DOI: 10.4149/BLL_2022_043

Bratisl Med J 2022; 123 (4)

268 – 275

STATISTICAL STUDY

Investigation of highly cited publications related to vaccines against COVID-19: current state and future predictions

ERENLER Ali Kemal[1], AY Mehmet Oguzhan[2], AY Ozlem Oymak[3], BAYDIN Ahmet[4]

Hitit University, School of Medicine, Department of Emergency Medicine, Corum, Turkey.
akerenler@hotmail.com

ABSTRACT

BACKGROUND: Since the date of declaring the COVID-19 outbreak a pandemic by the World Health Organization (March 11, 2020), vaccine studies have been initiated. In this article, we aimed to investigate highly cited articles on vaccines and guide researchers for future studies.

MATERIAL AND METHODS: Publications with 6 or more citations (highly cited publications) were extracted from Web of Science (WoS) database. These publications were investigated according to the number of citations, language, publication year, WoS categories, publication types, organizations involved, authors, countries and research areas. Additionally, top 20 articles were investigated in detail.

RESULTS: A total of 126 publications were determined. When WoS categories were investigated, 18 pertained to immunology (14.2 %), 17 to biochemistry (13.4 %) and 17 to multidisciplinary sciences (13.4 %). There were three types of publications, namely 80 original articles (63.4 %), 46 reviews (36.5 %) and 11 early access publications (8.7 %). Top universities were Harvard University (n=9, 7.1 %), Chinese Academy of Medical Sciences (n=7, 5.5 %) and University of California system (n=7, 5.5 %). Top authors were Qin CF with 4 articles (3.1 %), Wang L with 4 articles (3.1 %) and Baric RS with 3 articles (2.3 %). Top journals with the highest number of publications were Journal of Biomolecular Structure Dynamics (n=8, 6.3 %), Nature (n=8, 6.3 %) and Science (n=6, 4.7 %). Top countries were the United States of America (USA) with 45 articles (35.7 %), People's Republic of China with 44 articles (34.9 %), and India with 15 articles (11.9 %). Research areas of the publications were science technology other topics (n=21, 16.6 %), immunology (n=18, 14.2 %) and pharmacology (n=18, 14.2 %).

CONCLUSION: Vaccine studies play a pivotal role in the warfare against COVID-19. Our results revealed that under the leadership of the USA, China and India, the number of scientists focusing on vaccines is increasing and gratifying results are obtained from vaccine studies *(Tab. 3, Ref. 40)*. Text in PDF *www.elis.sk*

KEY WORDS: vaccine, COVID-19, citation, publication.

Introduction

Severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2) also known as the novel coronavirus responsible for coronavirus disease-19 (COVID-19), primarily attacks the human respiratory system. COVID-19 is a rapidly transmitted respiratory disease that has recently attracted the worldwide public health attention since it has been declared a pandemic by the World Health Organization (WHO) on March 11, 2020 (1). Since then, the disease has affected healthcare systems and social life like never before.

The most common signs and symptoms are fever, cough, and shortness of breath. These symptoms may appear 2–14 days after the exposure. The disease has a high infectivity and is transmitted from person to person in hospital and family settings. The limitation of human-to-human transmission in order to reduce secondary infections is essential. A proper diagnosis of COVID-19 is based on an algorithm which involves a combination of polymerase chain reaction (PCR) and thorax computed tomography (CT) (2).

A return to normality and limitation of further spread of infection depends on the success of vaccine trials (3). Besides, the success of vaccines depends on trust and confidence in any COVID-19 vaccine (4). Hence, transparency is required when declaring the results of vaccine studies. The peer-reviewed literature is growing at an unprecedented speed with articles published in various leading medical and related journals (5).

Material and methods

This study was conducted by entering the keywords "coronavirus" and "vaccines" to the Web of Science (WoS) database on December 5, 2020. WoS allows researchers to use its database

[1]Hitit University, School of Medicine, Department of Emergency Medicine, Corum, Turkey, [2]University of Health Sciences, Bursa Yüksek Ihtisas Education and Research Hospital, Department of Emergency Medicine, Bursa, Turkey, [3]University of Health Sciences, Bursa Yüksek Ihtisas Education and Research Hospital, Department of Otorhinolaryngology, Bursa, Turkey, and [4]Samsun Ondokuzmayıs University, School of Medicine, Department of Emergency Medicine, Samsun, Turkey

Address for correspondence: Ali Kemal ERENLER, MD, Assoc Prof, Hitit University, School of Medicine, Department of Emergency Medicine, Kuzey Kampusu, Cevre Yolu Blv., 19030 Merkez/Corum Postal Code: 19030 Corum, Turkey. Phone: +905324475563

Tab. 1. Characteristics of highly cited publications.

Categories	n	%	Ranking
Immunology	18	14.2	1
Biochemistry	17	13.4	2
Multidisciplinary sciences	17	13.4	3
Pharmacology	16	12.6	4
Virology	11	8.7	5
General internal medicine	10	7.9	6
Microbiology	10	7.9	7
Experimental medicine research	9	7.1	8
Biophysics	8	6.3	9
Cell Biology	6	4.7	10
Type of Publications			
Original article	80	63.4	1
Review	46	36.5	2
Early access publication	11	8.7	3
Institution			
Harvard University	9	7.1	1
Chinese Academy of Medical Sciences Peking Union Medical College	7	5.5	2
University of California system	7	5.5	3
National Institutes for Food and Drug Control	6	4.7	4
Wuhan University	6	4.7	5
Chinese Academy of Sciences	5	3.9	6
Harvard Medical School	5	3.9	7
University of North Carolina	5	3.9	8
University of North Carolina Chapel Hill	5	3.9	9
Academy of Military Medical Sciences China	4	3.1	10
Funding Agencies			
National Institutes of Health (NIH) USA	20	15.8	1
United States Department of Health Human Services	20	15.8	2
National Natural Science Foundation of China (NSFC)	16	12.6	3
NIH National Institute of Allergy Infectious Diseases (NIAID)	8	6.3	4
Bill Melinda Gates Foundation	6	4.7	5
Burroughs Welcome Fund	3	2.3	6
Canadian Institutes of Health Research CIHR	3	2.3	7
Hong Kong Research Grants Council	3	2.3	8
National Key Research and Development Program of China	3	2.3	9
National Science and Technology Major Project	3	2.3	10
Authors			
Qin CF	4	3.1	1
Wang L	4	3.1	2
Baric RS	3	2.3	3
Chen W	3	2.3	4
Deng YQ	3	2.3	5
Fan CF	3	2.3	6
Wang HY	3	2.3	7
Wang Y	3	2.3	8
Yang Y	3	2.3	9
Zhang L	3	2.3	10
Countries			
USA	45	35.7	1
People's Republic of China	44	34.9	2
India	15	11.9	3
England	9	7.1	4
Germany	8	6.3	5
Italy	8	6.3	6
Switzerland	6	4.7	7
Netherlands	5	3.9	8
Canada	4	3.1	9
Iran	4	3.1	10

for scientific purposes and helps obtain statistical information in a specific field. We preferred WoS as our main data source because it provides data analysis for publications and citations and allows the results to be sorted according to the number of citations. In addition, WoS attribution data are considered more reproducible and reliable than other databases, and WoS is used as standard by certain official organizations (6).

Scientometrics, also known as "science of science," is a popular statistical method analyzing scientific literature thoroughly in a certain field (7).

We extracted "highly cited publications" in the database. Highly cited publications are those with 6 or more citations. We determined 126 publications confirmed to be in line with this definition. Then we extracted statistics of these highly cited publications. The publications were investigated according to the number of citations, language, publication year, WoS categories, publication types, organizations involved, authors, countries, and research areas.

Also, top 20 articles were summarized and presented in form of a table. Data were given as numbers and percentages.

Due to the nature of the study, no ethical approval was required.

Results

A total of 126 publications were extracted from WoS database. These publications were cited 10,201 times (average citations per item: 80.9). All publications were in English language and published in the year 2020.

When WoS categories were investigated, it was determined that 18 (14.2 %) pertained to immunology, 17 (13.4 %) to biochemistry, 17 (13.4 %) to multidisciplinary sciences, 16 (12.6 %) to pharmacology and 11 (8.7 %) to virology.

There were three types of publications, namely 80 original articles (63.4 %), 46 reviews (36.5 %) and 11 early access publications (8.7 %).

Top organizations involved in vaccine studies were Harvard University (n=9, 7.1 %), Chinese Academy of Medical Sciences (n=7, 5.5 %), University of California system (n=7, 5.5 %;), National Institutes for Food and Drug Control (n=6, 4.7 %) and Wuhan University (n=6, 4.7 %).

Top funding agencies were National Institutes of Health (n=20, 15.8 %), United States Department of Health Human Services (n=20, 15.8 %), National Natural Science Foundation of China

Tab. 2. Characteristics of the top 10 journals with the highest number of publications.

Journals	Number of vaccine publications	%	Impact factor	h-index	Publication frequency	Publication policy	Overall rank	Subject area	Country
Journal of Biomolecular Structure Dynamics	8	6.3	3.2	62	18 issues per year	Hybrid	6682	Biochemistry, genetics, and molecular biology	England
Nature	8	6.3	42.7	1159	Weekly	Hybrid (as of January 2021)	30	Multidisciplinary	England
Science	6	4.7	41.8	1058	Weekly	Regular	45	Multidisciplinary	The USA
Viruses Basel	4	3.1	3.8	69	Monthly	Open Access	1629	Virology	Switzerland
Cell	3	2.3	38.6	747	24 issues per year	Hybrid	10	Biochemistry, genetics, and molecular biology	The USA
Emerging Microbes Infections	3	2.3	5.7	38	1 issue per year	Open Access	1241	Immunology and microbiology	England
European Review for Medical and Pharmacological Sciences	3	2.3	3	54	Continuous	Open Access	7803	Medicine	Italy
Journal of Medical Virology	3	2.3	2.04	105	Monthly	Hybrid	4590	Infectious diseases, virology	The USA
Lancet	3	2.3	60.3	747	Weekly	Hybrid	32	Medicine	England
Asian Pacific Journal of Allergy and Immunology	2	1.5	3.2	30	4 issues per year	Open Access	9640	Immunology and microbiology	Thailand

(n=16, 12.6 %), NIH National Institute of Allergy Infectious Diseases (n=8, 6.3 %) and Bill Melinda Gates Foundation (n=6, 4.7 %).

Top authors on the list were Qin CF with 4 articles (3.1 %), Wang L with 4 articles (3.1 %), Baric RS with 3 articles (2.3 %), Chen W with 3 articles (2.3 %), and Deng YQ with 3 articles (2.3 %).

Top journals with the highest number of publications were Journal of Biomolecular Structure Dynamics (n=8, 6.3 %), Nature (n=8, 6.3 %), Science (n=6, 4.7 %), Viruses-Basel (n=4, 3.1 %) and Cell (n=3, 2.3 %).

When publications were distributed according to countries, the results were as follows: 45 articles (35.7 %) from the USA, 44 articles (34.9 %) from the People's Republic of China, 15 articles (11.9 %) from India, 9 articles (7.1 %) from England and 8 articles (6.3 %) from Germany.

Research areas of the publications were science technology other topics (n=21, 16.6 %), immunology (n=18, 14.2 %), pharmacology (n=18, 14.2 %), biochemistry (n=17, 13.4 %) and general internal medicine (n=11, 8.7 %). See Table 1 for characteristics of the highly cited publications. Also, a brief summary of top 20 articles is presented in Table 2.

Discussion

To our knowledge, this is the first study to investigate highly cited vaccine-related publications. Scientific journals play an essential role in enhancing the social value of scientific validity because up-to-date information is required in the fight against COVID-19 (8). A great number of publications and citations on COVID-19 vaccines determined in our study is an indicator of intention of humanity to contain the pandemic.

In the first months of the pandemic, topic popularity trends indicated that the prevention and control of COVID-19 were the most important issues, and drug therapy or vaccine studies were the weak point in the response to COVID-19. As vaccines are the ultimate solution to the pandemic, a need for studies and publications regarding vaccines has emerged (9).

In a study investigating COVID-19 publications, medicine was the main area of publication in the field of health while the fields of internal medicine, and public environmental occupational health were upfront as subgroups (10). Another study revealed that infectious diseases and pharmacology were the most common fields (11). When vaccines are considered, our results revealed that immunology and biochemistry were the leading fields.

In their study, Martinez-Perez et al investigated COVID-19 studies published between January and July 2020. A total of 14,409 publications and 42,377 citation networks were found in WoS. Of these publications, 39.90 % were articles, 26.42 % were editorial material, 18.73 % were letters, 9.93 % were reviews, 4.3 % were news items, and 0.8 % were edits, book reviews, retractions, or meeting abstracts (10). In another study, among 7,185 articles regarding COVID-19, 2,898 were articles, 2,275 were editorial materials, 2,646 were early access publications, 1,621 were letters and 711 were reviews and other contributions (5). Accordingly, in

our study, 63.4 % of the publications were original articles, followed by reviews (36.5 %) and early access publications (8.7 %). When the importance of results of comprehensive vaccine trials is considered, research articles are the mainstays of vaccine development efforts.

It has been reported previously that the authors with the largest number of publications on COVID-19 were Wang Y (0.55 %), Mahase E (0.47 %) and Li Y (0.43 %) (10). Top authors on our list were Qin CF with 4 articles, Wang L with 4 articles and Baric RS with 3 articles. We need experienced researchers to share their experiences in order to collect updated and rapid information on vaccines.

The most preferred journals in our study were Biomolecular Structure Dynamics, Nature, and Science. The reason why these journals were chosen may lie in their scope, visibility, and impact factor. Scientometric analyses on COVID-19 revealed that leading journals were Journal of Medical Virology, which has the most publications, followed by Chinese Journal of Tuberculosis and Respiratory Diseases (n=9), Journal of Travel Medicine (n=8), Journal of Clinical Medicine (n=8), The Lancet (n=7), Radiology (n=6) and JAMA (n=5) (10). However, in such a dynamic process, results may vary. For instance, in another study, it was reported that the British Medical Journal published the highest number of papers (n=129) and The Lancet had the most citations (n=1439) (12). We determined that authors often choose journals with high impact factors and open access policy. This result may be attributed to the intentness of authors to reach a wider audience.

The most productive country in our study was the USA with 45 articles followed by China with 44 articles. A similar competition between these superpowers is observed in COVID-19 publications. Until the emergence of the pandemic in 2019, the USA ranked first in coronavirus literature followed by China (13). When COVID-19 publications are considered, various scientometric studies reveal that the USA has a superiority. Till date, the leading countries according to publication rates were the USA, China and Italy (5,10). In a more detailed investigation with keywords "coronavirus" and "COVID-19" separately, the results revealed that while researchers in the USA have contributed the highest number of research items to the topic of coronaviruses, followed by Chinese authors, this order was reversed in the literature published on COVID-19. On COVID-19, nearly 30 % of all published studies were found to originate in China, with the USA accounting for nearly 14 % (14). We believe that a closer collaboration between different institutes in different countries may contribute to the efforts in vaccine development.

In a study, the categories of COVID-19-related articles were found to be medicine, internal and general medicine, and infectious diseases. However, the number of studies in virology and microbiology was relatively low (15). According to WoS, science technology, immunology, pharmacology, and biochemistry were the most studied fields in vaccine literature. As mentioned above, the vaccine development is firmly attached to technological development, and importance given to immunological, pharmacological, and biochemical trials. It is not surprising that these fields have come into prominence. When vaccine studies are compared with COVID-19 studies, it is observed that fields of interest shift from general medicine to technological and immunological areas.

Top 20 most cited articles on COVID-19 were analyzed in a study. Seventeen were on symptoms, viral transmission, and experimental treatment methods. Two of them addressed unusual clinical symptoms and findings, and 1 was on the effects of comorbidities in COVID-19 patients (10). When it comes to top 20 most cited articles on vaccines, we determined that 10 articles were on search for an ideal protein target that vaccines should be aimed at (16, 17, 18, 19, 20, 21, 22, 23, 24, 25) (Tab. 3). Particularly, human angiotensin-converting enzyme 2, SARS-CoV-M-pro (mediates virus replication and transcription), CD (+) T cells, spike proteins, and nucleocapsid proteins (two latter proteins show no mutations which makes them good targets for vaccines) were put forward by researchers. Second most investigated field of interest was the selection of candidates for vaccination with 5 articles (26, 27, 28, 29, 30). Also, groups under the risk of possibility of not becoming eligible for vaccination, such as children and pregnant women, were discussed. Two articles were related to host-pathogen interactions (31, 32). While one article was sharing previous experiences with coronaviruses, the other two were a review regarding vaccine types and analysis of top vaccine articles (33, 34, 35). Accordingly in another study, it was reported that researchers focused mainly on potential targets of vaccines, safety, and efficacy against COVID-19 (4).

In 2020, 58 vaccines have been developed against COVID-19 in trials and some of them have been reported to have 90 % efficacy (4). There are four main categories of COVID-19 vaccines, namely live attenuated vaccine (LAV), inactivated virus vaccine, subunit vaccine, viral vector-based vaccine, DNA vaccine and RNA vaccine (36). Chimpanzee adenovirus vector-based vaccine ChAdOx1 nCoV-19 (AZD1222) developed by Oxford–AstraZeneca had an efficacy of more than 90 % in adults aged ≥ 18 years (4). Pfizer's mRNA vaccine was 95 % effective 28 days after the first dose (37). The vaccine BNT162b2 is based on a modified RNA that encodes a version of the SARS-CoV-2 spike protein containing mutations that lock the protein into a conformation that can induce neutralizing antibody responses. Although the vaccine needs to be stored at −70 °C, it is to its advantage that its overall efficacy was reported to be 95 % (3). Another developer, Sinopharm from China declared a vaccine with 86 % efficacy (38). As the vaccines are being administered on a global scale, the number of publications on vaccine availability, determination of vaccine candidates, challenges brought about by mass vaccination and complications related to vaccines are likely to increase in the literature.

Limitations

As in all scientometric analyses, our study also has some limitations. Due to the time-dependent nature of such studies, results may vary according to the period the study was conducted in. Also, there may be valuable studies that have been excluded from our study due to their relatively low numbers of citations.

Tab. 3. Summary of top 20 highly cited articles.

Authors (reference number)	Title	Journal (impact factor) date of publication	Number of citations	Article type	Language	Country	Summary
Ou XY, Liu Y, Lei XB, Li P, Mi D, Ren LL et al (16)	Characterization of spike glycoprotein of SARS-CoV-2 on virus entry and its immune cross-reactivity with SARS-CoV	Nature Communications (12.2) March 2020	361	Original Article	English	China	A study on potential targets that vaccines should be aimed at. Human angiotensin converting enzyme 2 (hACE2) is the receptor for SARS-CoV-2. SARS-CoV-2 enters 293/hACE2 cells mainly through endocytosis, that PIKfyve, TPC2, and cathepsin L are critical for entry, and that SARS-CoV-2 S protein is less stable than SARS-CoV S.
Jin, ZM, Du XY, Xu, YC, Deng, YQ, Liu MQ, Zhao Y et al (17)	Structure of M-pro from SARS-CoV-2 and discovery of its inhibitors	Nature (42.7) April 2020	326	Original Article	English	China	A program that aimed to rapidly discover lead compounds for clinical use, by combining structure-assisted drug design, virtual drug screening and high-throughput screening was developed. The program focused on identifying drug leads that target main protease (M-pro) of SARS-CoV-2: M-pro is a key enzyme of coronaviruses and has a pivotal role in mediating viral replication and transcription, making it an attractive drug target for SARS-CoV-2.
Prompetchara E, Kettoy C, Palaga T (31)	Immune responses in COV-ID-19 and potential vaccines: Lessons learned from SARS and MERS epidemic	Asian Pacific Journal of Allergy and Immunology (1.7) March 2020	321	Review	English	Thailand	Comparison of SARS-CoV, MERS-CoV and SARS-CoV-2. The review aims to provide a better understanding of the host-pathogen interaction, host immune responses, and the pathogen immune evasion strategies.
Gordon DE, Jang GM, Bouhaddou M, Xu JW, Obernier K, White KM et al (32)	A SARS-CoV-2 protein interaction map reveals targets for drug repurposing	Nature (42.7) April 2020	315	Original Article	English	The USA	The researchers cloned, tagged and expressed 26 of the 29 SARS-CoV-2 proteins in human cells and identified the human proteins that physically associated with each of the SARS-CoV-2 proteins using affinity-purification mass spectrometry. They identified 332 high-confidence protein-protein interactions between SARS-CoV-2 and human proteins.
Shereen MA, Khan, S, Kazmi, A, Bashir, N, Siddique R (33)	COVID-19 infection: Origin, transmission, and characteristics of human coronaviruses	Journal of Advanced Research (4.3) July 2020	292	Review	English	China	The authors summarized and comparatively analyzed the emergence and pathogenicity of COVID-19 infection and previous human coronaviruses, SARS-CoV) and MERS-CoV.
Grifoni A, Weiskopf D, Ramirez SI, Mateus J, Dan JM, Moderbacher CR et al (18)	Targets of T Cell Responses to SARS-CoV-2 Coronavirus in Humans with COVID-19 Disease and Unexposed Individuals	Cell (38.6) June 2020	266	Original Article	English	The USA	CD4 (+) T cell responses to spike, the main target of most vaccine efforts, were robust and correlated with the magnitude of the antiSARS-CoV-2 IgG and IgA titers. The M, spike, and N proteins each accounted for 11 %-27 % of the total CD4(+) response, with additional responses commonly targeting nsp3, nsp4, ORF3a, and ORF8, among others. For CD8 (+) T cells, spike and M were recognized, with at least eight SARS-CoV-2 ORFs targeted
Zhang L, Liu YH (26)	Potential interventions for novel coronavirus in China: A systematic review	Journal of Medical Virology (2) March 2020	240	Review	English	China	The nutritional status of each infected patient should be evaluated before the administration of general treatments and the current children‘s RNA-virus vaccines including influenza vaccine should be immunized for uninfected people and health care workers
Madjid M, Safavi-Naeini P, Solomon SD, Vardeny O (27)	Potential Effects of Coronaviruses on the Cardiovascular System A Review	JAMA Cardiology (12.7) March 2020	237	Review	English	The USA	It is emphasized that extensive efforts are underway to find specific vaccines and antivirals against SARS-CoV-2. Meanwhile, cardiovascular risk factors and conditions should be judiciously controlled per evidence-based guidelines.
Ahmed SF, Quadeer AA, McKay MR (19)	Preliminary Identification of Potential Vaccine Targets for the COVID-19 Coronavirus (SARS-CoV-2) Based on SARS-CoV Immunological Studies	Viruses-Basel (3.8) March 2020	224	Original Article	English	China	The researchers identified a set of B cell and T cell epitopes derived from the spike (S) and nucleocapsid (N) proteins that map identically to SARS-CoV-2 proteins. As no mutation has been observed in these identified epitopes among the 120 available SARS-CoV-2 sequences, immune targeting of these epitopes may potentially offer protection against this novel virus. For the T cell epitopes, they performed a population coverage analysis of the associated MHC alleles and proposed a set of epitopes that is estimated to provide broad coverage globally, as well as in China.
Tai WB, He L, Zhang XJ, Pu J, Voronin D, Jiang SB et al (20)	Characterization of the receptor-binding domain (RBD) of 2019 novel coronavirus: implication for development of RBD protein as a viral attachment inhibitor and vaccine	Cellular & Molecular Immunology (7.1) March 2020	223	Original Article	English	China	The CoV spike (S) protein plays the most important roles in viral attachment, fusion and entry, and serves as a target for development of antibodies, entry inhibitors and vaccines. The researchers identified the receptor-binding domain (RBD) in SARS-CoV-2 S protein and found that the RBD protein bound strongly to human and bat angiotensin-converting enzyme 2 (ACE2) receptors

Authors (reference number)	Title	Journal (impact factor) date of publication	Number of citations	Article type	Language	Country	Summary
Wang C, Li W, Drabek D, Okba NMA, van Haperen R, Osterhaus ADME et al (21)	A human monoclonal antibody blocking SARS-CoV-2 infection.	Nature Communications (12.1) May 2020	195	Original Article	English	Netherlands	A cross-neutralizing antibody that neutralizes SARS-CoV-2 (and SARS-CoV) in cell culture is presented.
Amanat F, Krammer F (34)	SARS-CoV-2 Vaccines: Status Report	Immunity (22.5) April 2020	193	Review	English	The USA	Describes RNA vaccines, DNA vaccines, recombinant protein vaccines, viral vector-based vaccines, live attenuated vaccines and inactivated vaccines. Emphasizes the importance of vaccines in preventing future waves.
Liu C, Zhou Q, Li Y, Garner LV, Watkins SP, Carter LJ et al (35)	Research and Development on Therapeutic Agents and Vaccines for COVID-19 and Related Human Coronavirus Diseases.	ACS Central Science (12.8) March 2020	187	Original Article	English	The USA	A summary of drugs and vaccines, targets of drugs and vaccines and top articles related to vaccines.
Schwartz DA, Graham AL (28)	Potential Maternal and Infant Outcomes from (Wuhan) Coronavirus 2019-nCoV Infecting Pregnant Women: Lessons from SARS, MERS, and Other Human Coronavirus Infections	Viruses-Basel (3.8) February 2020	171	Review	English	The USA	Adverse effects of COVID-19 in pregnancy. Emphasizes the lack of information in potential effects of vaccines in pregnancy. Highlights the potential benefits of vaccines in pregnant women.
Zimmermann P, Curtis N (29)	Coronavirus Infections in Children Including COVID-19: An Overview of the Epidemiology, Clinical Features, Diagnosis, Treatment and Prevention Options in Children.	The Pediatric Infectious Disease Journal (2.7) May 2020	156	Review	English	Switzerland	Children are also under risk for COVID-19 but they are more likely to become asymptomatic. However, the importance of children in transmitting the virus remains uncertain and this review underlines that the virus is transmitted to children by household contact and is often. presented with gastrointestinal complaints
Jin Y, Yang H, Ji W, Wu W, Chen S, Zhang W et al (22)	Virology, Epidemiology, Pathogenesis, and Control of COVID-19	Viruses-Basel (3.8) April 2020	146	Review	English	China	Summarizes pathogenesis, clinical findings, complications and potential therapeutics. Underlines that epitopes, mRNA, and S protein-RBD structure-based vaccines have been widely proposed.
Yang Y, Peng F, Wang R, Yange M, Guan K, Jiang T et al (30)	The deadly coronaviruses: The 2003 SARS pandemic and the 2020 novel coronavirus epidemic in China.	Journal of Autoimmunity (7.6) May 2020	144	Review	English	China	A review on pathophysiology and clinical findings of the disease. The article also involves recommendations about preventing virus spread and treatment methods. Emphasizes challenges in vaccine development.
Bao L, Deng W, Huang B, Gao H, Liu J, Ren L et al (23)	The pathogenicity of SARS-CoV-2 in hACE2 transgenic mice.	Nature (42.7) July 2020	142	Original Article	English	China	The investigated SARS-CoV-2 infected mice and observed weight loss as well as virus replication in the lungs of mice that have human ACE2 receptors. They proposed to aim these receptors in vaccine studies.
Zhu FC, Li YH, Guan XH, Hou LH, Wang WJ, Li JX, et al (24)	Safety, tolerability, and immunogenicity of a recombinant adenovirus type-5 vectored COVID-19 vaccine: a dose-escalation, open-label, non-randomized, first-in-human trial	Lancet (60.3) June 2020	141	Original Article	English	China	This study assesses the safety, tolerability, and immunogenicity of a recombinant adenovirus type-5 (Ad5) vectored COVID-19 vaccine. Low-middle and high doses were administered to participants. The most common complaints were pain in the injection site, fever, fatigue, headache, and muscle pain, respectively.
Gao Q, Bao L, Mao H, Wang L, Xu K, Yang M et al (25)	Development of an inactivated vaccine candidate for SARS-CoV-2	Science (41.8) July 2020	140	Original Article	English	China	The researchers report a pilot-scale production of a purified inactivated SARS-CoV-2 virus vaccine candidate which induced SARS-CoV-2-specific neutralizing antibodies in mice, rats, and nonhuman primates. The vaccine neutralized 10 representative SARS-CoV-2 strains with two doses.

Conclusion

Most vaccines have taken decades to develop while it has taken less than a year for COVID-19 vaccine to progress from theory to wide implementation (3). The development of vaccines is a vital part of any pandemic response. However, in all cases, starting with the great influenza pandemic of 1918–1919, the timeline for vaccine development, testing, approval, and production have been inadequate to have a substantial effect on mitigating the spread and impact of each pandemic. The first 2–3 waves are most likely to occur within 12–15 months of the virus originating and therefore it is crucial to focus on mitigating interventions targeting infection prevention strategies (39)

When faced with this crisis, humanity needs policymakers and emergency managers to elucidate their decisions through scientific evidence. For this purpose, rapid and timely accumulation of knowledge and empirical evidence is critical (14).

Justifiably, the journals are now actively seeking research on COVID-19 to be published quickly and with open access policy (40). According to our results, there is a growing interest in vaccine publications. Numerous institutions explain results of clinical trials under the leadership of the USA, China and India. Top articles focus on sites on the virus surface that vaccines should be aimed at.

References

1. Kotta S, Aldawsari HM, Badr-Eldin SM et al. Combating the Pandemic COVID-19: Clinical Trials, Therapies and Perspectives. Front Mol Biosci 2020; 7: 606393. DOI: 10.3389/fmolb.2020.606393.

2. Erenler AK, Baydin A. Challenges in COVID-19 diagnosis. Bratisl Med J 2020; 121 (12): 864. DOI: 10.4149/BLL_2020_142.

3. Rubin EJ, Longo DL. SARS-CoV-2 Vaccination - An Ounce (Actually, Much Less) of Prevention. N Engl J Med 2020; 383 (27): 2677–2678. DOI: 10.1056/NEJMe2034717.

4. Knoll MD, Wonodi C. Oxford-AstraZeneca COVID-19 vaccine efficacy [published online ahead of print, 2020 Dec 8]. Lancet 2020; S0140–6736 (20): 32623–32624. DOI: 10.1016/S0140-6736 (20)32623-4.

5. Grammes N, Millenaar D, Fehlmann T et al. Research Output and International Cooperation Among Countries During the COVID-19 Pandemic: Scientometric Analysis. J Med Internet Res 2020; 22 (12): e24514. DOI: 10.2196/24514.

6. Kendall S. LibGuides: PubMed, Web of Science, or Google Scholar? A behind-the-scenes guide for life scientists. Which one is best: PubMed, Web of Science, or Google Scholar? https: //libguides.lib.msu.edu/c.php?g = 96972&p = 627295. Accessed March 15, 2020.

7. Hood WW, Wilson CS. The literature of bibliometrics, scientometrics, and informetrics. Scientometrics 2001; 52 (2): 291–314. DOI: 10.1023/A: 1017919924342.

8. Smith MJ, Upshur REG, Emanuel EJ. Publication ethics during public health emergencies such as the COVID-19 pandemic. Am J Public Health 2020; 14: e1–e2. https: //doi.org/10.2105/AJPH.2020.305686.

9. Wang J, Hong N. The COVID-19 research landscape: Measuring topics and collaborations using scientific literature. Medicine (Baltimore) 2020; 99 (43): e22849. DOI: 10.1097/MD.0000000000022849.

10. Martinez-Perez C, Alvarez-Peregrina C, Villa-Collar C, Sánchez-Tena MÁ. Citation Network Analysis of the Novel Coronavirus Disease 2019 (COVID-19). Int J Environ Res Public Health 2020; 17 (20): 7690. DOI: 10.3390/ijerph17207690.

11. Tran BX, Ha GH, Nguyen LH et al. Studies of Novel Coronavirus Disease 19 (COVID-19) Pandemic: A Global Analysis of Literature. Int J Environ Res Public Health 2020; 17 (11): 4095. DOI: 10.3390/ijerph17114095.

12. DE Felice F, Polimeni A. Coronavirus Disease (COVID-19): A Machine Learning Bibliometric Analysis. In Vivo 2020; 34 (3 Suppl): 1613–1617. DOI: 10.21873/invivo.11951.

13. Şenel E, Topal FE. Holistic Analysis of Coronavirus Literature: A Scientometric Study of the Global Publications Relevant to SARS-CoV-2 (COVID-19), MERS-CoV (MERS) and SARS-CoV (SARS) [published online ahead of print, 2020 Aug 13]. Disaster Med Public Health Prep 2020; 1–8. DOI: 10.1017/dmp.2020.300.

14. Haghani M, Bliemer MCJ, Goerlandt F, Li J. The scientific literature on Coronaviruses, COVID-19 and its associated safety-related research dimensions: A scientometric analysis and scoping review. Saf Sci 2020; 129: 104806. DOI: 10.1016/j.ssci.2020.104806.

15. Pericàs JM, Arenas A, Torrallardona-Murphy O, Valero H, Nicolás D. Published evidence on COVID-19 in top-ranked journals: A descriptive study. Eur J Intern Med 2020; 79: 120–122. DOI: 10.1016/j.ejim.2020.07.005.

16. Ou X, Liu Y, Lei X et al. Characterization of spike glycoprotein of SARS-CoV-2 on virus entry and its immune cross-reactivity with SARS-CoV. Nat Commun 2020; 11 (1): 1620. DOI: 10.1038/s41467-020-15562-9.

17. Jin Z, Du X, Xu Y et al. Structure of Mpro from SARS-CoV-2 and discovery of its inhibitors. Nature 2020; 582 (7811): 289–293. DOI: 10.1038/s41586-020-2223-y.

18. Grifoni A, Weiskopf D, Ramirez SI et al. Targets of T Cell Responses to SARS-CoV-2 Coronavirus in Humans with COVID-19 Disease and Unexposed Individuals. Cell 2020; 181 (7): 1489–1501.e15. DOI: 10.1016/j.cell.2020.05.015.

19. Ahmed SF, Quadeer AA, McKay MR. Preliminary Identification of Potential Vaccine Targets for the COVID-19 Coronavirus (SARS-CoV-2) Based on SARS-CoV Immunological Studies. Viruses 2020; 12 (3): 254. DOI: 10.3390/v12030254.

20. Tai W, He L, Zhang X et al. Characterization of the receptor-binding domain (RBD) of 2019 novel coronavirus: implication for development of RBD protein as a viral attachment inhibitor and vaccine. Cell Mol Immunol 2020; 17 (6): 613–620. DOI: 10.1038/s41423-020-0400-4.

21. Wang C, Li W, Drabek D et al. A human monoclonal antibody blocking SARS-CoV-2 infection [published correction appears in Nat Commun 2020 May 14; 11 (1): 2511]. Nat Commun 2020; 11 (1): 2251. DOI: 10.1038/s41467-020-16256-y.

22. Jin Y, Yang H, Ji W et al. Virology, Epidemiology, Pathogenesis, and Control of COVID-19. Viruses 2020; 12 (4): 372. DOI: 10.3390/v12040372.

23. Bao L, Deng W, Huang B et al. The pathogenicity of SARS-CoV-2 in hACE2 transgenic mice. Nature 2020; 583 (7818): 830–833. DOI: 10.1038/s41586-020-2312-y.

24. Zhu FC, Li YH, Guan XH et al. Safety, tolerability, and immunogenicity of a recombinant adenovirus type-5 vectored COVID-19 vaccine: a dose-escalation, open-label, non-randomised, first-in-human trial. Lancet 2020; 395 (10240): 1845–1854. DOI: 10.1016/S0140-6736 (20)31208-3

25. Gao Q, Bao L, Mao H et al. Development of an inactivated vaccine candidate for SARS-CoV-2. Science 2020; 369 (6499): 77–81. DOI: 10.1126/science.abc1932.

26. Zhang L, Liu Y. Potential interventions for novel coronavirus in China: A systematic review. J Med Virol 2020; 92 (5): 479–490. DOI: 10.1002/jmv.25707.

27. Madjid M, Safavi-Naeini P, Solomon SD, Vardeny O. Potential Effects of Coronaviruses on the Cardiovascular System: A Review. JAMA Cardiol 2020; 5 (7): 831–840. DOI: 10.1001/jamacardio.2020.1286.

28. Schwartz DA, Graham AL. Potential Maternal and Infant Outcomes from (Wuhan) Coronavirus 2019-nCoV Infecting Pregnant Women: Lessons from SARS, MERS, and Other Human Coronavirus Infections. Viruses 2020; 12 (2): 194. DOI: 10.3390/v12020194.

29. Zimmermann P, Curtis N. Coronavirus Infections in Children Including COVID-19: An Overview of the Epidemiology, Clinical Features, Diagnosis, Treatment and Prevention Options in Children. Pediatr Infect Dis J 2020; 39 (5): 355-368. DOI: 10.1097/INF.0000000000002660.

30. Yang Y, Peng F, Wang R et al. The deadly coronaviruses: The 2003 SARS pandemic and the 2020 novel coronavirus epidemic in China [published correction appears in J Autoimmun 2020 Jul; 111: 102487]. J Autoimmun 2020; 109: 102434. DOI: 10.1016/j.jaut.2020.102434.

31. Prompetchara E, Ketloy C, Palaga T. Immune responses in COVID-19 and potential vaccines: Lessons learned from SARS and MERS epidemic. Asian Pac J Allergy Immunol 2020; 38 (1): 1–9. DOI: 10.12932/AP-200220-0772.

32. Gordon DE, Jang GM, Bouhaddou M et al. A SARS-CoV-2 protein interaction map reveals targets for drug repurposing. Nature 2020; 583 (7816): 459–468. DOI: 10.1038/s41586-020-2286-9.

33. Shereen MA, Khan S, Kazmi A, Bashir N, Siddique R. COVID-19 infection: Origin, transmission, and characteristics of human coronaviruses. J Adv Res 2020; 24: 91–98. DOI: 10.1016/j.jare.2020.03.005.

34. Amanat F, Krammer F. SARS-CoV-2 Vaccines: Status Report. Immunity 2020; 52 (4): 583–589. DOI: 10.1016/j.immuni.2020.03.007.

35. Liu C, Zhou Q, Li Y et al. Research and Development on Therapeutic Agents and Vaccines for COVID-19 and Related Human Coronavirus Diseases. ACS Cent Sci 2020; 6 (3): 315–331. DOI: 10.1021/acscentsci.0c00272.

36. Tsang HF, Chan LWC, Cho WCS et al. An update on COVID-19 pandemic: the epidemiology, pathogenesis, prevention and treatment strategies [published online ahead of print, 2020 Dec 29]. Expert Rev Anti Infect Ther 2020; 1–12. DOI: 10.1080/14787210.2021.1863146.

37. Mahase E. Covid-19: People with history of significant allergic reactions should not receive Pfizer vaccine, says regulator. BMJ 2020; 371: m4780. DOI: 10.1136/bmj.m4780

38. Mahase E. Covid-19: Oxford vaccine could be 59 % effective against asymptomatic infections, analysis shows. BMJ 2020; 371: m4777. DOI: 10.1136/bmj.m4777.

39. Viboud, C.; Grais, R.F.; Lafont, A.B.; Miller, M.A.; Simonsen, L. Multinational Influenza Seasonal Mortality Study Group: Multinational impact of the 1968 Hong Kong influenza pandemic: Evidence for a smoldering pandemic. Int. J. Infect. Dis 2005, 192, 233–248.

40. Mubarak M. COVID-19 and Biomedical Publishing: Challenges and Prospects. J Coll Physicians Surg Pak 2020; 30 (10): 92–93. DOI: 10.29271/jcpsp.2020.supp2.92.

Received October 21, 2021.
Accepted November 19, 2021.