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Scientometric study and network visualization of the last decade global scientific research response to Coronavirus - An overview

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Abstract

Corona virus infection in humans relates back to 1965 with no emphatic information on its impact to human health. Infection probably has taken ugly turn into deadly diseases like Severe Acute Respiratory Syndrome (SARS) in 2003 and Middle East Respiratory Syndrome Corona virus (MERS-CoV) in 2012. But, its recent version of COVID-19 has wrecked the economic prospects and disarrayed many corresponding socio-political configurations across globe. Scientometric study of scientific research response on Coronavirus can provide insight on the research trends in the subject area and can serve as a blueprint for strengthening of research collaboration(s) amongst individuals, institution(s) and countries to fight this catastrophic pandemic. Therefore, the present study was contemplated to get an overview of the scientific communication(s) on Coronavirus spanning the last decade. A total of 5769 valid entries published between 2010 and 2019, were considered for scientometric analysis. A total of 138 countries contributed to the articles on this aspect, United States being in the lead role. University of Hong Kong contributed the highest number of articles on Coronavirus followed by the University of North Carolina. The present devastating condition of world due to COVID-19 has steered global scientific community to deliver extra efforts on research on coronavirus. In pursuit of this, we too have given our thrusts to identify various academias, research clusters with their primary objectives and contributions made on coronavirus for our futuristic research collaborations and advancements.

Keywords: Coronavirus, SARS, MERS-CoV, COVID-19, Scientometric, Network visualization

Belonging to family *Coronaviridae*, corona viruses are well-established pathogens of humans and animals. The virus possesses three most important antigenic proteins, spike (S), membrane (M) and nucleocapsid (N) proteins (Peiris, 2012). These viruses have a unique morphology and the name of virus has been derived from the outer fringe, or "corona" of embedded envelope protein (Burrell *et al*., 2017). Corona virus can cause common cold, fever, cough, shortness of breath, breathing difficulties and in severe cases may lead to pneumonia, severe acute respiratory syndrome, kidney failure and even death (WHO, 2020a). Corona viruses are zoonotic having transmission incidences between animals and human beings.

Corona virus infection was first described in 1931 and the first coronavirus (HCoV-229E) was isolated from humans in 1965 (Korsman *et al*., 2012). The first human coronavirus named B814 was found in 1965 by Tyrrell and Bynoe, in human embryonic tracheal organ cultures obtained from the respiratory tract of an adult with a common cold (Kahn & McIntosh, 2005). From the ongoing research during 3-4 decades, it was found that respiratory corona virus infections occur more often in the winter and spring than in the summer and fall. Severe Acute Respiratory Syndrome (SARS) was first recognized on the 26th February 2003 in Hanoi, Vietnam. Similar to this disease, Chinese Government had already reported a different type of pneumonia in November 2002 in Guangdong Province. The main symptoms were high fever (>38 degrees C), cough, shortness of breath or breathing difficulties (WHO, 2003). SARS spread in 29 countries in North America, South America, Europe and Asia. This disease had 15% mortality rate viz. 774 deaths out of a total of 8098 confirmed cases (Ries, 2020).

Thereafter, Middle East Respiratory Syndrome Corona virus (MERS-CoV) was identified in Saudi Arabia in 2012. Studies have shown that humans got infection through direct or indirect contact with infected dromedary camels (WHO, 2019a). Later, this disease was also identified in other countries of Middle East, Africa and South Asia, having a high mortality rate World Health Organization (WHO) has notified 2494 confirmed cases

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of MERS-CoV with 858 deaths spread in 27 countries all over the world (WHO, 2019b).

Recent human affiliated corona virus infection has triggered fiery like situation across the globe, risking health care system and dwindling it to near collapse in many countries with an exponential rise in morbidity and mortality. The infection has decimated human population to a great extent in some countries like China, Italy, Spain and now an ongoing wave of infection is nearly sweeping a large toll on human life in United States of America.

The most recently discovered corona virus called novel corona virus (WHO, 2020e) was first reported from Wuhan, China, on 31st December 2019 (WHO, 2020b). Though, the virus responsible for novel corona virus is genetically related to the virus that caused the epidemic of Severe Acute Respiratory Syndrome (SARS), however it causes quite different malaise. Therefore, the International Committee on Taxonomy of Viruses (ICTV) has termed the new virus as "Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2)" and WHO has named this new disease as "COVID-19" by following the guidelines developed with the World Organisation for Animal Health (OIE) and the Food and Agriculture Organization (FAO) (WHO, 2020d). Fever, tiredness and dry cough are the common symptoms of COVID-19. Aches and pains, nasal congestion, runny nose, sore throat or diarrhea may also be noticed in some patients. According to the Centers for Disease Control and Prevention, United States Department of Health and Human Services, COVID-19 spreads mainly from person-to-person through respiratory droplets produced when an infected person coughs or sneezes and other people catching these droplets. Currently, the whole world is suffering from COVID-19 pandemic outbreak and WHO has declared it as a situation of Emergency (WHO, 2020b).

COVID-19 pandemic is spreading at a very fast rate as compared to SARS or MERS viz. for the first 1000 people to get infected, SARS took 130 days, MERS took 903 days and COVID-19 took only 48 days (World Economic Forum, 2020). WHO have been publishing Situation Reports on daily basis about the confirmed cases of Novel Coronavirus (2019-nCoV) or COVID-19 since 21st January, 2020. The first report of WHO (WHO, 2020c) published on 21st January, 2020 provides the insights into the spread of this epidemic. This deadly disease was first reported to the WHO office in China on 31st December, 2019 as cases of pneumonia of unknown etiology detected in Wuhan City of Hubei Province and a total of 44 such cases were reported till 3rd January 2020. On 7th January 2020, a new type of coronavirus was detected and on 12th January its genetic sequence was shared by China. Subsequently, on 13th, 15th and 20th January, 2020, Thailand, Japan and Republic of Korea, respectively, reported their first case of import of 2019-nCoV in their country. Six deaths were reported from Wuhan, China during this period. As per the third and fourth Situation Reports of WHO, United States of America and French Republic confirmed their first case of 2019-nCoV on 23th and 24th January, 2020, respectively. On 1st February, 2020, twenty three countries throughout the world got affected with COVID-19. The total number of affected cases crossed ten thousand globally viz. 11953 including 11821 cases in China alone with 259 people losing their lives in China. The number of confirmed cases of COVID-19 crossed 50,000 worldwide viz. 50,580 with 50,054 cases from China alone on 15th February, 2020 and the death toll reached 1524. On 28th February, 2020 COVID-19 had spread in more than 50 countries. Total number of confirmed cases of COVID-19 reached 1,00,000 on 07th March, 2020 and more than hundred countries getting affected with this deadly disease by 08th March, 2020. Total cases of COVID-19 rapidly crossed 1,50,000 by 15th March, 2020 and 2,00,000 on 19th March, 2020. The number of deaths due to this disease in Italy crossed the number of death in China and on 19th March, 2020 and the total number of deaths in world crossed 10,000 on 20th March, 2020. The figures became alarming with total number of confirmed cases of COVID-19 crossing 7,00,000 in just 10 days i.e. on 31st March, 2020. The situation has turned to be distressing with confirmed cases becoming almost three times viz. 20,74,529 in just 17 days i.e. on 17th April, 2020 and death toll rising to 1,39,378, and is still in ascendancy. This situation has been equated as massive conflagration leading to near decimation of socio-economic activities.

Scientometric studies are useful in ascertaining and envisaging the research trends in concerned subject(s). Such study on Coronavirus is need of the hour to provide an overview of the trends in scientific communications and to serve as a road map for strengthening of research collaborations amongst individuals, institutions and countries. The network visualization can further facilitate the cognitive envisaging of scientific flow of knowledge on the Coronavirus.

Therefore, the present study aims to attain the following objectives:

1. Provide an overview of the scientific communications on Coronavirus during the last decade, i.e. 2010-2019.
2. To identify the most productive institutions and countries, and visualization of collaboration trends amongst them.
3. Perform subject analysis based on keywords and give a pictorial overview of the research trends during period under study.

Materials and Methods

Dataset

For the purpose of this study, the data were accessed from the Scopus database on 29th January 2020 using the phrase '*coronavirus*' and '*coronaviridae'*. Though a large number of articles have been published thereafter on COVID-19, this study is confined to scientometric analysis of publications till the advent of pandemic. The Boolean operator 'OR' was applied to get results represented by either of the search terms. The search was filtered for occurrence of search terms in the title, abstract and keywords of records. Since the journal articles and other type of publications (e.g., book chapters) had unsymmetrical bibliographical fields making it difficult to analyze and visualize data, the search results were filtered to include only journal articles that had similar bibliographical fields. Moreover, journals are primary carriers of scientific communication, publishing and disseminating nascent information and knowledge. The string search retrieved 13545 entries. The data was downloaded to computer. Further, the data pertaining to the last decade i. e. 2010-2019 was retained, resulting to the 5769 valid entries for analysis.

Analysis of subject terms and institutions

The words/phrases listed in the "keyword" field in the Scopus data (i.e., those defined as Author-generated Keywords) were considered for subject analysis. For the records where author-generated keywords were not available, the index keywords provided in the bibliographical data retrieved from Scopus were considered as Author-Generated keywords for the purpose of performing subject analysis. The singular and plural terms representing same subject were further standardized to avoid duplicity in occurrence of terms in subject visualization map. Further, the keywords conveying same meaning were also replaced with single term or phrase to draw meaningful innuendo. The subject analysis was performed by using author-generated and index keywords (n=18166, including 56 having 100 or more occurrences) after removing duplicity due to plural forms and appearance of different terms representing the same subject.

Authors encountered another problem during basic analysis of institutional contributions, i. e. the institutional names were not listed in uniform style. Instances were observed where the name of a given institution was listed differently in different articles, viz. some articles listed complete name of an institution, other enlisted abbreviated name and sometimes name of the department/college/laboratory was also attached to the institution name. This made the assessment of inter-institutional productivity and collaborations difficult to map out. Hence, all institutional names were examined individually and manually standardized. The institutions having multiple campuses at different places within a country were treated as a single institution when examining inter-institutional collaborations.

Data Visualization

The scientific productivity on Coronavirus was mapped using free-to-use data visualization software. The most productive institutions and countries were identified and visualized to have nodes and edges. The nodes represent institutions, countries and subject terms and the edges are the links between nodes establishing their inter-connectivity. The thickness of edges represents the strength of collaboration between institutions and countries and co-occurrence of key-words in subject analysis. The size of the nodes represents the number of articles contributed by respective institutions and countries, and the frequency of occurrence of keywords in articles.

Results and Discussion

Chronological trends in Corona virus publications

During the years 2010 to 2019, a total of 5769 publications were recorded in the Scopus database on corona virus. The chronological growth of articles on coronavirus published in journals is illustrated in Fig. 1.

Though the scientific communications have increased by almost 50% from the year 2010 to 2019,

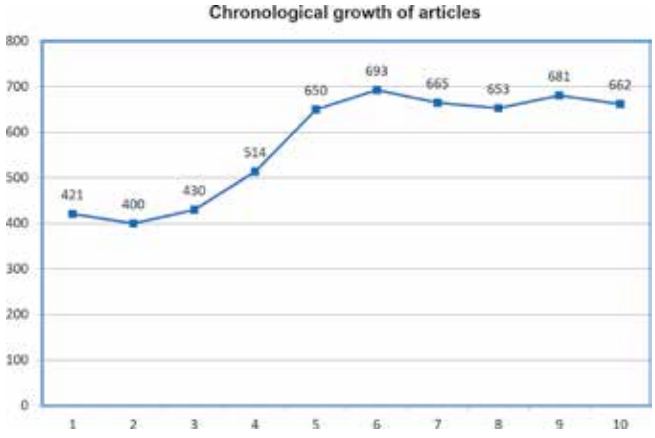


Fig. 1: Chronological growth of publications

the rate of growth of publications on the subject flatted after this period. This has not been in line with the growth in scientific literature on other science subjects. The growth arc of publications on corona virus during last five years appears to be static. As the COVID-19 has shattered the world and instigated the situation for extra efforts for quick research on this subject, the curve of growth of scientific communications is expected to shoot upwards quickly in coming years.

Authorship Trends

All except 03.76% articles of the total 5769 under study have been an outcome of the collaborative authorship. Author information was not available for 13 articles. More than 33% (1955/5769) articles were contributed by 2 to 5 authors and 43.18% (2491/5769) articles were authored by 6-10 co-authors each. Interestingly, 18.95% articles have been an outcome of collaborative efforts of more than 10 authors each, one having 264 authors. In total, 21668 authors contributed to the 5769 scientific communications on Coronavirus. Out of these, 7.09% (1536) authors contributed to 5 or more articles, whereas remaining majority of authors contributed on Coronavirus occasionally. Seventy one authors contributed to 30 or more articles each. Based on above data, a strong collaborative research commitment among scientific fraternity is observed to contain the Coronavirus.

Major contributing countries

Authors from a total of 138 countries contributed the 5769 records. Forty two countries from Asian continent lead by China contributed to the highest number of scientific communications, i. e. 3197 articles. Forty nations from the Europe collectively contributed to the second highest number of records (n=2317), followed by contribution of 2087 records from 12 North American nations, and 336 articles from 32 African countries. Australia/ Oceania contributed to 21 records and Australasia contributed to 160 records.

Five of these 138 countries did not have international collaboration. Thirty one countries from the African continent, 41 from Asia, 39 from Europe, 11 nations from North America, 9 from South America and one each from Australia/ Oceania and Australasia worked in international collaboration on Coronavirus in form of journal articles.

The network visualization map of the countries having contributed at least twenty articles on Coronavirus was developed using *Visualization software*. The top 42 countries with highest number of articles on Coronavirus are shown in Fig. 2.

There are total of four country clusters represented by Fig. 2. The clusters have been developed using *Visualization software* based on the co-occurrence of terms. Each cluster represents conjointly related nodes and each node in a network fall under one cluster only.

Each of the top seven countries including United States, China, South Korea, United Kingdom, Germany, Saudi Arabia and Netherlands contributed to more than 5% of the total scientific communications on Coronavirus. The United States occupies the leading position with contribution of the highest number of records (31.74%, 1831/5769 documents) on the subject. Research contributions from researchers representing different continents of the world are in line with the incidences of Coronavirus in different parts of the world. China contributed second highest number of scientific communications on coronavirus (22.47%, 1296/5769), followed by South Korea (07.28%, 420/5769), United Kingdom (06.63%, 383/5769), Germany (06.09%, 351/5769), Saudi Arabia (05.25%, 303/5769) and Netherlands (5.04%, 281/5769). The United States has strong collaboration strength with China (Fig. 4) followed by United Kingdom, Saudi Arabia, Germany and Canada. It is interesting that European countries United Kingdom, Austria, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Netherlands, Norway, Poland, Spain, Sweden and Switzerland along with a few Asian countries form a different cluster based on their mutual research

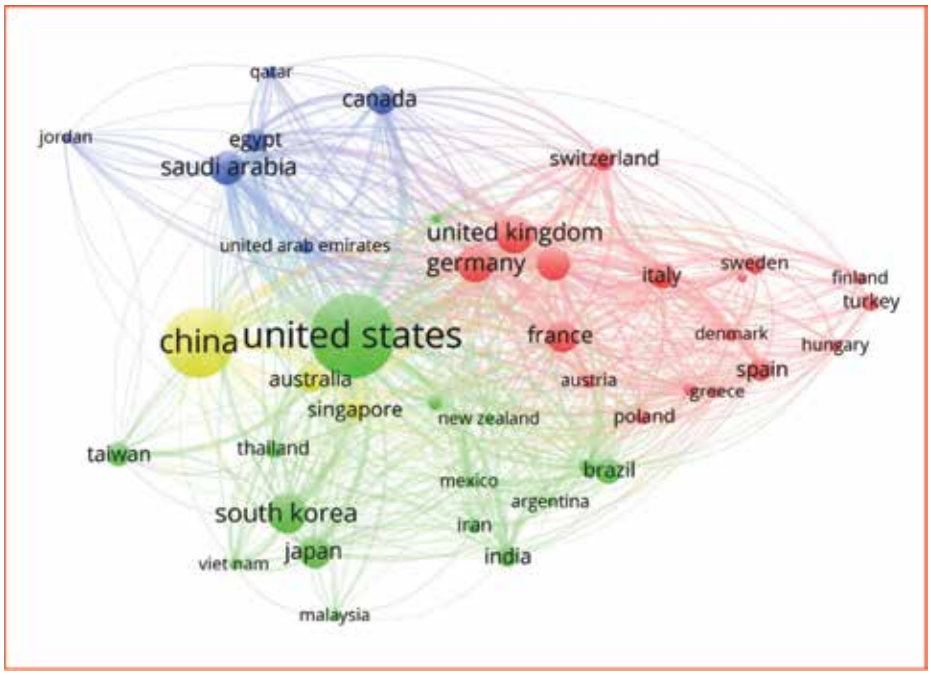


Fig. 2: Most productive countries and collaboration trends amongst them

The number of articles, links and total Link Strength of top 10 countries is listed here. L-Links, LS-Link Strength, D-Documents. United States (L-41, LS-1313, D-1829), China (L-38, LS-614, D-1296), South Korea (L-33, LS-138, D-419), United Kingdom (L-41, LS-605, D-383), Germany (L-41, LS-497, D-351), Saudi Arabia (L-38, LS-398, D-303), Netherlands (L-40, LS-74, D-290), France (L-41, LS-373, D-267), Japan (L-34, LS-130, D-252), Canada (L-32, LS-223, D-207).

collaborations. During the analysis, it has been noticed that out of total 138 nations, 41 nations contributed to more than 20 records each, 15 countries added to 11-20 records. 23 contributed to 5-10 records. Remaining majority, i.e., 59 countries were occasional contributors of 1 to 4 records only.

The analysis of geographical distribution of journal articles depicts that the authors from all over the world representing different continents made academic/ research contribution towards Coronavirus.

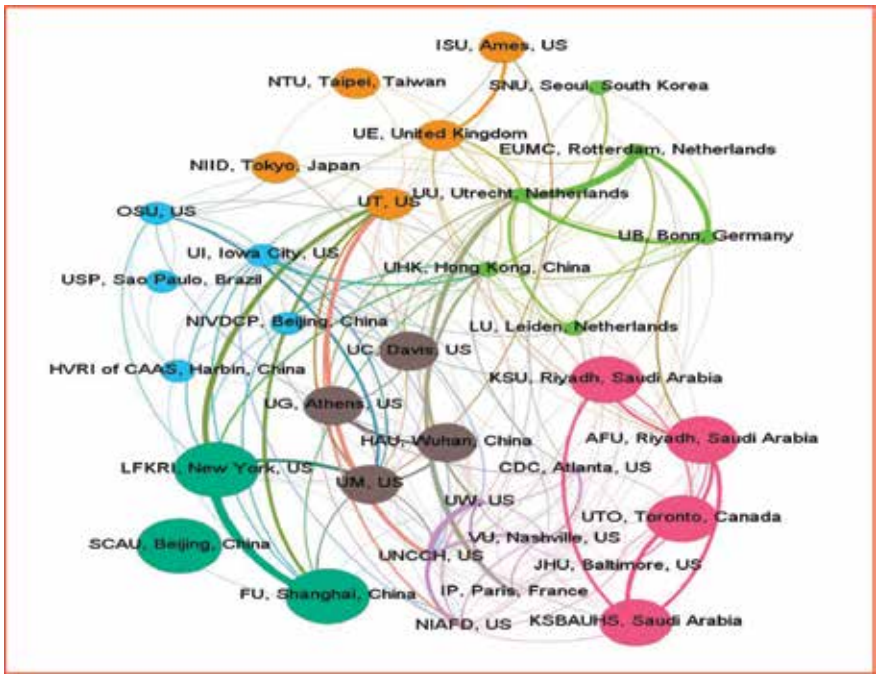
Institutional productivity

Interestingly, authors from 6131 institutions/ organizations contributed to the total of 5769 scientific communications under study. The collaboration visualization map of 34 institutions/ organizations having contributed to 40 or more articles each is represented in Fig.3. The publication matrix of top 10 institutions/ organizations with contribution of highest number of articles is also given.

The University of Hong Kong, Hong Kong, China has contributed highest number of articles on Coronavirus (n=166), followed by the University of North Carolina at Chapel Hill, United States with addition of 106 articles. Centers for Disease Control and Prevention, Atlanta, United States,

Utrecht University, Utrecht, Netherlands, National Institute of Allergy and Infectious Diseases, United States, Seoul National University, Seoul, South Korea, Erasmus University Medical Center, Rotterdam, Netherlands, University of Bonn, Bonn, Germany, University of Texas, United States and University of Iowa, Iowa City, United States are among the top ten contributors of scientific communications on Coronavirus with contribution of 96, 90, 86, 82, 74, 74, 73 and 72 articles respectively.

A look at the Fig. 3 reveals that various institutions from United States including University of North Carolina at Chapel Hill, Centers for Disease Control and Prevention, National Institute of Allergy and Infectious Diseases, University of Washington, and Johns Hopkins University in collaboration with Institut Pasteur, Paris, France form a separate cluster, depicting prevalence of strong inter-institutional collaboration at national level. Similarly, institutions from United States have also worked in international collaboration



Name of University	Weight Links	Citations	Weight total links strength	Number of Documents
University of Hong Kong, Hong Kong, China	18	1227	55	166
University of North Carolina at Chapel Hill, United States	20	985	74	106
Centers for Disease Control and Prevention, Atlanta, United States	11	339	26	96
Utrecht University, Utrecht, Netherlands	17	1133	77	90
National Institute of Allergy and Infectious Diseases, United States	19	400	48	86
Seoul National University, Seoul, South Korea	5	704	8	82
Erasmus University Medical Center, Rotterdam, Netherlands	11	189	50	74
University of Bonn, Bonn, Germany	11	34	44	74
University of Texas, United States	16	499	61	73
University of Iowa, Iowa City, United States	19	321	47	72

Fig. 3: Most productive institutions on Coronavirus

AFU-Al Faisal University, CDC-Centers for Disease Control and Prevention, EUMC-Erasmus University Medical Center, FU-Fudan University, HVRI of CAAS-Harbin Veterinary Research Institute of the Chinese Academy of Agricultural Sciences, HAU-Huazhong Agricultural University, IP-Institut Pasteur, ISU-Iowa State University, JHU-Johns Hopkins University, KSBAUHS-King Saud Bin Abdulaziz University for Health Sciences, KSU-King Saud University, LU-Leiden University, LFKRI-Lindsley F. Kimball Research Institute, NIVDCP-National Institute for Viral Disease Control and Prevention, NIVDCP-National Institute of Allergy and Infectious Diseases, NIID-National Institute of Infectious Disease, NTU-National Taiwan University, OSU-Ohio State University, SNU-Seoul National University, SCAU-South China Agricultural University, UB-University of Bonn, UC-University of California, UE-University of Edinburgh, UG-University of Georgia, UHK-University of Hong Kong, UI-University of Iowa, UM-University of Minnesota, UNCCH-University of North Carolina at Chapel Hill, USP-University of Sao Paulo, UT-University of Texas, UTO-University of Toronto, UW-University of Washington, UU-Utrecht University, VU-Vanderbilt University.

with institutions from China, Brazil, Japan, Taiwan and United Kingdom. The University of Hong Kong, China, Utrecht University, Netherlands, Seoul National University, South Korea, Erasmus University Medical Center, Netherlands, University of Bonn, Germany and Leiden University, Netherlands form a separate cluster of research collaborators. The institutions from Saudi Arabia including King Saud University, Al Faisal University and King Saud Bin Abdulaziz University for Health Sciences form a separate cluster of collaborators with University of Toronto, Toronto, Canada. The different clusters represented by Fig. 3 shows that institutions from different nations of different continents have worked in tandem to contain the virus.

Institutional collaboration and participation on corona virus research indicates adoption of sectional approaches which is visible from few independent and isolated research groups working especially on MERS-CoV in Riyadh, Saudi Arabia having partnership with some research groups from Canada with intermediary connection with groups from USA. A multiple, small to big research groups having strong commonality for research on corona virus is evident and a great chunk of it belongs to researcher from either China or USA. Apart from it, a strong research connection can also be seen between researchers from Japan, Taiwan, South Korea with both UK and USA. Smaller research groups do exists in some countries of Europe namely Germany and Netherlands potentially pursuing research on corona virus.

Subject Analysis

Subject Analysis based on keywords

The top 54 keywords (out of total 18166, after standardization) having been cited in 100 or more articles were considered for cluster analysis (Figure 7). A total of three clusters were identified by clustering schema of visualization software. The nodes in figure represent the keywords/ subject terms and edges reveal the relation between different keywords representing subjects.

The current outbreak of COVID-19 (SARS-CoV-2) is believed to have originated from animal source i.e. from Horse shoe bat that perhaps transcended beyond animal kingdom and unbecomingly sneaked into human system. This virus belongs to family *Coronaviridae* has some degree of commonality to earlier reported corona virus infection of human beings which has significantly affected certain human races of populations viz; oriental people with SARS-CoV-1 and MERS-CoV i.e. Middle east respiratory syndrome to the people of middle east region of globe through dromedary camels. Nevertheless, the global impact of earlier two syndromes was little inconsequential to the current outbreak of Cov-2. However, having some acerbic experiences from these two outbreaks, the scientific and medical fraternity conjointly decided to confront the situation by undertaking mammoth degrees of investigations and attempts on gathering scientific linkages if any, which essentially have helped them in garnering vital leads and remarkable pieces of information. This accrued knowledge may prove beneficial in the upcoming attempts to tackle COVID-19 menace through our scientific endeavours. Going by the scientiometric analysis, we were successful in relating the importance of biotic and abiotic factors besides diagnostic and therapeutic attempts that helped us in assessing the general trends of global research against this virus. The analysis categorically suggests a holistic approach being meted out in every aspect of this virus infection to dissect each and every bit of information for benefiting human and animal health system and for their future safety. Our understanding suggests, a great deal of research on corona virus was undertaken in poultry and of swine origin in China, even several decades before, the global attempts to pursue research on SARS-CoV 1 and MERS-CoV. The earlier research attempts on animal corona virus includes isolation and purification of virus, identification of its genomic origin, sequence analysis and its classification based on host susceptibility and ranges particularly among veterinary patients. The major impetus until then was given on animal origin corona virus research especially on poultry specific isolates, which is responsible for causing infectious bronchitis (IB) in chickens and adult laying hens that impinges significantly on economic fronts to poultry farmers. Though, its (virus) affinity to affect respiratory system was remotely and limitedly known to poultry practitioner and poultry researchers, however a major impulsion was gained during the studies conducted on MERS-CoV in human beings. Regarding its structural analysis, it can be believed that poultry specific corona virus isolates were initially and extensively considered for protein sequence analysis and due to known variability within spike protein sequence(s) among isolates of various host origins; a detailed analysis was therefore conducted using SARS-CoV isolates of human origin. A significant understanding on the epidemiologic aspect of corona virus infection was

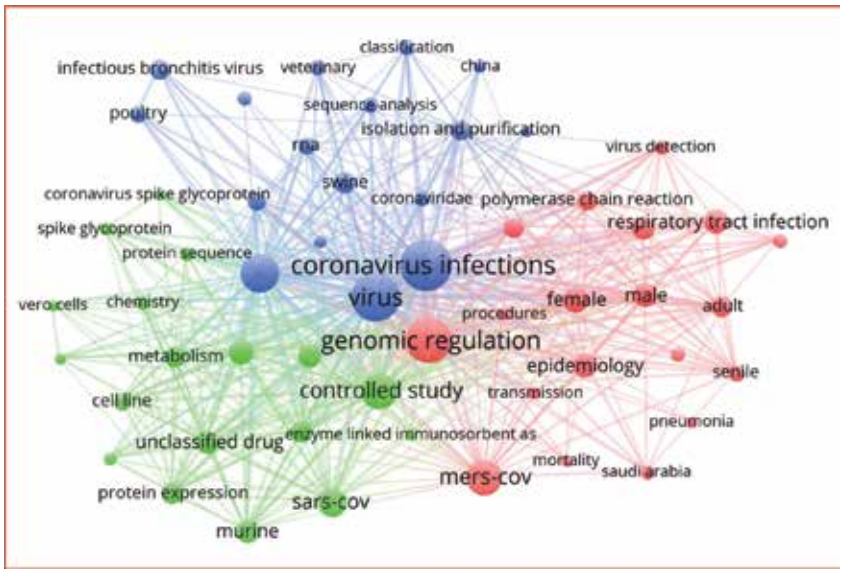


Fig. 4: Keyword visualization map

O-Occurrences, L-Links, LS-Total Link Strength; Top 15 keywords along with occurrences, links and total link strength are: Coronavirus Infections: O-1931, L-53, LS-11444; Virus: O-1742, L-53, LS-12759; Genomic Regulation: O-1539, L-53, LS-12298; Animal: O-1108, L-53, LS-9436; Controlled Study: O-974, L-53, LS-8769; Mers-Cov: O-928, L-52, LS-3974; Sars-Cov: O-623, L-53, LS-3622; Female: O-511, L-53, LS-4892; Male: O-466,L-53, LS-4344; Respiratory Tract Infection: O-460, L-50, LS-2210; Nongenomic Regulation: O-456, L-53, LS-4245; Epidemiology: O-451, L-53, LS-2519; Immunity: O-391, L-53, LS-3236; Children: O-389, L-53; LS-2727.

attained while attending case studies from MERS-CoV outbreak in Saudi Arabia associated with dromederal camels. During and aftermath of this infection study, an important knowledge emerged out which indicates age and gender susceptibility in contribution towards maintenance of corona virus infection in population, a similar trend previously observed in poultry affiliated corona virus infection. However, a little contravention attached with human corona virus infection, where adults with increasing ages were found to be mostly affected with respiratory tract infections culminating into pneumonia like conditions, unlike poultry where mostly reproductive tract and urinary systems are involved. A detailed *in vitro* study pertaining to virus (SARS-CoV) and host cell interaction using Vero-cell line indicated major work undertaken on understanding impact of virus particle on cellular metabolism, protein expression and immunological regulations by host cells. Further confirmed and controlled experimental study using murine model of infection was developed where indication on role of immunity and host affiliated protein expression in combating virus infection was undertaken. Studies on Enzyme linked immunosorbent assay (ELISA) was probably undertaken for initial and extensive testing of antibody detection specific to early phases of virus infection in host and was standardized through murine based *in vivo* experimental study. Additionally, a recent and highly specific detection technique known as Polymerase chain reaction (PCR) was put in place for immediate and rapid identification of diseased individuals. PCR was more aggressively practiced during MERS-CoV outbreak to contain further spread out. Research emanated on other aspects had also included gene expression studies as paramount to understand various host's regulatory factor and immuno-pathogenetic aspects of corona virus infection deciding the course of infection in hosts. Such attempts was equitably pursued in all the three corona affiliated virus i.e, against infectious bronchitis of poultry, SARS-CoV1 and MERS- CoV. Surprisingly, a major thrust in research and development of drug molecule was attempted instead of vaccine formulation against human corona viruses; however poultry vaccines against corona virus are available and widely practiced in endemic areas. A probable reason could be cited as continuously emerging new serotypes and genotypes of pathogen which potentially masquerading vaccine variants present in live vaccines, and evading host immune response mechanism.

Conclusions

The present study has found that, though, there is a strong collaborative research commitment among scientific community for contribution towards Coronavirus

and the authors from all over the world representing different continents made academic/ research efforts, the scientific communications on Coronavirus grew slightly during the span of first five years under study. But the overall growth rate of publications on Coronavirus during last five years has been negative, indicating the need for attention on the subject. With the disastrous situation created due to emergence of novel coronavirus and the ongoing research efforts to contain the deadly diseases, the scientific communications are expected to increase tremendously in coming years. Interestingly, strong research milieu and collaboration has been revealed by the findings of study at author, institutional and country level. All but 03.76% of the articles have been an outcome of collaborative research efforts of individuals. Similarly, contribution to 5769 articles from authors of 138 countries and 6000+ institutions/organizations depicts the concerns of global scientific community on Coronavirus, which have been enunciated through network visualization for deciphering the most productive countries vis-à-vis institutions for better comprehension of the subject for having a working model as a living road map for having strategies in place to combat this menace of COVID-19.

Subject analysis has clearly indicated employment of multifactorial approach in understanding the nature of virus along with their impact over various hosts including animal species. We considered that the diagnostic testing(s) developed over a small period of time against this infection was remarkable and has given us enormous relief in implementing them in the shortest possible time. The requisite thrust on containment of the disease through vaccine research or therapeutic approach was however marginally applied probably due to several occasions of failure, now warrant(s) super special effort(s) in this direction to implement in the current face of outbreak. Several laboratories across the globe are currently focusing on developing a suitable vaccine(s) to ward off this global disaster, besides applying permutation and combinations of already existing antiviral and anti-protozoal drugs such Chlorhydroxyquine besides immunotherapeutic concepts. In our view, the practice of adoptive immunity transfer may yield wider success until the phases of vaccine development, with appropriate cautions to immunoreactivity in individual humans/ animals.

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