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Global Scientific Research on Coronavirus : a Scientometric Study

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Abstract

To understand the global research trend of the scientific publication on coronavirus, this scientometric study was carried out for the period 2002 to 2019 based on scientometric indicators such as growth of publication, productive authors and institutions, collaboration among authors and institutions, the hotspot of research area and the citation pattern. A total of 8541 records downloaded from PubMed formed the dataset for the study and were analysed using Bibexcel and VOSviewer. The findings reveal that the research on coronavirus was noticeable but it was not significant. A correlation between the number of publications and emergence of SARS in 2002 and MERS in 2012 was also visible. The trend of publication was found to be fluctuating during the period of study. The findings demonstrate that collaboration among institutions was not very strong. Keyword analysis indicates that animals, humans, female, male, mice, molecular sequence data are commonly used.

Key Words: Coronovirus, COVID-19, Scientometric Study, PubMed, Global Scientific Publications, Bibexcel, VOSviewer

Introduction

The global pandemic caused due to the coronavirus which has evolved as a human virus, has increased the R&D about this family of virus. Coronavirus belong to the family of the viruses which are predominately related to infection which affects the respiratory system of living beings. The discovery of coronavirus was not new and it dates back to 1930. The various strains of corona virus were found to be a major cause of infection in animals and the first symptomatic evidence of the same was found when Severe Acute Respiratory Syndrome (SARS) were found in domesticated chickens and their cause of infection was diagnosed to be due to coronavirus strain now known as avian bronchitis virus (IBV). (Peiris 2012).

The evolution of the coronavirus and its transformation from animal virus to a human virus is a major cause of concern amongst the medical fraternity. The name ‘Corona’ to this family of viruses is due to their peculiar crown like structure. Since 1960, there has been substantial mutation of Corona virus DNA structure which resulted in its being converted into a purely human virus (Kahn and McIntosh 2005) (Tyrrell and Bynoe 1966).The evolutionary history of coronavirus records major incident of SARS outbreak in 2002 and Middle East Respiratory Syndrome (MERS) outbreak in Saudi Arabia in 2012.

But recently a new coronavirus has emerged and has set off a global pandemic which has so far killed over 4 lakh people and infected over 7.43 million people across the world .(Anon n.d. 2020). The need of the hour is to ensure that the eruption is fully understood and contained. Since there is no effective treatment available till now owing to lack of specific vaccine, scientists all over the world are in race of crucial knowledge for preparing a vaccine or antiviral drugs to curb the spread of infection. All the concerted efforts in this direction will usher to a new roadmap for dealing with any sort of Pandemic in present as well as for future.

A lot of literature is available about the coronavirus with different aspects of coronavirus infection, medical complications and treatment, infectious nature of the study, treatment of coronavirus, use of new methods and techniques in treatment of corona infection are a few of them. Scientometric study of a particular infection or disease in various aspects has been proved to be very beneficial to supplement further development pertaining to the disease, its research and its treatment as well.

Review of Literature

Scientometrics is the study of the quantitative aspects of the process of science as a communication system. Several scientometrics studies in the past have been carried out dealing with the research performance / productivity of various medical researches of particular country, different subjects, individual persons and various institutions. Various scientometric studies are carried out to know about publication trends and patterns of various diseases (Tran et al. 2019), (Biglu, Eskandari, and Asgharzadeh 2011), (Erfanmanesh, Gholamhosseinzadeh, and Jahromi 2013), (Gupta and Bala 2011), (Bayoumy et al. 2016), (Sorensen 2009). All these studies reflect the importance of scientometric studies of publication pattern which through the projection of highly cited articles, highly productive author, and most active research countries engaged in these research and other aspects lead to a major continuum in facilitating a breakthrough in R& D in the treatment of diseases. Technological development and

innovations has open number of avenues for the detail study of various virus induced diseases. Bach Xuan Tran (2019) introduced the concept like Artificial intelligence being exhaustively used in medical research. Also various collaborative research had been on rise (Chang et al. 2019), (Ali-Khan et al. 2013). Similarly scientometric studies had also been carried out worldwide and on various chronic and infectious diseases (Zarei et al. 2017), (Emami et al. 2018), (Rasolabadi et al. 2015), (Rezaee Zavareh and Alavian 2017), (Fricke et al. 2013) , (Singh 2016). Thus various countries like Iran, United States of America, Middle East Asia, India, Latin America are a few to name which are seriously involved in these research.

Objectives

The main objective of the present study is to map the trend of publication on coronavirus during 2002 to 2019 by way of analysing the following scientometric indicators.

- To find out year-wise growth of publications,
- To identify the prolific authors having large number of publications,
- To find out the collaboration of authors and organisations,
- To check the co-occurrence of key words
- To find out the highly preferred journals for publication

Methodology

Scientists all over the world are in race of crucial knowledge for preparing a vaccine or antiviral drugs to curb the spread of coronavirus infection. So making available the findings of research on related field as quickly as possible is not only a social responsibility but also a moral responsibility of every researcher to avoid duplication of research. To examine the trend of research on coronavirus from a quantitative perspective, the PubMed is considered as it is an open access database. PubMed comprises more than 30 million citations for biomedical literature from MEDLINE, life science journals, and online books. (PubMed, 2020) .

Data for the present study was retrieved, using the search terms “coronavirus” on May, 30, 2020. SARS out broke in southern China in 2002 and the novel coronavirus (COVID-19) is believed to have first detected in Wuhan, China, in late 2019 and has set off a global pandemic. (Anon n.d.) As, already published literature plays a crucial role in accelerating the ongoing research in a positive direction, literature published between the first major outbreaks in 2002 to the latest in 2019 has been taken into consideration for this study. Search was performed without language restriction; however the filter “Free full text” was applied while searching the data. The data of 8541 articles was downloaded in PubMed

format and scientometric indicators like annual research output, languages, countries, institutions, journals, prolific authors, co-authorship and keywords relations were investigated through Bibexcel. VOSviewer software was used to create density and network visualization maps.

Limitation

The study is based on data retrieved from PubMed which is a large open access database for biomedical literature. Hence the paid resources are not part of the study. Secondly the results are the output of some popularly used bibliometrics softwares and tools whose hundred percent efficacies cannot be claimed though every possible attempt has been made to make the data as well as the results more accurate.

Analysis and Discussion

Characteristics of Publication Output

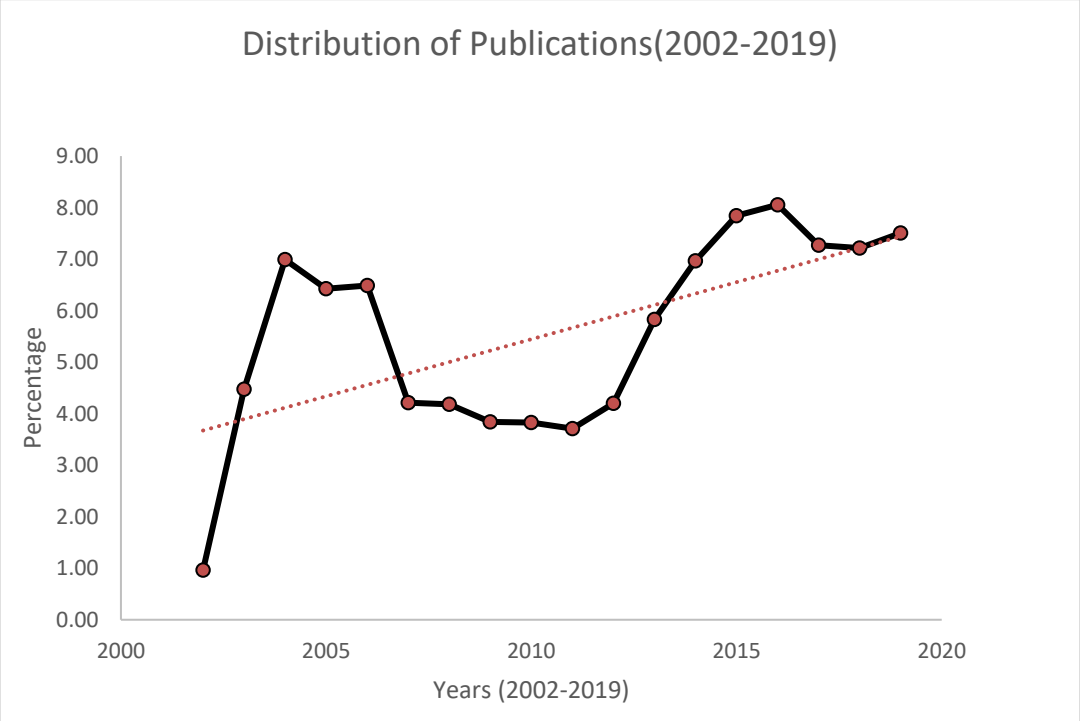
The year-wise distribution of publications on coronavirus research during the period (2002-2019) is shown in Table 1. The observation of data indicated that the growth rate of publications were not uniform in the overall time period and varies considerably. From 2002 onwards the output started increasing rapidly and the rise was an indication of the spurt in research on coronavirus after the SARS virus discovery in 2002.The increase of research during this span of study reached a peak in 2016 with 688 publications (8.06%), followed by 621 publications (7.27%) in year 2017, and the lowest publication 82(0.96%) were published in the start year (2002) of the period of study. From the overall observation it is clear that there has been a continuous research carried out on Corona Virus since 2002.

Table - 1 : Year wise Distribution of Publication

S.No.	Year	No of output	Percentage	Cumulative percentage
1	2002	82	0.96	----
2	2003	382	4.47	5.43
3	2004	597	6.99	12.42
4	2005	549	6.43	18.85
5	2006	554	6.49	25.34
6	2007	360	4.21	29.55
7	2008	357	4.18	33.73

8	2009	328	3.84	37.57
9	2010	327	3.83	41.40
10	2011	317	3.71	45.11
11	2012	359	4.20	49.32
12	2013	498	5.83	55.15
13	2014	595	6.97	62.11
14	2015	670	7.84	69.96
15	2016	688	8.06	78.01
16	2017	621	7.27	85.28
17	2018	616	7.21	92.50
18	2019	641	7.50	99.99
Total	***18 years***	***8541***	***100.00***	

Figure -1 : Distribution of Publications



Annual Growth Rate of Publications

The annual growth rate of publications of Corona virus research from the marked period of 2002 to 2019 of study is shown in below table-2. On the observation of table 2, it is clearly shown that the maximum AGR **365.85** was recorded in the year 2003, followed by **56.28** annual growth rate was recorded in the year 2004, and AGR **38.72** in the year 2013. In the below table 1, it showed the overall annual growth rate of publication. The annual growth

rate (AGR) is calculated on the formula given by (Kumar and Kaliyaperumal, 2015) and mention below:

AGR = End Value - First Value / First Value x 100

Table - 2 : Annual Growth Rate (AGR) of Publication

S.No.	Year	No of Output	Annual Growth Rate (AGR)
1	2002	82	0.00
2	2003	382	365.85
3	2004	597	56.28
4	2005	549	-8.04
5	2006	554	0.91
6	2007	360	-35.02
7	2008	357	-0.83
8	2009	328	-8.12
9	2010	327	-0.30
10	2011	317	-3.06
11	2012	359	13.25
12	2013	498	38.72
13	2014	595	19.48
14	2015	670	12.61
15	2016	688	2.69
16	2017	621	-9.74
17	2018	616	-0.81
18	2019	641	4.06
		8541	

Compound Annual Growth Rate (CAGR)

The compound annual growth rate is calculated by taking the n_{th} root of the total percentage growth rate, where *n* is the number of years in the period being considered. Compound Annual Growth Rate is used to make future projections about the growth rate of publications on a particular topic of study. Table 3 illustrates the compound annual growth rate of publications in the field of the coronavirus 2002-2019. The overall compound annual growth rate of publication shown in below table 3.The maximum 784.3 CAGR was recorded in the year 2017, followed by 763.8 recorded in the year 2016, and 707.9 CAGR was recorded in the year 2018. The lowest CAGR(93.5) was recorded in the year 2003.

Compound Annual Growth Rate (CAGR) = [(Ending Value/Beginning Value)$^{1/n}$]-1

(Murphy n.d.2020).

Table – 3 : Compound Annual Growth Rate

S. No.	Year	No of Output	CAGR
1	2002	82	0
2	2003	382	93.5
3	2004	597	435.5
4	2005	549	680.6
5	2006	554	625.9
6	2007	360	631.6
7	2008	357	410.4
8	2009	328	407.0
9	2010	327	373.9
10	2011	317	372.8
11	2012	359	361.4
12	2013	498	409.3
13	2014	595	567.7
14	2015	670	678.3
15	2016	688	763.8
16	2017	621	784.3
17	2018	616	707.9
18	2019	641	702.2
		8541	
Calculation based on Compound Annual Growth Rate of 14%			CAGR= 14%

Relative Growth Rate and Doubling Time of Publication

Table 4 shows the relative growth rate and doubling time of publication in coronavirus research during the period 2002-2019. The growth rate of all publication has been measured on the basis of RGR and Dt model, the particular model is developed by Mahapatra (Mahapatra 1985). RGR is calculated to analyse the increase in the number of publications on time and the Dt is directly related to RGR. The mathematical representation of the mean relative growth rate of articles over a specific period is derived from the following formula:

$$\mathbf{RGR = W_2 - W_1 / T_2 - T_1}$$

Where,

RGR = Growth Rate over the specific period of the interval,

W1 = Log_e (natural log of the initial number of contributions)

W2 = Log_e (natural log of the final number of contributions)

T1 = the unit of initial time

T2 = the unit of final time

The maximum RGR 0.827 was recorded in the year 2004, followed by 0.417 RGR was recorded in the year 2005, and the highest doubling time 8.88 was recorded in the year 2019, followed by 8.56 Dt. was recorded in the year 2018. The overall data related to relative growth rate and doubling time of publication has been shown in below table 4.

Doubling Time

From the calculation, it is defined that there is a direct equivalence existing between the RGR and Dt. If the number of contributions of a subject doubles, from 2002-2019, then the difference between the logarithm of the numbers at the starting and at the last of the period must be the logarithms of the number 2. If one uses a natural logarithm, this difference has a value of 0.693 **(**Beaie and Acol, 2009).

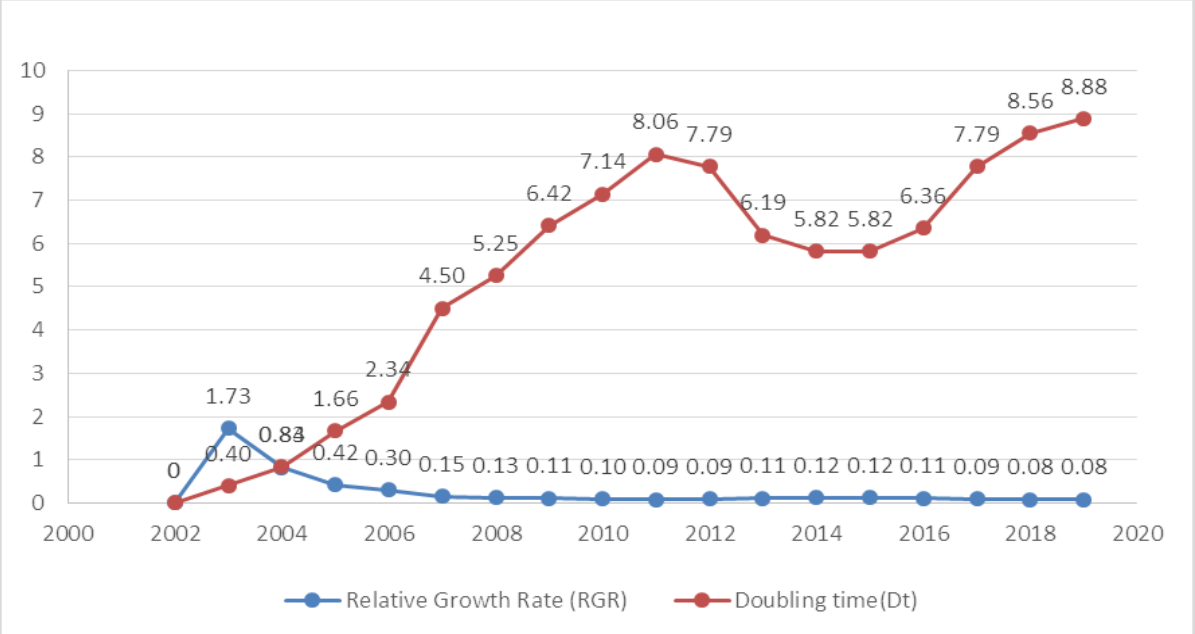
Doubling Time D(t) = 0.693/R

Table - 4 : Relative Growth Rate (RGR) and Doubling time [D (t)]

S.No.	Year	No of Output	Cummalative No.of Publications	Loge1 P	Loge2 P	RGR R(P)	Mean [R(P)]	[Dt(P)] 0.693/R(P)	Mean [Dt(P)]
1	2002	82	82		4.407		0.47		3.569
2	2003	382	84	4.407	6.139	1.732		0.40	
3	2004	597	87	6.139	6.966	0.827		0.84	
4	2005	549	91	6.966	7.383	0.417		1.66	
5	2006	554	96	7.383	7.679	0.296		2.34	
6	2007	360	102	7.679	7.833	0.154		4.50	
7	2008	357	109	7.833	7.965	0.132		5.25	
8	2009	328						6.42	

			117	7.965	8.073	0.108			
9	2010	327	126	8.073	8.170	0.097		7.14	
10	2011	317	136	8.170	8.256	0.086		8.06	
11	2012	359	147	8.256	8.345	0.089		7.79	
12	2013	498	159	8.345	8.457	0.112		6.19	
13	2014	595	172	8.457	8.576	0.119		5.82	
14	2015	670	186	8.576	8.695	0.119	0.10	5.82	7.252
15	2016	688	201	8.695	8.804	0.109		6.36	
16	2017	621	217	8.804	8.893	0.089		7.79	
17	2018	616	234	8.893	8.974	0.081		8.56	
18	2019	641	252	8.974	9.052	0.078		8.88	
		8541							

Figure -2 : Relative Growth Rate and Doubling time of Publications



Language and Place of Publication of Journals

A total of 13 different languages were encountered in retrieved articles while three are bilingual in nature. English (total records = 8541; 98.5%) was the most common followed by French (total records = 37; 0.43%), Spanish (total records = 18; 0.21%), and Chinese (total records = 15; 0.18%). Articles written in other languages are shown in Table 5.

Table – 5: Language wise Publications

Rank	Language	No. of Records	Percentage (n=8541)
1	English	8419	98.57
2	French	37	0.43
3	Spanish	18	0.21
4	German	17	0.20
5	Chinese	15	0.18
6	Japanese	8	0.09
7	English; French	7	0.08
8	Turkish	7	0.08
9	English; Spanish	3	0.04
10	Norwegian	3	0.04
11	Russian	1	0.01
12	Swedish	1	0.01
13	Dutch	1	0.01
14	English; Russian	1	0.01
15	Portuguese	1	0.01
16	Korean	1	0.01

Place of Publication

The analysis shows that 8541 articles were published in 570 journals which are originated from 33 countries out of which more than 50% journals are published by three countries only. USA has lion's share of 161 (28.24 %) journals. Japan had published 81 (14.21%) journals closely followed by China from where 70 (12.28%) journals originated.

Productivity Authors and Collaboration Analysis

Productivity of authors are depicted in Table -6 with details of no. of publications, average no. of citations per year and h index of the authors. When analysing the aspect of number of publication during the period it was found that Yuen KY is the most productive author with highest number of publication followed by Baric RS. However it can be seen that there is no correlation between the number of publications, citations and h index. Notably Wang Y, who

has the highest number of citations as well as h index was in the 10th position as per the ranking based on total number of publications.

Table - 6 : Productivity of Authors

Ranking	No. of documents	Name of Author	Average Number of citations per year	h index (2002 – 2019)
1	120	Yuen KY	3085.39	111
2	104	Baric RS	1055.5	77
3	100	Perlman S	2021.39	92
4	88	Memish ZA	2833.28	84
5	86	Li Y	41242	22
6	77	Jiang S	9851.33	211
7	77	Zhang J	36488.72	495
8	71	Chen Y	38456.61	511
9	70	Drosten C	1786.06	87
10	70	Wang Y	41297.67	551

(The number of citations and h index was calculated by Publish or Perish software.)

Figure – 3 : Network Map of Co authorship

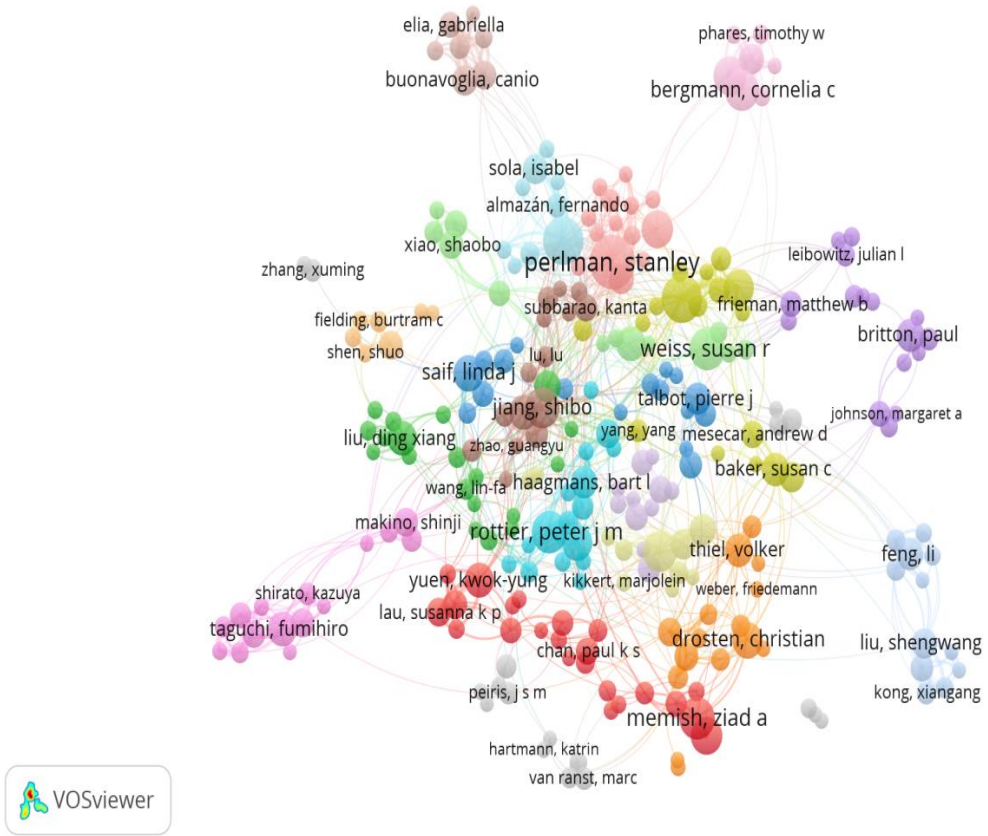


Figure – 4 : Density Map of Co authorship

Collaboration among authors as measured by VOSviewer is shown in Figure – 3 and Figure - 4. The network contains 262 items 1075 co authorship links and 23 clusters. The network is the outcome of those authors who had at least 10 publications. Of the 21506 authors 294 met the threshold. Out of the 294 authors 262were connected with each other. The network is the result of those 262 authors. Each node in the figure represents an author's productivity and the links between the authors denote the collaboration among them. The size of the circles depicts the quantum of publications of the authors and thickness of the lines show the frequency of collaboration among the authors. The colour of the circle remains same for all the authors in the same cluster.

Productivity and Collaboration of Institutions

Analysis of the productivity and collaboration of institutions are depicted in Table – 7 and Figure - 5. It is found that out of the 496 institutions which have made the total contribution of 8451 articles, Division of Avian Infectious Diseases, State Key Laboratory of Veterinary Biotechnology, Harbin Veterinary Research Institute is the most productive institution having a contribution of 136 articles followed by Lindsley F" Kimball Research Institute, New York Blood Center, New York with a contribution of 97 articles.

Collaboration network by VOSviewer was made where the institutions having at least 5 publications were considered for networking. Out of the 496 total institutions, 120 met the threshold. Each node represents the institution's productivity and the links between the institutions denote the collaboration established through co authorship. Figure depicts the network of institutions of 24 nodes and 43 links and 88 total link strength. The size of the node shows the publication frequency of the institutions.

Table - 7 : Productivity of Institutions

Rank	Name of Organisation	No. of Publication (n=8541)
1	Division of Avian Infectious Diseases, State Key Laboratory of Veterinary Biotechnology, Harbin Veterinary Research Institute, the Chinese Academy of Agricultural Sciences, Harbin 150001, People's Republic of China"	136
2	Lindsley F" Kimball Research Institute, New York Blood Center, New York, NY 10065;FAU - Baric, Ralph S	97
3	State Key Laboratory of Veterinary Biotechnology, Harbin Veterinary Research Research Institute, Chinese Academy of Agricultural Sciences, Harbin, China"	76
4	State Key Laboratory of Agricultural Microbiology, College of Veterinary Medicine, Huazhong Agricultural University, Wuhan 430070, China"	70
5	Virology Division, Department of Infectious Diseases and Immunology, Faculty of Veterinary Medicine, Utrecht University, Utrecht, The Netherlands"	64
6	Department of Microbiology, The University of Hong Kong, Hong Kong, China"	62
7	Department of Internal Medicine, Seoul National University College of Medicine, Seoul, Korea"	61
8	State Key Laboratory of Agricultural Microbiology, College of Veterinary Medicine, Huazhong Agricultural University, Wuhan, China"	58
9	Department of Epidemiology, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina, USA"	56
10	College of Animal Science, South China Agricultural University, Guangzhou, China"	53

Figure – 5 : Network of Collaboration of Institutions

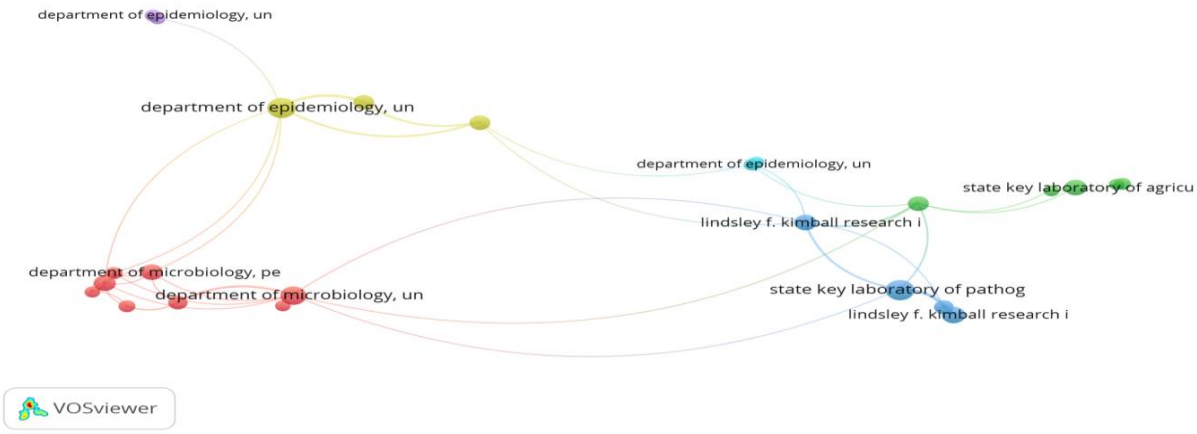
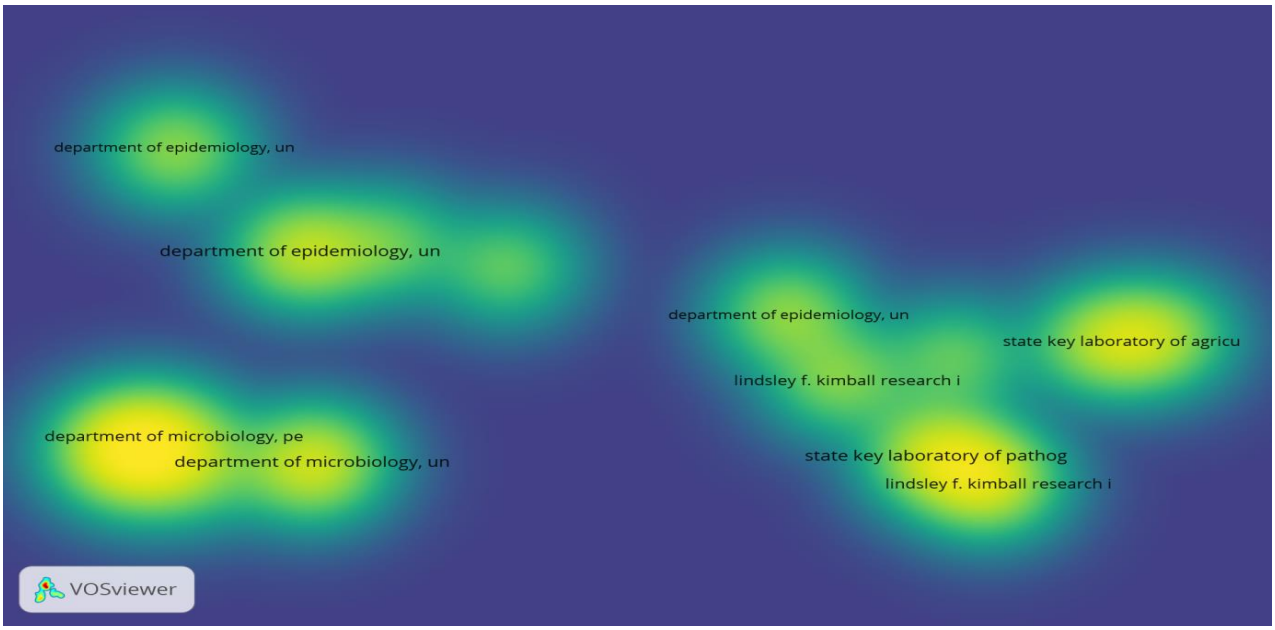


Figure – 6 : Density of Collaboration of Institutions



Co-occurrence of Keywords

The co-occurrence of key words represents the hotspot in the domain of research. The Medical Subject Headings (MeSH) were calculated by Bibexcel and visualisation graph was made by VOSviewer which shows a nearly same findings. Table - 7 shows the output of Bibexcel where it can be seen that the word “animal” was occurred 4583 times and “ human” was used in the database for 4303 times. In the Figure – 7 and figure – 8 which depict the visualisation of the co-occurrence of key words, these two words are represented by big circles which reveals that the frequency of the availability of these words in the datasets were more in comparison to the other key words. The network was formed by sorting the key

words by a minimum occurrence of 25 times. Out of the total 4963 keywords, 531 met the threshold. The network contains 326 keywords, 30254 co-occurrence and 4 clusters. Keywords with the same Colour suggest that these keywords have close relation and usually co-occur.

Figure – 7 : Network of Co-occurrence of Keywords

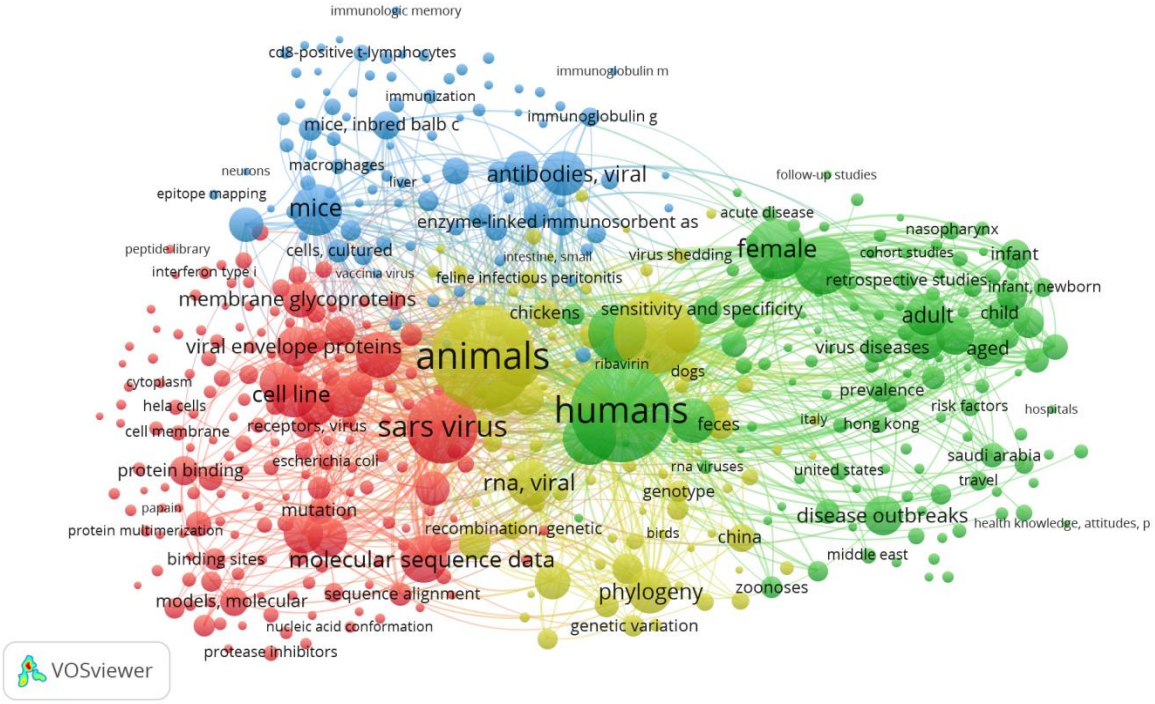


Figure – 8 Density of Co-occurrence of Keywords

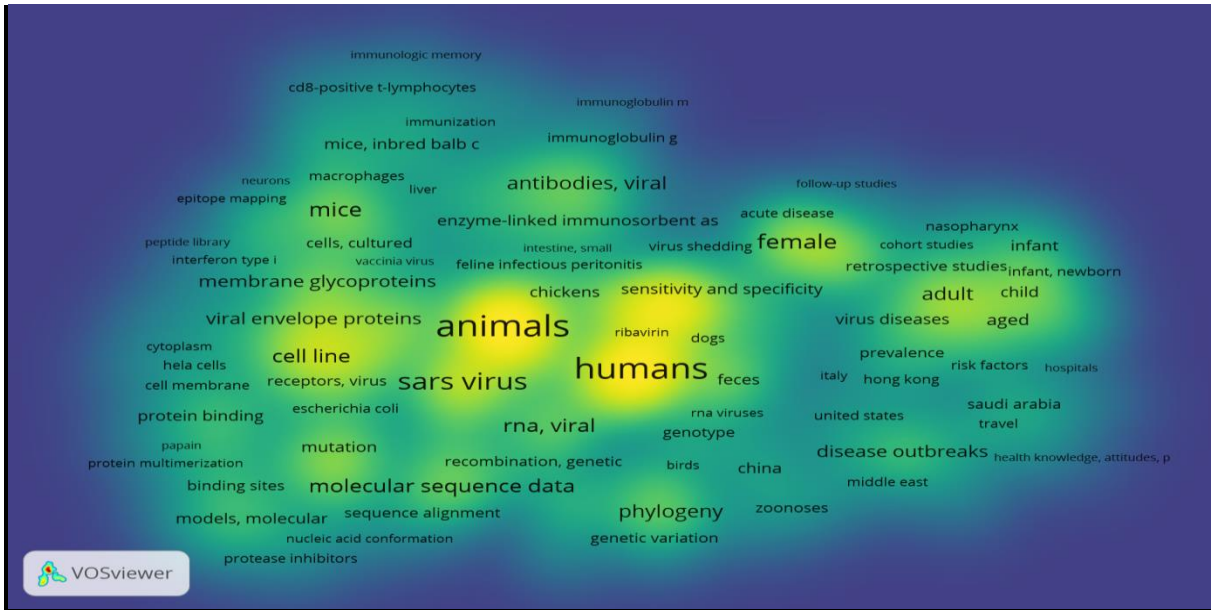


Table – 8 : Co-occurrence of Key Words

S.No.	Frequency of occurrence	Key words
1	4583	Animals
2	4303	Humans
3	1540	Female
4	1378	Male
5	1103	Mice
6	952	Molecular Sequence Data
7	893	Cell Line
8	800	Phylogeny
9	749	Adult
10	660	Amino Acid Sequence
11	654	Middle Aged
12	635	Chlorocebus aethiops
13	630	Swine
14	534	SpikeGlycoprotein, Coronavirus
15	494	Aged

Preferred Journal

Table – 9 : Preferred Journals

Ranking	No. of papers	Name of journal	Place of Publication	Percentage (n=8541)
1	786	Journal of Virology	USA	9.20
2	270	Emerging Infectious Diseases	USA	3.16
3	257	Virology"	USA	3.01
4	230	PLoS One"	USA	2.69
5	180	Virus research	Netherlands	2.11
6	153	Viruses	Switzerland	1.79
7	139	Veterinary microbiology	Netherlands	1.63
8	139	Journal of virological methods	Netherlands	1.63
9	137	Archives of virology	Austria	1.60
10	111	Advances in experimental medicine and biology	USA	1.29

The total 8541 articles are published by 570 journals. Table 9 depicts the highly preferred journals and its place of publication analysed by Bibexcel. The results shows that Journal of Virology published from USA is the most sought after journal which has published 786 articles (9.20%) out of 8541 total articles. The second most preferred journal is Emerging

Infectious Diseases again a USA publication which has published 270 articles (3.16%) of the total publication.

Findings and Conclusion

The present study was an attempt to quantify and describe the worldwide trend of research on coronavirus based on published literature retrieved from PubMed. The findings have proved that this domain of medical research had not attracted many until the outbreak of COVID – 19 which has created a global health crisis. It was found from the study that though the research output in this field was noticeable it was not quite significant. The publication on coronavirus had grown from 82 articles in 2002 to 641 articles in 2019. However the growth was not steady throughout the period. The global productivity on coronavirus during 2002 to 2019 was found to be 8541 articles where the Compound Annual Growth Rate (CAGR) was 14%. The mean of the Relative Growth Rate (RGR) was 0.47 while the doubling rate of publication was found to be 3.569. No correlation between the number of documents published and the average citation per year and h index of the productive authors was visible.

Unlike the novel coronavirus though the earlier discovered human coronavirus was not that alarming still the research on human coronavirus was notable. A sizeable portion of articles were contributed by authors associated with institutions in China. All the preferred journals are published from America and European countries though the most productive authors and institutions are from China.It can be inferred from the present findings that the collaboration among institutions is not very significant whereas the degree of collaboration among authors was remarkable. This is an evolving situation and hence to meet the future challenges of the diseases and limit the spread it can be hypothesised that more collaboration in scientific and health research will speed up hunt for vaccine to combat COVID – 19. The present study which provides an update on research and development on coronavirus will help the scientific community to work more effectively and efficiently by avoiding unnecessary duplication of researches to accelerate the ongoing researches.

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