44
	Panama	2	8616	249
	Paraguay	2	740	11
	Sudan	2	1817	90
	Uruguay	2	717	19
	Belarus	1	25840	149
	Bulgaria	1	2069	96
	Cambodia	1	122	0
	Costa Rica	1	804	7
	Czech Republic	1		
	Dominican Republic	1	11196	409
	Ecuador	1	30486	2334
	Estonia	1	1751	61
	Hungary	1	3 380	436
	Kyrgyzstan	1	1 082	12
	Lithuania	1	1 505	54
	Maldives	1	955	4
	Malta	1	508	6
	Montenegro	1	324	9
	Philippines	1	11618	772
	Puerto Rico	1	2329	115
	San Marino	1	647	41
	Serbia	1	10 295	222
	Seychelles	1	11	0
	Sri Lanka	1	915	9
	Tunisia	1	1032	45
	Yemen	1	72	13
	Zambia	1	446	7
	Zimbabwe	1	37	4

Table 12: *Coronavirus research after 2019.*

**, ** - Data taken from WHO.*

In the present year, (i.e. from January 2020 to May 2020) there are 1269 publications by scholars from 96 countries of the world. It can be observed that the sudden hike in the research productivity is due to the sudden outbreak of the virus in Wuhan, China in December 2019. Since it has started in China, the research productivity is more from China. The second leading country is coronavirus research in 2020 is USA followed by Italy and UK whose mortality rate are more. The correlation coefficient of incidence of coronavirus in different countries and their research productivity is negative and very weak (-0.1982). But the correlation coefficient of mortality rate of coronavirus in different countries and their research productivity is positive and very strong (0.97). This shows that the mortality rate due to corona virus and not the prevalence of coronavirus is the catalyzing factor to conduct research in this field.

Conclusion

Coronaviruses infect many species of animals, including humans. Coronaviruses have been described for more than 50 years; the isolation of the prototype murine coronavirus strain JHM, for example, was reported in 1949 [9,10]. The molecular mechanisms of replication as well as the pathogenesis of several coronaviruses have been actively studied since the 1970s. Coronavirus has been crucial only after 2003 (SARS-CoV) and taken various forms such as HCoV-NL63 (2004), HCoV-HKU1 (2005) and MERS-CoV (2012). Unlike the previous coronaviruses, the present coronavirus SARS-CoV2 (2019) now termed as COVID-19 is a pandemic one which spreads very fast. That is the reason why research is going on in a faster rate (more than 5 times as that of 2019 within 4 months) than the period earlier to 2020. Also, the more the mortality rate due to coronavirus in a country, the more will be research productivity.

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