Acta Scientific MICROBIOLOGY (ISSN: 2581-3226)

Volume 5 Issue 4 April 2022

Research Article

COVID-19 Pandemic: A Scientometric Assessment of Relevant Global Publications on Medicinal Plants as Potential Source of Phytomolecules Against an Infamous Foe

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DOI: 10.31080/ASMI.2022.05.1040

Received: February 18, 2022

Published: March 18, 2022

Abstract

The global use of medicinal plants increased astronomically during the COVID-19 pandemic, due to claims that phytomedicines with immunomodulatory or anti-inflammatory activities can prevent or cure COVID-19 infections. The present study employed scientometric techniques to analyse 830 publications retrieved from Scopus database using VOSviewer. The search for potent and safe medicinal plants against COVID-19 infections were divided into three main components namely review of literatures, *in silico* studies *vis-á-vis* molecular docking and molecular dynamics simulations, and network pharmacology. Our studies revealed that international institutional collaborations increased during the period under review. Our findings also indicated close research and publication efforts amongst scientist in both developed and the developing countries. Some medicinal plants with appreciable publication visibilities screened for their therapeutic potentials against COVID-19 infections included *Allium sativum*, *Artemisia annua*, *Azadirachta indica*, *Ocimum sanctum*, *Tinospora cordifolia* and *Withania somnifera*. Some phytocompounds with high occurrences included kaempferol, emodin, curcumin, artemisinin, catechin, ursolic acid, luteolin, myricetin and rutin. *In silico* investigations served as a vital component of medicinal plant research, which helped in the identification many natural compounds with the potential of targeting SARS-CoV-2. More *in vitro* and *in vivo* studies are recommended to validate the potential of these natural compounds in the mitigation of SARS-CoV-2. Specific preclinical and clinical trials are required to evaluate the effects of herbal immunoregulators need more attention. Medicinal plants remain an important source for finding and developing remedies against COVID-19.

Keywords: Scientometrics; Bibliometrics; SARS-CoV-2; COVID-19; Medicinal Plants; Phytomolecules; Phytotherapeutics; Herbal Remedies; Prevention; Cure

Introduction

Coronaviruses belong to a large family of enveloped, non-segmented, and positive (+) sense single stranded RNA viruses that circulate within different animal species including bats, cats, dogs, camels etc. These viruses are named coronaviruses due to their structural resemblance to a crown or corona [1]. Coronavirus disease 19 (COVID-19) or severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection was discovered in late De-

cember 2019, in Wuhan China [2]. The disease severity of SARS-CoV-2 especially in the elderly and patients with co-morbidities, is characterized by hypercytokinemia, an exaggerated immune response associated with an uncontrolled and excessive release of proinflammatory cytokine mediators also known as cytokine storm [3].

Concerns and worries within communities, especially amongst the middle- and low-income groups acutely affected by the economic impact of forced lockdowns, led to increased interest in exploring alternative choices of medicinal plant-based therapeutics [4]. The global use of medicinal plants increased astronomically during the COVID-19 pandemic [5], largely due to claims or beliefs that phytomedicines with immunomodulatory activities can prevent or cure COVID-19 infections [6]. Other reports indicated that herbal medicines with anti-inflammatory properties may be effective in managing COVID-19 infections via the inhibition of viral entry and replication, mitigation of cytokine storm, immunomodulatory activity and organ protection [1,7]. There is currently no specific antiviral drug for the treatment of COVID-19. Most treatment strategies focus on symptomatic management and supportive therapy. As such, several drug discovery efforts are ongoing for potent therapeutic agents, with medicinal plants gradually gaining ascendancy [8]. The investigation of bioactive compounds with specific anti-COVID 19 therapeutic efficacy is the primary focus of many biomedical researches. In view of the latter, *in silico* and network pharmacology has become a very important tool in the quick discovery of drugs against SARS-CoV-2 infections [9].

The information on the potentials of medicinal plants and/or natural products to combat COVID-19 is based on data-driven approaches such as literature surveys using online databases like Scopus, Web of Science, Google scholar, PubMed etc., and the application of rational computational chemical biology techniques [10]. Specifically, molecular docking is foremost amongst some of the drug discovery efforts. In *silico* techniques were used to investigate a plethora of medicinal plants, such *Glycyrrhiza glabra*, *Hibiscus sabdariffa*, *Cichorium intybus*, *Chrysanthemum coronarium*, *Nigella sativa*, *Anastatica hierochuntica*, *Euphorbia spp*, *Psidium guajava*, *Withania somnifera* (Ashawagandha), *Tinospora cordifolia*, *Allium sativum* (Garlic), *Zingiber officinale* (Ginger), *Curcuma longa* (Turmeric), Cinnamon, *Moringa oleifera* (Drumsticks), *Azadirachta indica* (Neem), *Ocimum tenuiflorum*, *Ocimum sanctum*, *Camellia sinensis* (Green tea), *Astragalus membrenaceus*, *Piper longum*, *Phyllanthus emblica*, *Cinchona officinalis*, *Curcuma xanthorrhiza*, *Althaea officinalis*, *Commiphora molmol*, *Hedera helix*, *Sambucus nigra*, *Andrographis paniculata*, *Echinacea angustifolia*, *Echinacea purpurea*, *Eucalyptus globulus* essential oil, *Justicia pectoralis*, *Vernonia amygdalina*, *Eurycoma longifolia Magnolia officinalis*, *Mikania glomerata*, *Pelargonium sidoides*, *Pimpinella anisum*, *Salix spp*, *Sutherlandia frutescens*, *Hypoxis hemerocallidea*, *Xysmalobium undulatum*, *Acacia senegal* and *Epilobium hirsutum*.

Approximately, 16500 phytoconstituents were investigated for their ability to prevent or inhibit the replication of SARS-CoV-2 RNA by targeting viral proteins, enzymes and modulation of the host's immunity [1,4,5,8,11-13]. Flavonoids, are very important specialised metabolites of plants, that have long been studied for their therapeutic interventions in inflammatory diseases due to their cytokine-modulatory effects [3]. Some of the compounds with activity against prostaglandin G/H synthase (PTGS2), interleukin 2 (IL2), interleukin 1 beta (IL1b), vascular cell adhesion molecule 1 (VCAM1) and tumor necrosis factor (TNF) include quercetin, ursolic acid, kaempferol, isorhamnetin, luteolin, glycyrrhizin, acetoside, glyasperin, arabic acid, L-canavanine, hypoxoside, uzarin isorhamnetin, and several flavonoid compounds and apigenin [8,12]. Other phytocompounds found in many plants with the potentials of reducing the symptoms of acute respiratory distress syndrome (ARDS) symptoms include resveratrol, a phenolic compound with the potential to suppress cytokine storm and severe inflammation caused by SARS-CoV-2, and with strong activity against various types of DNA/RNA viruses

The COVID-19 pandemic has not yet been fully controlled considering the recent spate of outbreaks of COVID-19 variants globally. Consequently, bibliometric analysis of medicinal plant publications in relation to COVID-19 infection mitigation is very important and timely. The current undertaking will help identify related subjects that require further research. The basic idea of bibliometrics is to quantify academic or research output of authors, regions and institutions; inferences are usually drawn from figures (networks), number of occurrences (size of the node), association or connection of items [14]. Thus, to provide insights into future research priorities, the present study evaluated publications related to medicinal plant researches on COVID-19 and analyzed current top publications, most productive journals, countries and institutions.

Methodology

Data source

Data was retrieved from Scopus database (https://www.scopus.com) on the 5th of January 2022. Keywords such as "COVID-19" OR "SARS-CoV-2" OR "nCoV-2" AND "Medicinal plants" OR "Phytotherapeutics" OR "Phytotherapy" were searched in the – Title-Abstract-Keyword field. The edited dataset was saved as *.csv file and exported to visualisation of similarities viewer (VOSviewer) for further scientometric analysis. VOSviewer is a free licensed user-friendly software. It is Java powered and able to generate high-resolution visual images of bibliographic networks. The software offer opportunities for researchers to examine bibliographic work [15,16].

Data analysis

Methods used by Elisha and Viljoen [17], were adopted with some modifications. Briefly, documents retrieved were analysed using the Scopus built-in function to "analyse data", while VOSviewer was used to determine the co-occurrence of terms in the title and abstract field, generate term maps and explore bibliographic data for research themes. Default settings and in some instances, parameters were adjusted to construct and analyse network maps and other visualisations.

Result and Discussion

Within the purview of documents retrieved from Scopus database this is the first bibliometric study summarizing relevant evidences on the potential use of medicinal plants and other natural products via qualitative surveys, *in vitro* and to large extent *in silico* studies. Publication output is quickly rising partly due to the urgency to discover new, effective and safe herbal medicines or specialised metabolites with anti-COVID-19 potentials. Knowledge of existing publications may help researchers better understand issues that require further research.

A summary of retrieved publication statistics

This study covered the year 2020-2021, a period that has recorded remarkable scientific researches and advancements on COVID-19. The year 2020 had 273 publications, while 2021 had 557 related papers. The total number of articles analysed was 830 publications, with total citations of 7999 and H-index 39. The document types were full research articles (476), review papers (282), while letters, conference papers, editorial, book chapter, notes, short surveys were 72 respectively. The most important forms of written output were publications in journals.

Performance analysis of authors, journals, regions and contributing institutions

A total of 4122 authors participated in all the publications and approximately, 0.58% of the authors had ≥ 5 publications. Furthermore, 1.24% of the authors individually published ≥ 4 papers, while 3.25% published ≥ 3 articles and 11.8% published at least ≥ 2 documents respectively. The aforementioned, suggests greater opportunities for scientist to venture more into this field of research. Worthy of note is that during the period under review, 370 journals contributed in the publications. These journals have high visibility with high impact factors, they traverse a plethora of publication titles across disciplines. Most of the sources have similar objectives which include investigating medicinal plants known to have antiviral activities; specific attention on COVID-19 infection. The scope of some of these journals included organic chemistry, medicinal chemistry, natural products, inorganic chemistry, basic and clinical pharmacology, pharmacy and toxicology. In many instances, the journals concentrated on publications targeting clinical applications of herbs and natural products in medicine. Other sources published research outcomes on the mechanism of action of plant extracts or isolated bioactive phytoconstituents using -omics and computational technologies, general translational research, drug target identification, network pharmacology, virtual drug design and combinational therapy.

In-depth analysis of the density map (Figure 1), revealed that the ten most productive sources included the Journal of Biomolecular Structure and Dynamics with 37 documents, 1035 citations and current impact factor 3.392, this was followed by Molecules (35:257:4.411); Frontiers in Pharmacology (33:249:5.81); Phytotherapy Research (27:256:5.882); International Journal of Research in Pharmaceutical Sciences (25:27:0.604); Phytomedicine (14:213:5.34); IOP Conference series: Earth and Environmental Science (13:4:0.41); Pharmacological Research (10:438:7.65); Natural Product Communications (9:44:0.96) and Current Pharmaceutical Design (9:16:2.208) respectively. Molecules had the strongest total link strength with 27.3% of all the sources that contributed in the entire publications. This is an indication of the weight of association or connection with other journals in the cur-

rent field of study, referenced or co-cited or have close match to publication titles or subject areas. Frontiers in Pharmacology was second with 19.5% connection to other sources, Phytotherapy Research, 14.1% and Journal of Biomolecular Structure and Dynamics 13.8% respectively. A limitation in VOSviewer visualisation is the inability of some items in the network to be captured because they are masked by other items with large nodes or bubbles. The subject areas covered in this bibliometric study have the highest to the lowest categories in pharmacology, toxicology and pharmaceutics (42%), medicine (37.1%), biochemistry, genetics, and molecular biology (32%), agricultural and biological sciences (15.1%), chemistry (14%), immunology and microbiology (9.2%), computer science (3.7%) respectively.

Figure 1: Density visualisation of the most productive journals in medicinal plants and related research towards prevention or cure of COVID-19 (SARS-CoV-2) infections globally.

Ninety-eight (98) countries or regions participated in the current study. The legend in Figure 2 describes the publication weight of the different countries. The leading and most productive countries in the literature analyzed were India (259 publications representing 31.2% of total documents), China (112 articles, 13.4%), United States (84 articles, 10.1%), Saudi Arabia (56 articles, 6.7%) and Egypt (42 articles, 5.1%) respectively. The most cited countries were China (2273 citations), India (2160 citations), Saudi Arabia (897 citations), United States of America (792 citations), and United Kingdom (609 citations). The co-authorship evaluation of the contributing countries based on the closeness of nodes and the thickness of the connecting lines in the visualisation networks indicated a very strong association between India, USA, South Korea, France, Lebanon and Finland; a strong publication or research connection with Saudi Arabia and moderate publication partnership with United Kingdom, Nigeria, Israel, South Africa and Malaysia. China had a very strong research association with Brazil, Austria, Germany, Iran and Malaysia, while a strong connection with Hong Kong, Pakistan, USA, South Korea and India (Figure 3).

Altogether, 3039 organizations contributed in all the publications during the period under review. From the tabulated record

Figure 2: Publication output of the 98 countries contributing to medicinal plant and related research for the prevention or cure of COVID-19 (SARS-CoV-2) infections globally, retrieved from Scopus database.

Figure 3: Network visualisation of the productivity and Co-authorship association of the 98 participating countries in medicinal plant and related research for the prevention or cure of COVID-19 (SARS-CoV-2) infections retrieved from Scopus database.

showing the 20 most productive organisations, the organisation ranked first based on total publications was Mahatma Gandhi Ayurved College Hospital and Research Centre in India with 18 publications and 22 citations, followed by Ministry of Education, Beijing China (15:378), Datta Meghe Institute of Medical Sciences, India (14:16), King Saud University, Riyadh Saudi Arabia (13:135), China Academy of Chinese Medical Sciences, Beijing China (11:154), see Supplementary table 1. Additionally, the top 20 institutions contributed 207 (25%) of the entire publications and 2240 citations. Fifty-six (56) countries representing 57.1% of the participating countries in this study teamed up to research and publish. The institutions have different research expertise that ranges from antiviral activity screening, anti-inflammatory screening, immunomodulatory assays, *in vitro* and *in vivo* pharmacological research, computational investigations (molecular docking and molecular dynamics). Some of the organisations are located in countries most affected by the pandemic, other institutions have substantial resources, facilities and funding for research. Especially institutions from developed countries, most of which have well-developed and reliable data management systems. The more institutions collaborate internationally, the better the quality and output of their research, the higher the chances of translating findings for the benefit of the public. Subsequently, the Universita Degli Studi Di Napoli Federico II (Italy) had the highest number international collaborations in their publications with 24 countries, followed by Universidade de Porto (Portugal) involving 23 countries and Quaid-i-Azam University Islamabad (Pakistan) with 21 contributing countries. India contributed 65% of the institutional publications followed by China and the United Kingdom (55%), USA and Saudi Arabia (45%), Egypt and Germany (40%), with Malaysia collaborating in 35% of the institutional publications (Table S1). There is a strong link between developed countries and developing in the networks.

Ranking	Institution	TP	TC	HI	Country	No. CI	Country of CI	Research activity
1	Mahatma Gandhi Ayurved College Hospital and Research Centre	18	22	3	India	5	India	Ayurvedic research and herbal formulation
2	Ministry of Education, Beijing	15	378	5	China	53	China, India, Sudan, Pakistan, United Kingdom, Egypt, USA, Hong Kong, Malaysia, Macau, South Korea, Iraq	Traditional Chinese Medicine, molecular docking and molecular dynamics
3	Datta Meghe Institute of Medical Sciences	14	16	2	India	5	India	Ayurvedic research and herbal formulation
4	King Saud University, Riyadh	13	135	5	Saudi Arabia	49	Saudi Arabia, India, South Korea, Egypt, China, United Kingdom, Morocco, Sudan, Ukraine	Antiviral screening, molecular docking and molecular dynamics
5	China Academy of Chinese Medical Sciences, Beijing	11	154	5	China	46	China, Hong Kong, Denmark, Canada, Germany, Ireland, USA, United Kingdom	Traditional Chinese Medicine, Molecular docking
6	King Abdulaziz University, Jeddah	10	47	3	Saudi Arabia	37	Saudi Arabia, Australia, China, Egypt, India, United States of America, Jordan, Pakistan, Sri Lanka, United Kingdom	Antiviral activity screening, computational investigations

7	Università degli Studi di Napoli Federico II, Naples	10	120	7	Italy	78	Italy, Bangladesh, Spain, Iran, Turkey, United Kingdom, Austria, China, Croatia, Finland, France, Germany, India, Indonesia, Israel, Oman, Portugal, Romania, South Africa, South Korea, Sweden, Switzerland, Taiwan, United States of America	Molecular docking and Molecular dynamics
8	Chinese Academy of Sciences, Beijing	10	67	4	China	52	China, Pakistan, Australia, Denmark, Georgia, Hong Kong, United Kingdom, United States of America	Computational investigations
9	University of Ilorin, Ilorin, Kwara State	9	126	5	Nigeria	29	Nigeria, Egypt, Argentina, Germany, India, Malaysia, Saudi Arabia	Antiviral activity screening and computational investigations
10	National Research Centre, El Buhoth St., Cairo	9	61	5	Egypt	40	Egypt, Saudi Arabia, United Kingdom, France, Germany, Iraq, Jordan, Lebanon, Tunisia, United States of America	Antiviral activity screening and Molecular docking and molecular dynamics
11	Alagappa University, Alagappa Puram, Karaikudi TN	9	168	5	India	11	India, China, Chile, Jordan, Malaysia, Thailand	Computational study of phytochemicals
12	College of Pharmacy, King Saud University, King Khalid Rd, Riyadh	8	62	3	Saudi Arabia	26	Saudi Arabia, India, Egypt, China, Morocco, Ukraine, United Kingdom	Ethnomedicine
13	Minia University, Main Road - Shalaby Land, Minia	8	61	5	Egypt	38	Egypt, Saudi Arabia, Armenia, Jordan, United Kingdom, Germany, Taiwan	Anti-inflammatory activity screening, molecular docking
14	Shanghai University of Traditional Chinese Medicine, Shanghai	8	121	6	China	10	China	Traditional Chinese Medicine and computational investigations
15	Mahidol University, Nakhon Pathom	8	71	4	Thailand	24	Thailand, Denmark, India, Nepal, United Kingdom	*In vitro* and *in vivo* pharmacological research

16	Jamia Millia Islamia, Jamia Nagar, New Delhi	8	210	4	India	11	India, Saudi Arabia, Nigeria	Ayurvedic medicine, molecular docking and molecular dynamics
17	Quaid-i-Azam University, Islamabad	8	55	4	Pakistan	50	Pakistan, China, Australia, Bolivia, Brazil, Egypt, Georgia, Germany, Indonesia, Iraq, Italy, Macao, Malaysia, Romania, Saudi Arabia, South Africa, Spain, Sweden, Turkey, United Arab Emirates, United States of America	Ethnopharmacology
18	Academy of Scientific and Innovative Research AcSIR, Ghaziabad UP	8	213	3	India	16	India, Malaysia	Ethnopharmacology and computational investigations
19	Harvard Medical School, Boston MA	7	114	4	United States of America	28	United States of America, China, Jamaica, Bangladesh, Finland, Germany, Malaysia	Phytochemistry and Phytomedicine
20	Universidade do Porto, Porto	7	39	3	Portugal	69	Portugal, India, Egypt, Chile, Colombia, Croatia, Finland, France, Iran, Australia, Cameroon, Germany, Italy, Malaysia, Nigeria, Pakistan, Saudi Arabia, South Korea, Spain, Switzerland, Turkey, United Kingdom, United States of America	Ethnopharmacology and computational investigations

Table S1: The top 20 institutions that published papers in medicinal plants and related research for the prevention or cure of COVID-19 (SARS-CoV-2) infections globally, retrieved from Scopus database.

TP: Total Publications; TC: Total Citations; HI: Hirsch Index; No. CI: Number of Collaborating Institutions in all publications; CI: The country of the contributing institutions; 3039 institutions contributed in the Scopus database publications.

Relevant terms cartographic analysis

The term analysis was based on the co-occurrences of common keywords in the title and abstracts fields of the 830 papers. The number of co-occurrences of two keywords can be used to make an inference of commonalities or on-going patterns in research [18]. To identify popular terms in medicinal plant research papers, we selected terms that appeared at least 10 times. Based on this criterion, 19373 terms were identified. Five hundred and sixty-five (565) terms met the threshold. Three hundred and thirty-nine (339) met the 60% relevance score. The network of visualisation is composed of clusters and presents them in groups based on their commonalities. The size of the label and the node of the term represents the importance of the article and the thickness of the lines is indicative of the strength of the links or connection between the items [18]. Figure 4 indicated three clusters, represented in red, blue and green colours, with each of them focusing on different elements of COVID-19 targeted medicinal plants and other related study.

Figure 4: Network visualisation of relevant terms from Title and Abstract field.

The red cluster consist of 57% of the items selected. The cluster can be broadly categorized as review of literatures. Two quick and effective methods adopted by scientist globally in the fight against COVID-19 pandemic is the use of web databases such as PubMed, Google scholar, Web of science, Scopus to search for information on botanical medicine, phytomolecules or products with the potential to treat or prevent SARS-CoV-2 infections from previously published and archived data. The second method employed is drug repurposing for effective and safe use of already known medicaments for antiSARS-CoV-2 infections. The survey of herbs, spices or foods is mostly narrowed on the immunity boosting or immunomodulating action, viral disease mitigation, antibacterial activity, antihypertensive potential, anti-inflammatory activity, especially cytokine storm mitigating potentials. Publications on two traditional systems stood out in this cluster, namely the Ayurveda and Traditional Chinese Medicine (TCM). Herbs or polyherbal formulations from these traditional medical systems target the immune system of the host.

The second cluster is coloured green and it is made up of 43% of the chosen terms. It is broadly classified under *in silico* research. This cluster is widely contrasted by molecular docking and molecular dynamics. The publications that defined this cluster were concerned with the use of computer technology to predict the different mechanism of action of herbal extracts, phytocompounds or known antiviral drugs against the entry and replication of SARS-CoV-2 in the host cell spike protein and the interaction of phytomolecules with several other enzymes and proteins. Some medicinal plants with appreciable occurrences in published articles included *Allium sativum*, *Artemisia annua*, *Azadirachta indica*, *Ocimum sanctum*, *Tinospora cordifolia* and *Withania somnifera*. Some phytocompounds with high publication visibility include kaempferol, emodin, curcumin, artemisinin, catechin, ursolic acid, luteolin, myricetin and rutin. Known drugs with high publication profile from our bibliometric study include chloroquine, remdesivir and favipiravir. The third cluster coloured blue, though limited, could be best described as the search for anticovid-19 specialised metabolites using network pharmacology.

Analysis of the 100 most relevant publications

Supplementary table 2 presents the 100 most relevant articles along with their relative ranks. Fifty-six (56) countries participated

in the top 100 publications. It can be observed that the focus of this study was not entirely on the analysis of the 100 most cited papers, but 100 articles whose published contents have strong association in the selected field of research. It behoves the authors at this point to clarify the differences between the rankings obtained from Scopus database and VOSviewer. Scopus selection and ranking of published documents is usually based on the citation of the article. The older an article is in the literary space the higher its chances of being cited. Newer articles seldom have high citations except in cases where it is either a new research method or the review of a trending field of study at a given time. VOSviewer however uses the citation score of a document, the total link strength, match of the document titles to the research field, institutional, country or author connections to rank an item. The total link strength is a measure of the strength of connections between two documents or shared references or co-citation in the pool of the selected documents in a network or map. A look at the title of documents and equivalent positioning in Table S2 attest to these statements [16,19]. Consequently, from the 100 top listed documents 38 were full research papers, while 62 were review articles. India had the highest contribution with 31 publications, distantly followed by China with 17 publications, Saudi Arabia (11), USA (9), Germany (7), Malaysia (7) and Iran (6) respectively. The ongoing COVID-19 pandemic has resulted in many fatalities on a global scale, fostering the scientific communities into Research and Development activities in many fields related to SARS-CoV-2. Enormous scholarly literatures abound in this regard. Results from recent analysis of WHO COVID-19 database indicated a rise in studies related to virology, diagnosis, treatment and other clinical investigations [20,21]. To validate our findings Ahmad et al.,[20], reported that there was considerable growth in Indian publications on COVID-19 related to Indian medicinal plants for antiviral, immunomodulatory and antiallergic/ant-inflammatory activities. Six hundred and twenty-four (624) authors participated in the 100 listed publications, an average of six authors per paper. A breakdown of the number of authors in the top 100 papers indicated that 13% of them were 2 and 5 authored publications, 12% of the publications involved 4 authors, and 10% were 3-authored articles, while only 6% were single authored publications. The highest recorded number of authors in the selected articles is 21, from the paper titled High-content screening of Thai medicinal plants revealed *Boesenbergia rotunda* extract and its component Panduratin A as anti-SARS-CoV-2 agents published in Scientific Report, all the authors were from the same country – Thailand (Table S2). It could be inferred that the fight against the scourge of COVID-19 involved collaboration amongst authors, countries and institutions (Tables S1 and Table S2). Sixty-eight (68) journals contributed in publications of the 100 most relevant articles. The selected 100 articles had 3391 citations, representing 42.4% of the total citations from 830 retrieved articles. Molecules contributed 11% of the 100 most relevant papers on potential remedies for prevention or cure of COVID-19, with 121 citations, followed by Phytotherapy Research contributing 9% and 163 citations, Frontiers in Pharmacology contributed 7% with 117 citations and Journal of Biomolecular Structure and Dynamics with 4% and 74 citations (Table 1). Of the publications from Molecules in the 100 list, 72.7% were reviews, while 27.3% are full research articles. For Phytotherapy Research 77.8% of the articles are reviews and 22.2% research articles, for Frontiers in Pharmacology, 85.7% are reviews and 14.4% research articles. In general, we observed that review articles from the aforementioned journals were online literature searches on the mechanism of action of medicinal plants, their bioactive constituents against viruses, especially COVID-19, ethnobotanical or ethnomedicinal surveys of medicinal plants from different communities and traditional knowledge systems for phytomolecules against COVID-19 infections. Most of the full research papers are reports of the use of phytomolecules from many medicinal plant extracts targeting main protease of SARS-CoV-2 using molecular docking or molecular dynamics simulations. Worthy of note in this category is that 100% of contributing papers from the Journal of Biomolecular Structure and Dynamics are full research articles. This is not surprising as the journal encourages publication of original research articles in fields such as computational science, atomic structural biology, bioinformatics, virtual drug design, genomics and biological networks. A closer look at the research articles from the Journal of Biomolecular Structure and Dynamics showed that the publications were reports on structure-based drug discovery approaches using *in silico* methods for prophylactic or therapeutic potentials of known immunomodulatory agents in or/from medicinal plant extracts from a plethora of traditional medical systems with high

S/ No.	Author and Year	# A	Document Details	TC	Link	DT	CC
1	Tahir Ul Qamar., *et al*. 2020	4	Structural basis of SARS-CoV-2 3CL^{pro}and anti-COVID-19 drug discovery from medicinal plants. Journal of Pharmaceutical Analysis 10(4):313-319	426	29	A	China, Saudi Arabia
2	Vellingiri., *et al*. 2020	15	COVID-19: A promising cure for the global panic. Science and Total Environment 725:138277	269	28	R	India, United Kingdom, South Korea
3	Malekmohammad and Rafieian-Kopaei 2021	2	Mechanistic Aspects of Medicinal Plants and Secondary Metabolites against Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). Current Pharmaceutical Design 27(38):3996-4007	2	22	R	Iran
4	Saha., *et al*. 2021	6	Jeopardy of COVID-19: Rechecking the Perks of Phytotherapeutic Interventions. Molecules 26,6783	0	16	R	India, Saudi Arabia, USA
5	Villena-Rejada., *et al*. 2021	10	Use of medicinal plants for COVID-19 prevention and respiratory symptom treatment during the pandemic in Cusco, Peru: A cross-sectional survey. PLoS ONE 16(9): e0257165	2	16	A	Peru
6	Ren., *et al*. 2020	3	Traditional Chinese medicine for covid-19 treatment. Pharmacological Research 155:104743	263	16	R	China
7	Pagano, 2021	1	The pharmacological potential of plant compounds and preparations in COVID-19: A PTR virtual issue. Phytotherapy Research. 2021;35:1683-1685	1	15	R	Italy
8	Khadka., *et al*. 2021	10	The use of medicinal plants to prevent COVID-19 in Nepal. Journal of Ethnobiology and Ethnomedicine 17:5	9	14	A	Nepal, China
9	Singh., *et al*. 2021	5	Ayurveda Rasayana as antivirals and immunomodulators: potential applications in COVID-19. Environmental Science and Pollution Research 28:55925-55951	0	12	R	India, France
10	Orhan and Senol Deniz, 2020	2	Natural Products as Potential Leads Against Coronaviruses: Could They be Encouraging Structural Models Against SARS-CoV-2?. Natural Products and Bioprospecting 10:171-186	44	11	R	Turkey
11	Ngwa., *et al*. 2020	8	Potential of Flavonoid-Inspired Phytomedicines against COVID-19. Molecules 25(11):2707	58	11	A	USA
12	Wink, 2020	1	Potential of DNA Intercalating Alkaloids and Other Plant Secondary Metabolites against SARS-CoV-2 Causing COVID-19. Diversity 12,:175	35	11	R	Germany

13	Benarba and Pandiella, 2020	2	Medicinal Plants as Sources of Active Molecules Against COVID-19. Frontiers in Pharmacology 11:1189	46	10	R	Algeria, Spain
14	Wang., *et al*. 2020	4	Review of the 2019 novel coronavirus (SARS-CoV-2) based on current evidence. International Journal of Antimicrobial Agents 55:105948	502	10	R	China
15	Jahan and Onay, 2020	2	Potentials of plant-based substance to inhibit and probable cure for COVID-19. Turkish Journal of Biology 44:228-241	37	10	R	Turkey
16	Llivisaca-Contreras., *et al*. 2021	9	Plants and Natural Products with Activity against Various Types of Coronaviruses: A Review with Focus on SARS-CoV-2. Molecules 2:4099	6	9	R	Ecuador, Belgium
17	Brendler., *et al*. 2021	13	Botanical drugs and supplements affecting the immune response in the time of COVID-19: Implications for research and clinical practice. Phytotherapy Research. 2021;35:3013-3031	14	9	R	South Africa, USA, Oman, Austria, United Kingdom, Taiwan, Iran, Italy, Sweden, Israel
18	Sa-Ngiamsuntorn., *et al*. 2021	18	Anti-SARS-CoV-2 Activity of *Andrographis paniculata* Extract and Its Major Component Andrographolide in Human Lung Epithelial Cells and Cytotoxicity Evaluation in Major Organ Cell Representatives. Journal of Natural Products 84, 1261−1270	18	9	A	Thailand
19	Sytar., *et al*. 2021	9	COVID-19 Prophylaxis Efforts Based on Natural Antiviral Plant Extracts and Their Compounds. Molecules 26:727	11	9	R	Slovakia, Ukraine, Czech Republic, Iran, Azerbaijan, Italy
20	Mouffouk., *et al*. 2021	5	Flavonols as potential antiviral drugs targeting SARS-CoV-2 proteases ($3CL^{pro}$ and PL^{pro}), spike protein, RNA-dependent RNA polymerase (RdRp) and angiotensin-converting enzyme II receptor (ACE2). European Journal of Pharmacology 89:173759	20	9	A	Algeria
21	Liana and Phanumartwiwath, 2021	2	Leveraging knowledge of Asian herbal medicine and its active compounds as COVID-19 treatment and prevention. Journal of Natural Medicines 1-18. doi: 10.1007/s11418-021-01575-1	0	9	R	Thailand
22	Vougogiannopoulou., *et al*. 202	5	Natural and Nature-Derived Products Targeting Human Coronaviruses. Molecules 26(2), *448*	10	9	R	Greece, Italy
23	Shi., *et al*. 2020	9	Andrographolide and its fluorescent derivative inhibit the main proteases of 2019-nCoV and SARS-CoV through covalent linkage. Biochemical and Biophysical Research Communications 533:467e473	23	9	A	Taiwan

24	Chinsembu, 2020	1	Coronaviruses and Nature's Pharmacy for the Relief of Coronavirus Disease 2019. Revista Brasileira de Farmacognosia 30:603-621	8	9	R	Namibia
25	Silveira., *et al*. 2020	10	COVID-19: Is There Evidence for the Use of Herbal Medicines as Adjuvant Symptomatic Therapy?. Frontiers in Pharmacology 11:581840	51	9	R	United Kingdom, Ireland, Venezuela, Brazil, Poland
26	Hensel., *et al*. 2020	7	Challenges at the Time of COVID-19: Opportunities and Innovations in Antivirals from Nature. Planta Medica 86(10): 659-664	34	9	R	Germany, Austria, United Kingdom
27	Balachandar., *et al*. 2020	9	COVID-19: emerging protective measures. European Review for Medical and Pharmacological Sciences 24:3422-3425	50	9	R	India
28	Anand., *et al*. 2021	14	Medicinal Plants, Phytochemicals, and Herbs to Combat Viral Pathogens Including SARS-CoV-2. Molecules 26(6):1775	13	8	R	India, South Korea, Saudi Arabia
29	Sharma., *et al*. 2021	3	Natural Products in Mitigation of SARS CoV Infections. Current Medicinal Chemistry 28(22):4454-4483	1	8	R	India
30	Gurung., *et al*. 2020	5	Unravelling lead antiviral phytochemicals for the inhibition of SARS-CoV-2 M^{pro} enzyme through *in silico* approach. Life Sciences 255:117831	60	8	A	India, Saudi Arabia, South Korea
31	Al-Karmalawy., *et al*. 2021	10	Naturally Available Flavonoid Aglycones as Potential Antiviral Drug Candidates against SARS-CoV-2. Molecules 26:6559	1	7	A	Egypt, Germany, Saudi Arabia
32	Nawrot-Hadzik., *et al*. 2021	8	*Reynoutria* Rhizomes as a Natural Source of SARS-CoV-2 Mpro Inhibitors-Molecular Docking and *In vitro* Study. Pharmaceuticals 14:742	3	7	A	Poland, Germany
33	Paramita., *et al*. 2021	4	A Short Overview of *Curcuma aeruginosa* with Curative Potentials Against COVID-19. Asian Journal of Chemistry 33(4):789-792	0	7	R	Indonesia
34	Adhikari., *et al*. 2021	9	Potential roles of medicinal plants for the treatment of viral diseases focusing on COVID-19: A review. Phytotherapy Research 35:1298-1312	29	7	R	Nepal, Australia
35	Lim., *et al*. 2021	7	*Andrographis paniculata* (Burm. F.) Wall. Ex Nees, Andrographolide, and Andrographolide Analogues as SARS-CoV-2 Antivirals? A Rapid Review. Natural Product Communications 16(5): 1-15	2	7	R	Malaysia
36	Mirzale., *et al*. 2020	5	A narrative literature review on traditional medicine options for treatment of corona virus disease 2019 (COVID-19). Complementary Therapies in Clinical Practice 40:101214	44	7	R	Iran

37	Luo., *et al*. 2020	8	Analysis on herbal medicines utilized for treatment of COVID-19. Acta Pharmaceutica Sinica B 10(7):1192e1204	35	7	A	China, Ireland, Denmark
38	Polansky and Lori, 2020	2	Coronavirus disease 2019 (COVID-19): first indication of efficacy of Gene-Eden-VIR/ Novirin in SARS-CoV-2 infection. International Journal of Antimicrobial Agents 55:105971	29	7	R	USA
39	Gyebi., *et al*. 2020	6	Prevention of SARS-CoV-2 cell entry: insight from *in silico* interaction of drug-like alkaloids with spike glycoprotein, human ACE2, and TMPRSS2. Journal of Biomolecular Structure and Dynamics 1-25	9	7	A	Nigeria, Egypt
40	Gour et.al 2021	5	Flavonoids as potential phytotherapeutics to combat cytokine storm in SARS-CoV-2. Phytotherapy Research. 35:4258-4283.	3	7	R	India, Malaysia
41	Abiri., *et al*. 2021	9	A Brief Overview of Potential Treatments for Viral Diseases Using Natural Plant Compounds: The Case of SARS-CoV. Molecules 26:3868	2	6	R	Malaysia, Ukraine, Iran, Brazil, India, Russia, United Kingdom, France
42	Alam., *et al*. 2021	7	Traditional Herbal Medicines, Bioactive Metabolites, and Plant Products Against COVID-19: Update on Clinical Trials and Mechanism of Actions. Frontiers in Pharmacology 12:671498.	3	6	R	Bangladesh, China, USA, Malaysia
43	Das., *et al*. 2021	7	Role of phytoconstituents in the management of COVID-19. Chemico-Biological Interactions 341:109449	1	6	R	India
44	Trivedi., *et al*. 2021	16	Prophylactic and therapeutic potential of selected immunomodulatory agents from Ayurveda against coronaviruses amidst the current formidable scenario: an *in silico* analysis. Journal of Biomolecular Structure and Dynamics, DOI: 10.1080/07391102.2021.1932601	1	6	A	India
45	Iqubal., *et al*. 2021	4	Natural Products, a Potential Therapeutic Modality in Management and Treatment of nCoV-19 Infection: Preclinical and Clinical Based Evidence. Current Pharmaceutical Design 27(9):1153-1169	3	6	R	India
46	Yang., *et al*. 2020	10	Food as medicine: A possible preventive measure against coronavirus disease (COVID-19). Phytotherapy Research 34:3124-3136	32	6	R	China, Pakistan, Georgia
47	Kanjanasirirat., *et al*. 2020	21	High-content screening of Thai medicinal plants reveals *Boesenbergia rotunda* extract and its component Panduratin A as anti-SARS-CoV-2 agents. Scientific Reports 10:19963	23	6	A	Thailand

48	Parida., *et al*. 2020	3	The natural way forward: Molecular dynamics simulation analysis of phytochemicals from Indian medicinal plants as potential inhibitors of SARS-CoV-2 targets. Phytotherapy Research. 2020;34:3420-3433	9	6	A	India
49	Asif., *et al*. 2020	5	COVID-19 and therapy with essential oils having antiviral, anti-inflammatory, and immunomodulatory properties. Inflammopharmacology (2020) 28: 1153-1161	42	6	R	Pakistan, Malaysia
50	Chojnacka., *et al*. 2020	5	Phytochemicals containing biologically active polyphenols as an effective agent against Covid 19-inducing coronavirus. Journal of Functional Foods 73:104146	48	6	A	Poland
51	Haq., *et al* 2020	9	*Artemisia annua*: Trials are needed for COVID-19. Phytotherapy Research 34:2423-2424.	24	6	R	Pakistan
52	Siddiqui., *et al*. 2020	13	Plants-Derived Biomolecules as Potent Antiviral Phytomedicines: New Insights on Ethnobotanical Evidences against Coronaviruses. Plants 9:1244	21	6	R	Saudi Arabia, India, Romania, Tunisia
53	Shawky., *et al*. 2020	3	Potential role of medicinal plants and their constituents in the mitigation of SARS-CoV-2: identifying related therapeutic targets using network pharmacology and molecular docking analyses. RSC Advances 10:27961-27983	19	6	A	Egypt
54	Grigore., *et al*. 2021	4	Herbal medicine, a reliable support in COVID therapy. Journal of Immunoassay and Immunochemistry, 41(6):976-999	3	6	R	Romania
55	Shree., *et al*. 2020	7	Targeting COVID-19 (SARS-CoV-2) main protease through active phytochemicals of ayurvedic medicinal plants - *Withania somnifera* (Ashwagandha), *Tinospora cordifolia* (Giloy) and *Ocimum sanctum* (Tulsi) - a molecular docking study. Journal of Biomolecular Structure and Dynamics, 40(1):190-203	50	6	A	India
56	Mishra., *et al*. 2021	4	Andrographolide: A Herbal-Chemosynthetic Approach for Enhancing Immunity, Combating Viral Infections, and Its Implication on Human Health. Molecules 26:7036	0	5	R	Czech Republic, Poland
57	Hu., *et al*. 2021	8	Overview of Viral Pneumonia Associated With Influenza Virus, Respiratory Syncytial Virus, and Coronavirus, and Therapeutics Based on Natural Products of Medicinal Plants. Frontiers in Pharmacology 12:630834.	0	5	R	China

58	Dutta., *et al*. 2021	14	Appraisals of the Bangladeshi Medicinal Plant Calotropis gigantea Used by Folk Medicine Practitioners in the Management of COVID-19: A Biochemical and Computational Approach. Frontiers in Molecular Biosciences 8:625391	4	5	A	Bangladesh, Indonesia, Saudi Arabia
59	Khanna., *et al*. 2021	10	Herbal immune-boosters: Substantial warriors of pandemic Covid-19 battle. Phytomedicine 85:153361	18	5	R	India, Ukraine, China, Saudi Arabia
60	Van de sand., *et al*. 2021	11	Glycyrrhizin Effectively Inhibits SARS-CoV-2 Replication by Inhibiting the Viral Main Protease. Viruses 13,609	28	5	A	Germany
61	Vicidomini., *et al*. 2021	3	Molecular Basis of the Therapeutical Potential of Clove (*Syzygium aromaticum* L.) and Clues to Its Anti-COVID-19 Utility. Molecules *26:*1880	15	5	R	Italy
62	Khan and Al-Balushi, 2021	3	Combating COVID-19: The role of drug repurposing and medicinal plants. Journal of Infection and Public Health 14:495-503	13	5	R	Oman
63	Fatima., *et al*. 2021	6	Herbal approach for the management of C0VID-19: an overview. Drug Metabolism and Personalized Therapy 36(1):1-8	5	5	R	Saudi Arabia, India, USA
64	Boozari and Hossainzadeh, 2021	2	Natural products for COVID-19 prevention and treatment regarding to previous coronavirus infections and novel studies. Phytotherapy Research 35:864-876	34	5	R	Iran
65	Liu., *et al*. 2021	10	*Scutellaria baicalensis* extract and baicalein inhibit replication of SARS-CoV-2 and its 3C-like protease *in vitro*. Journal of Enzyme Inhibition and Medicinal Chemistry 36(1):497-503	30	5	A	China
66	Lee., *et al*. 2021	4	Traditional Chinese herbal medicine at the forefront battle against COVID-19: Clinical experience and scientific basis. Phytomedicine 80: 153337	34	5	A	China, Germany
67	Muhseen., *et al*. 2021	5	Promising terpenes as SARS-CoV-2 spike receptor-binding domain (RBD) attachment inhibitors to the human ACE2 receptor: Integrated computational approach. Journal of Molecular Liquids 320:114493	34	5	A	China, Iraq
68	Upadhyay., *et al*. 2020	6	Evaluation of medicinal herbs as potential therapeutic option against SARS-CoV-2 targeting its main protease. Phytotherapy Research 34(12):3411-3419	17	5	A	India
69	Signer., *et al*. 2020	12	*In vitro* virucidal activity of Echinaforce®, an *Echinacea purpurea* preparation, against coronaviruses, including common cold coronavirus 229E and SARS-CoV-2. Virology Journal 17:136	24	5	A	Switzerland

70	Vardhan and Sahoo, 2020	2	*In silico* ADMET and molecular docking study on searching potential inhibitors from limonoids and triterpenoids for COVID-19. Computers in Biology and Medicine 124:103936	42	5	A	India
71	Bhulyan., *et al*. 2020	4	Plants Metabolites: Possibility of Natural Therapeutics Against the COVID-19 Pandemic. Frontiers in Medicine 7:444	27	5	R	Bangladesh
72	Ali and Alharbi, 2020	2	COVID-19: Disease, management, treatment, and social impact. Science of the Total Environment 728:138861	154	5	A	Saudi Arabia, India
73	Zhou and Huang, 2020	2	Current Findings Regarding Natural Components With Potential Anti-2019-nCoV Activity. Frontiers in Cell and Developmental Biology 8:589	9	5	R	China
74	Yang, 2020	1	Use of herbal drugs to treat COVID-19 should be with caution. Lancet 395:1689	32	5	R	China
75	Luo., *et al*. 2020	8	Treatment efficacy analysis of traditional Chinese medicine for novel coronavirus pneumonia (COVID-19): an empirical study from Wuhan, Hubei Province, China. China Medicine 15:34	76	5	A	Macao, China
76	Wicaksono and da Silva, 2020	2	Is COVID-19 impacting plant science, and is plant science impacting COVID-19?. Notulae Scientia Biologicae 12(3):769-772	1	5	R	Indonesia, Japan
77	Ahmad., *et al*. 2020	3	An alternative approach to minimize the risk of coronavirus (Covid-19) and similar infections. European Review for Medical and Pharmacological Sciences 4030-4034	28	5	R	Saudi Arabia
78	Chandramouli., *et al*. 2021	5	Phytomolecules Repurposed as Covid-19 Inhibitors: Opportunity and Challenges. Current Microbiology 78:3620-3633	0	4	R	India, USA
79	Das., *et al*. 2021	9	Korean traditional foods as antiviral and respiratory disease prevention and treatments: A detailed review. Trends in Food Science and Technology 116:415-433	2	4	R	South Korea, Mexico, Portugal, Colombia, Australia
80	Phumthurn., *et al*. 2021	3	Medicinal Plants Used for Treating Mild Covid-19 Symptoms Among Thai Karen and Hmong. Frontiers in Pharmacology. 12:699897.	0	4	A	Thailand, Denmark
81	Jezova., *et al*. 2021	5	Food Enrichment with *Glycyrrhiza glabra* Extract Suppresses ACE2 mRNA and Protein Expression in Rats—Possible Implications for COVID-19. Nutrients 13:2321.	3	4	A	Slovakia, Germany, USA
82	Joshi., *et al*. 2021	7	Recent efforts for drug identification from phytochemicals against SARS-CoV-2: Exploration of the chemical space to identify druggable leads. Food and Chemical Toxicology 152:112160	2	4	R	India

83	Komolafe., *et al*. 2021	7	Coronavirus Disease 2019 and Herbal Therapy: Pertinent Issues Relating to Toxicity and Standardization of Phytopharmaceuticals. Revista Brasileira de Farmacognosia (2021) 31:142-161	5	4	R	Nigeria
84	Ahmad., *et al*. 2021	6	Structure-Based Virtual Screening Identifies Multiple Stable Binding Sites at the RecA Domains of SARS-CoV-2 Helicase Enzyme. Molecules 26(5):1446	5	4	A	Pakistan, United Arab Emirates
85	Thakkar., *et al*. 2021	3	Magical bullets from an indigenous Indian medicinal plant *Tinospora cordifolia*: An *in silico* approach for the antidote of SARS-CoV-2. Egyptian Journal of Petroleum 30:53-66	4	4	A	India
86	Dash., *et al*. 2021	4	A Scoping Insight on Potential Prophylactics, Vaccines and Therapeutic Weaponry for the Ongoing Novel Coronavirus (COVID-19) Pandemic- A Comprehensive Review. Frontiers in Pharmacology 11:590154	3	4	R	India
87	Takeda., *et al*. 2021	5	The SARS-CoV-2-Inactivating Activity of Hydroxytyrosol-Rich Aqueous Olive Pulp Extract (HIDROX®) and Its Use as a Virucidal Cream for Topical Application. Viruses 13, 232	8	4	A	Japan
88	Gowrishankar., *et al*. 2021	8	Promising phytochemicals of traditional Indian herbal steam inhalation therapy to combat COVID-19 - An *in silico* study. Food and Chemical Toxicology 148:111966	13	4	A	India
89	Remali and Aizat, 2021	2	A Review on Plant Bioactive Compounds and Their Modes of Action Against Coronavirus Infection. Frontiers in Pharmacology 11:589044	14	4	R	Malaysia
90	Balkrishna., *et al*. 2021	7	Phytometabolite profiling of Coronil, a herbal medicine for COVID-19, its identification by mass-spectroscopy and quality validation on liquid chromatographic platforms. Journal of Separation Science 44:4064-4081	10	4	A	India
91	Alagu Lakshmi., *et al*. 2021	4	Ethnomedicines of Indian origin for combating COVID-19 infection by hampering the viral replication: using structure-based drug discovery approach. Journal of Biomolecular Structure and Dynamics 39(13):4594-4609	14	4	A	India
92	Khare., *et al*. 2020	4	Current approaches for target-specific drug discovery using natural compounds against SARS-CoV-2 infection. Virus Research 290:198169	12	4	R	India

93	Divya., *et al*. 2020	5	South Indian medicinal plants can combat deadly viruses along with COVID- 19? - A review. Microbial Pathogenesis 148:104277	19	4	R	India, China, Chile
94	Zaki., *et al*. 2020	4	Molecular docking reveals the potential of Cleome amblyocarpa isolated compounds to inhibit COVID-19 virus main protease. New Journal of Chemistry 44**:**16752-16758	30	4	A	Egypt
95	Rahman, 2020	1	Potential benefits of combination of *Nigella sativa* and Zn supplements to treat COVID-19. Journal of Herbal Medicine 23:100382	19	4	R	Malaysia
96	Oladele., *et al*. 2020	8	A systematic review on COVID-19 pandemic with special emphasis on curative potentials of Nigeria based medicinal plants. Heliyon 6:e04897	12	4	R	Nigeria, Argentina
97	Prasad., *et al*. 2020	3	Synergistic antiviral effects against SARS-CoV-2 by plant-based molecules. Plant Cell Reports (2020) 39:1109-1114	22	4	R	India
98	Ren., *et al*. 2020	18	Identifying potential treatments of COVID-19 from Traditional Chinese Medicine (TCM) by using a data-driven approach. Journal of Ethnopharmacology 258:112932	45	4	A	China
99	Rajkumar, 2020	1	Ayurveda and COVID-19: Where psychoneuroimmunology and the meaning response meet. Brain, Behavior, and Immunity 87:8-9	38	4	R	India
100	Boukhatem and Setzer, 2020	2	Aromatic Herbs, Medicinal Plant-Derived Essential Oils, and Phytochemical Extracts as Potential Therapies for Coronaviruses: Future Perspectives. Plants 9:800	35	4	R	Algeria, USA

Table S2: The 100 most relevant documents on medicinal plants and related research endeavours in finding the cure or prevention for COVID-19 (SARS-CoV-2) infections globally.

#, A - Number of Authors; TC: Total Citation; DT: Document Type; A: Full Research Article; R: Review Article; CC: Contributing countrie.

predictive values against SARS-CoV-2 entry into host cells and inhibition of viral replications.

Conclusion and Recommendations

The COVID-19 pandemic has not yet abated even with the ongoing vaccinations. Recent outbreaks of variant strains makes this scientometric assessment pertinent. The present study analysed and summarised relevant publications on the potential use of medicinal plants and other natural products as remedies for COVID-19 infections using VOSviewer. Performance assessment of various bibliometric indicators provided insights into research areas that will need improvement. Findings from this study indicated that ninety-eight (98) countries participated in the 830 publications. We observed high international institutional collaborative efforts, especially amongst the developed and developing countries. A wide range of expertise was observed amongst the various institutions which ranged from antiviral activity screening, anti-inflammatory assays, immunomodulatory assays, *in vitro* and *in vivo* pharmaco-

logical research, computational investigations (molecular docking and molecular dynamics). Multidisciplinary collaborations enhance the output and quality of research finding, and increases the chances of translating findings for public benefits. Because of the devastations of SARS-CoV-2 infections we observed a paradigm shift from amassing publications in databases for the sake of academic promotions and other accolades to a quick web based review of literatures for the purpose of identifying herbal remedies against COVID-19. Howbeit, huge successes were recorded in a short time. If researchers globally could adopt these methods to find solutions to other ailments that have ravaged humanity, many drugs or supplements would be development that could improve public health and standard of living.

The first classification publications in this study could best be described as review of literatures. This we have already highlighted. Online databases provided vital information to scientist on the way forward against the 'unseen foe'. We also observed increase in searches from the documents of ancient traditional medical practices such as Ayurveda and Traditional Chinese Medicine. Other traditional herbal pharmacopoeia and traditional knowledge systems were used. There was an increase in the formulation of polyherbal remedies from India and China during the period under review. The second category of this study is described as *in silico* studies. Under this section we observed a high use of computational techniques such as molecular docking and molecular dynamics to determine and predict the mechanism of action, safety and the potential of converting plant extracts or specialised metabolites into anti-COVID drugs.

Some medicinal plants with appreciable therapeutic potentials against COVID-19 infections include *Allium sativum*, *Artemisia annua*, *Azadirachta indica*, *Ocimum sanctum*, *Tinospora cordifolia* and *Withania somnifera*. Some phytocompounds with high publication visibility include kaempferol, emodin, curcumin, artemisinin, catechin, ursolic acid, luteolin, myricetin and rutin. Lastly, *in silico* investigations as a vital component of medicinal plant research has helped identify many natural compounds with the potential of targeting SARS-CoV-2. However, further *in vitro* and *in vivo* studies are recommended to validate the potential of these natural compounds in the mitigation of SARS-CoV-2. Specific preclinical and clinical trials to evaluate the effects of herbal immunoregulators need more attention. Medicinal plants remain an important source for finding and developing remedies against COVID-19. Policy makers and funding agencies should invest more in this regard

Funding Statement

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data Availability Statement

Data included in article/supplementary material/referenced in article.

Declaration of Interest's Statement

The authors declare no conflict of interest.

Additional Information

No additional information is available for this paper.

Supplementary Table 1 (Table S1). The top 20 institutions that published papers in medicinal plants and related research for the prevention or cure of COVID-19 (SARS-CoV-2) infections globally, retrieved from Scopus database

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