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COVID-19 VACCINATION CAMPAIGN: A BIBLIOMETRIC ANALYSIS

Abstract. *This study provides the bibliometric analysis of publications addressing the COVID-19 pandemic and preventive measures to overcome it. This study aims to analyze, systematize, and build clusters of world schools of thought that changed their research directions in connection with the COVID-19 pandemic. The relevance of solving the scientific problem is urgent to quickly restore the economy, education, tourism, and other spheres of society affected by the pandemic. The authors emphasized that vaccination is one of the effective ways to reduce COVID-19 morbidity. Therefore, the study sample was generated with articles indexed by keywords "COVID-19" and «vaccination» in the Web of Science and Scopus databases. The study period covers 2020-2021. To operate with the most relevant publications, the study sample was limited by the English publication language and subject areas, excluding the publications in the categories of medicine and pharmacology. The case study involved the VOSviewer software, Web of Science, and Scopus database analysis tools in analyzing the scientific background on the issue of trust in the vaccination campaign. The visualization of findings was conducted using the VOSviewer software tools. The obtained results showed most of the work was published by the scholars of American, English, Chinese, German and Italian affiliations. The study identified at least 10 research directions on the investigated topic: the reasons for differentiating the intentions to be vaccinated; attitudes towards vaccinations depending on gender, age, and social status; forecasting different recovering scenarios; consequences of misinformation and fight against misinformation; effectiveness of social pressure on the population; the role of social networks; sufficiency of using personal protective equipment; the self-responsibility in creating collective immunity; the need medical staff visits; testing the effectiveness of the vaccine, etc. The findings of the bibliometric analysis could be useful for further empirical studies to find cause-and-effect relationships and mathematical modeling of the reasons for vaccination refusal and predicting different pandemic scenarios.*

Keywords: bibliometric analysis, COVID-19, vaccination, pandemic, VOSviewer.

Introduction. The COVID-19 pandemic has transformed the education, medical, social, economic, institutional, political, financial, and public sectors. The quarantine restrictions and lockdown significantly slowed down economic growth in most countries and increased unemployment. With the rise in morbidity, more pharmaceutical campaigns have changed the vector of their developments to invent an effective vaccine that would prevent seasonal outbreaks. In December 2020, vaccines with clinically proven high efficacy were launched worldwide. However, new difficulties arose because the population hardly perceived and trusted these vaccines. Despite understanding the devastating pandemic consequences for the world economy, the vaccination campaign has slowed down because of public distrust in vaccines.

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The above resulted from vaccines' high inventing speed, the existence of the anti-vax movement, the unpredictable side effects, the existence of myths about conspiracy theories, etc.

Literature Review. The analysis of scientific literature showed a high scientific interest in the issues of public perception vaccination against COVID-19, modeling the scenarios of successful and failed vaccination campaigns. This issue is relevant as for the world economy, as medical and social security. Drażkowski and Trepanowski (2021) applied the theory of planned behavior and found that desire to be vaccinated depends on a person's age and gender. Therefore, these findings could be used to encourage people to the immunization campaign better. Delgado-Gallegos et al. (2021) used a binary regression to search a set of variables that correlated strongly with people's desire to be vaccinated. The scholars concluded that people aged 18 to 34 were the most motivated to be vaccinated. Besides, the authors concluded that gender, education, religion, or economic status are not strongly correlated with the level of xenophobia before immunization.

Bodner et al. (2021) used the hierarchical regression analysis to investigate the relationship between population anxiety rates of possible fatalities and fears of vaccination. The scholars theoretically demonstrated a positive association between fatal anxiety and pre-immunization anxiety. Ali et al. (2021) tested the effectiveness of explanatory work on the benefits and myths about vaccination by interviewing students before and after a scientific seminar. The findings showed that the scientific seminars contribute to raising the number of those who wish to be vaccinated.

Pakpour et al. (2021) emphasized that the most effective way to fight against the virus is to use a mass vaccination campaign. Besides, Afolabi and Ilesanmi (2021) believed that achieving collective immunity through mass immunization of the population is the most effective way to combat the coronavirus. The scholars noted that building a national or global roadmap to involve the population in the immunization campaign is ineffective.

Mennini et al. (2021) applied econometric modeling with a time lag of the dependence of accelerating or slowing down the vaccination campaign on the speed of economic recovery of a country affected by quarantine restrictions. However, the authors emphasized the slowdown in creating the collective immunity from COVID-19 decreases the pace of economic recovery.

Ansari-Moghaddam et al. (2021) used a combination of empirical surveys and theoretical data processing with a system of structural equations to investigate people's desire to get vaccines. The findings proved that people's desire for immunization helps spread positive vaccination experiences and confirm the vaccine's effectiveness. Guillon and Kergall (2021) used theoretical analysis and logistic regression to study determinants that affect people's intentions to vaccinate. The obtained results showed that 30% of respondents agreed with vaccination. On the contrary, 30% of respondents strongly disagreed because they believe that the risk of negative consequences of vaccination is greater than the risk of COVID-19 complications.

Yu et al. (2021) analyzed the public intentions to be vaccinated. The findings revealed the lowest level of readiness among the elderly and young people and single women. Besides, the total number of people ready to be vaccinated did not exceed 14%. Wong and Yang (2022) found that the fear of getting the vaccine outweighs the risk of getting sick.

McPhedran and Toombs (2021) conducted a scientific experiment to identify factors influencing public participation in vaccination. The obtained results showed that vaccine quality was the most influential factor.

Campos et al. (2021) used mathematical methods to analyze the COVID-19 issues. In turn, Abdy et al. (2021) used the SIR model for the COVID-19 spread with variable characteristics of the number of interactions, desire to be vaccinated, and age. Furthermore, Alqahtani and Abdelhamid (2021) modified the compartment SIR model. In conjunction with the bifurcation theory, the SEIR model was used to find the value at which the stability of the model is achieved. Liao et al. (2021) have proposed short- and

medium-term forecasts using the LST model based on deep learning technology. Buturoiu et al. (2021) determined the triggers of the population's intention to be vaccinated. Gil-Aluja et al. (2021) combined fuzzy set theory with uncertainty theory for each group's population cluster analysis and vaccination scenarios. Jankhonkhan and Sawangtong (2021) applied the theory of differential equations to the pandemic model for the first three waves of COVID-19 incidence. The sum of squares error was used to predict future outbreaks and a strategy of preventive measures. Therefore, research analysis related to the COVID-19 vaccination campaign has revealed many scientific issues, so it is necessary to visualize and summarize all views.

Methodology and research methods. *Step 1. Formation of study sampling on Scopus and Web of Science databases.* The search of the articles applied the keywords «COVID-19» and «vaccination». The results determined 9479 publications in the Scopus database and 9474 articles in the Web of Science (WoS) database for 2020-2021. However, the obtained publications were filtered to select the most relevant using the following limitations: the language of the article – English; the medical and pharmaceutical subject areas were excluded.

Therefore, the study sample includes 274 documents indexed in the Scopus database and 278 – in the Web of Science database. Figure 1 demonstrates the TOP-20 countries that published most of the investigated articles. Besides, there is indicated the contribution of Ukrainian scholars. The total number of countries engaged in the investigated topic is 69 by Scopus database and 62 countries in WoS databases.

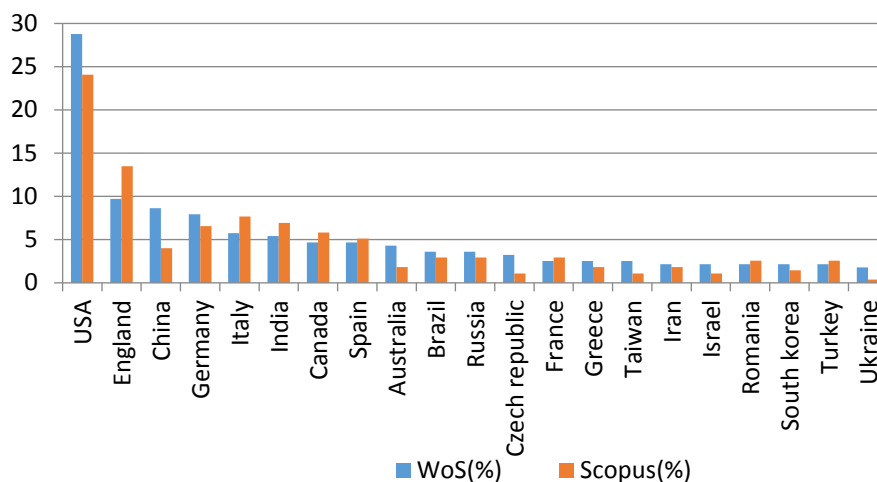


Figure 1. Comparing the scope of publication activity on «COVID-19» and «vaccination» between Scopus and Web of Science databases (2020-2021)

Sources: developed by the authors.

Figure 1 shows that the most significant number of scientific papers indexed in Scopus/WoS databases were published by the authors from the United States (29%/24%), the United Kingdom (10%/14%), China (9%/4%), and Italy (6%/8%). It stands to mention that these countries recorded the largest outbreaks of COVID-19. Therefore, it could be assumed that the COVID-19 prompted scientists to change the vector of their scientific interests to find an effective algorithm to combat the pandemic.

On the hand, the analysis showed the publications cover (average for Scopus/WoS) 35.4% of Social Sciences, 20.8% of Computer Science, 18.3% of Engineering, 13.9% of Arts and Humanities, 13.9% of

Mathematics, 12% of Psychology, 9.5% of Materials Science, and 6.6% of Business, Management, and Accounting. The above indicates a multidisciplinary research interest in overcoming the pandemic.

Step 2. Building links among research keywords, COVID-19, and vaccination.

A more in-depth analysis of bibliometric sources was performed using VOSViewer 1.6.10 software. Figure 2 demonstrates the item network to clarify and visualize bibliographic data retrieved from the Scopus database. Thus, the network map consists of 120 keywords combined into 20 clusters.

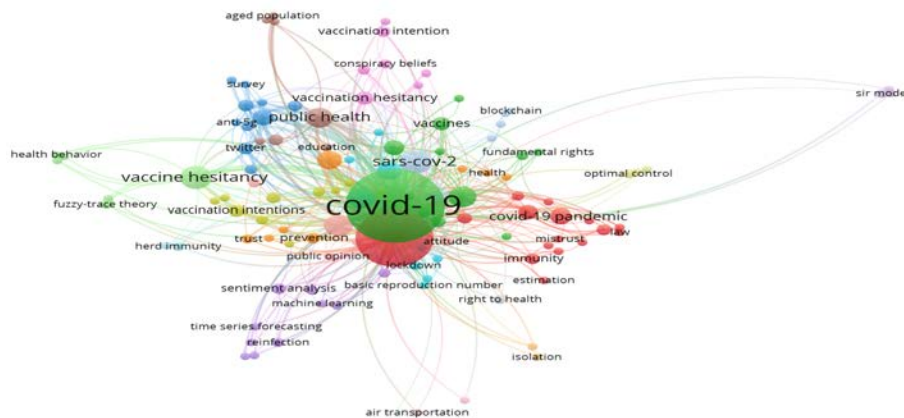


Figure 2. The co-occurrence network of keywords «COVID-19» and «vaccination» with other terms by the Scopus database

Sources: developed by the authors using the VOSviewer software tools.

The largest (red) cluster covers the items of COVID-19 pandemic, estimation, ethics, human rights, immunity, law, mathematical modeling, mistrust, model predictive control, modeling, policy, uncertainty, vaccinations, etc. Most links to the topic of COVID-19 vaccination in the Scopus database correlate with the concepts of mathematical modeling of the vaccination consequences and the reasons for differentiating the readiness of people for immunization.

The second (green) cluster includes keywords: COVID-19, pandemic, vaccines, artificial intelligence, biotechnology, compulsory vaccination, fundamental rights, optimization, personal protective equipment, prediction, and social justice. Therefore, the second cluster focused mostly on social issues, such as compulsory vaccination as an individual and collective protection against the virus and changes in civil law and free choice.

The third cluster (blue) covers the key concepts of anti-vaccination, disinformation, infodemic, misinformation, social media, social network analysis, survey, Twitter, and vaccination status. The enormous amount of information about the vaccination campaign on various social networks caused the spread of unverified information. Thus, many myths have emerged, and, as a result, many people have opposed any vaccination. As a result, it has negatively affected the dynamics of vaccination.

The fourth cluster (yellow) includes the keywords: decision making, health beliefs, intention to vaccinate, perceived risk, risk communication, sars-cov-2 vaccine, vaccine intentions, vaccine acceptance, and vaccine efficacy. This cluster indicates the scientific interest in investigating people's intentions to be vaccinated and verifying information on the risks of vaccination and its absence. Besides, this cluster shows the counseling assistance of the population (by medical staff, authorities, scientists, etc.) on the risks of refusing immunization is an effective way to combat the disinformation on the vaccination threat.

The fifth cluster connects the terms of epidemic model, time series forecasting, epidemiology, machine learning, reinfection, sentiment analysis, simulation, vaccination strategy, etc. This cluster complements the first cluster by considering different mathematical modeling techniques to build an effective vaccination campaign roadmap.

The rest of the clusters are much smaller but consider the current topics related to the COVID-19 pandemic, such as economic impact, impact on education, mortality, tourism decline, cloud development, etc.

On the contrary, Figure 3 illustrates the item network (164 keywords grouped into more than 20 clusters) of publications retrieved from the WoS database. Showing.

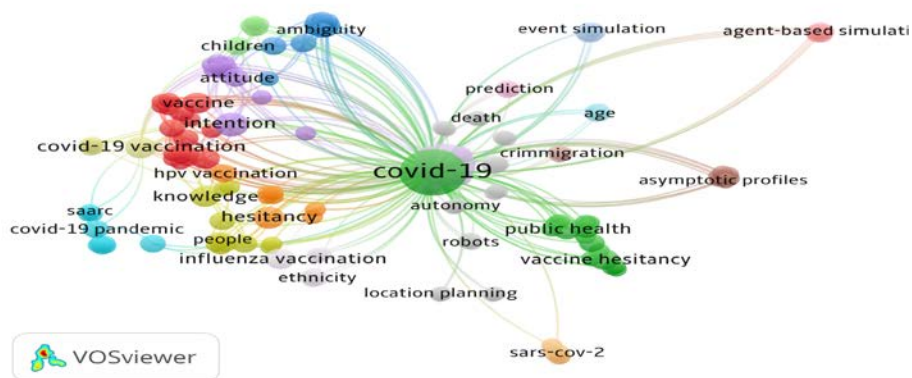


Figure 3. The co-occurrence network of keywords «COVID-19» and «vaccination» with other terms by the Web of Science database

Sources: developed by the authors using the VOSviewer software tools.

The largest (red) cluster includes such concepts as air pollution, attitudes, behavior, coronavirus, covid-19 vaccination, health belief model, health care practice, human-papillomavirus, immunization, impact, intention to get covid-19, literacy, models, outbreak, predictors, protection motivation theory, regulation, social distancing, vaccine, and willingness to vaccinate.

Therefore, in the Web of Science database, the COVID-19 vaccination research correlates with the issues of preventive measures and motivation for infection avoidance. The scholars have devoted their studies to issues of human behavior, social distance, and healthy living practices for effectively maintaining health.

The second (green) cluster involves the terms: college students, Covid-19 vaccination intentions, deservingness, emergency medicine, experiment, framework, misinformation, parent perceptions, public health, public opinion, rates, vaccination mandates, and vaccination hesitancy. This cluster emphasizes that many scientists equate the concept of public health with coronavirus vaccination. Thus, by supporting the immunization campaign, a person tries to care for others.

The third (blue) cluster consists of 12 keywords: ambiguity aversion, breast cancer, communication, coverage, preference, risk, rural-urban continuum, threat, uncertainty, and women. This cluster shows the research interest in detecting the influence of different factors (gender, the level of urbanization, etc.) on the vaccination coverage.

The fourth (yellow) cluster covers 12 items: advising vaccination, anxiety, depression, factors, health-care workers, knowledge, life satisfaction, nurses, nursing students, people, perceived vulnerability, and preventive behavior. These keywords unveil the involvement of medical staff at various levels in the

vaccination campaign to advise the population, dispel myths about the topic and the direct immunization procedure, and people's awareness of the consequences of vaccination and its refusal. The fifth (purple) cluster includes the studies on affective attitudes, anticipated affective reaction, attitude, conspiracy, determinants, herd-immunity, human-papillomavirus vaccination, intention, planned behavior, science, and survey. This cluster indicates the scientific interest in COVID-19 vaccination among sociologists and psychologists studying the society's attitudes toward immunization, determinants of negative attitudes, and affective attitudes through a survey.

The sixth cluster (blue) contains the keywords: COVID-19 pandemic, COVID-19 vaccines, dread risk, media, public perception, responsible leadership, unknown risk, and vaccination intention. In this cluster, researchers emphasized the importance of the media and social networks in responsibly communicating the real risks of vaccination to the population and the importance of misinformation.

The seventh cluster (brown) combines the words: asymptotic profiles, compartmental modeler, dynamics, economics, endemic equilibrium, epidemiology, and infection diseases. Therefore, the scientists focussed on finding causal links between the dynamics of the pandemic and economic indicators.

The rest of the clusters shown in Figure 3 are small. Moreover, they duplicate the main issues discussed in the first seven clusters. Thus, a bibliometric analysis of keywords used by researchers in the Web of Science database in a non-medical subject area related to the terms «COVID-19» and «vaccination». Moreover, most researchers emphasize the public consciousness growth and the great role of informing the population.

Step 3. Identifying world scientific schools researching issues related to COVID-19 and vaccination.

To process and visualize the obtained results, VOSviewer software was used. Figure 4 demonstrates the co-authorship network (42 related articles by 11 countries).

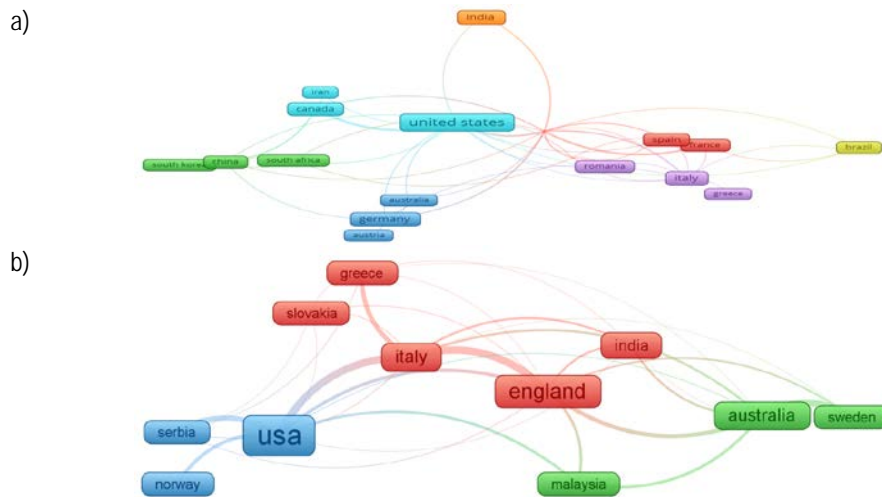


Figure 4. Affiliations of scholars investigating the concepts of «COVID-19» and «vaccination» according to the database a) Scopus; b) Web of Science

Sources: developed by the authors using the VOSviewer software tools.

Figure 4 shows that according to the Scopus database, the scientists from 66 countries investigated vaccination issues and the COVID-19 pandemic. In turn, scientists from 24 countries collaborated under

7 schools of thought. The first school involved the scientists from the United States, Iran, and Canada; the second – the United Kingdom, France, Poland, Turkey, and Spain; the third – China, Saudi Arabia, South Africa, and South Korea; the fourth – Australia, Austria, and Germany; fifth – Brazil, Japan, and Serbia, the sixth – Greece, Italy, and Romania; the seventh – India and the Netherlands.

According to the Web of Science database, the findings identified 3 schools of thought out of 11. The first school is centered around the United Kingdom and includes countries such as Italy, India, Greece, and Slovakia. The second group covers Australia, Sweden, and Malaysia. The third group was created by scientists from the United States, Serbia, and Norway.

These results indicate a high level of collaboration among scientists worldwide to address the pandemic issues in the medical, economic, political, and social spheres.

Results. Visualization of the relationship between the concepts of «COVID-19» and «vaccination» with other terms in the publications of Scopus and Web of Science databases showed the high relevance of research on the vaccination campaign. The results of the bibliometric analysis showed around 20 research directions concerning the investigated topic indicating its relevance. It stands to mention that the desire for voluntary vaccination differs between countries. Ritchie et al. (2020) noted that as of 30 December 2021, the vaccinated population with at least one dose accounted for 90% in Chile, Portugal, and Cuba. In turn, in Ukraine, Egypt, and Albania, this share was only 40%. Therefore, the search for determinants of intention to be vaccinated is one of the leading areas of scientific research worldwide.

The most popular research direction in that analyzed scope of literature is predicting different pandemic scenarios and the strength of their consequences, depending on the speed of the vaccination campaign. Along with the topic of vaccinations, the problem of misinformation spread, mainly on social networks, was considered. Another research direction is the analysis of the different scenarios' effectiveness in informing the population and coercing or encouraging them to get vaccinated. Some scholars dedicated their studies to testing the efficacy of vaccines and comparing public confidence in each.

Besides, researchers widely applied mathematical modeling methods to measure the level of transformation in economic and social life. Another research direction is the individual responsibility of everyone in creating collective immunity.

Conclusions. This study presents the results of the bibliometric analysis of the studies on the COVID-19 vaccination campaign indexed in Scopus and Web of Science databases. The study period covers 2020-2021. The findings showed most studies were published by the authors from the United States, the United Kingdom, China, Germany, and Italy.

Besides, at least seven multinational scientific schools collaborated on the course of the vaccination campaign. Thus, the United States, the United Kingdom, Australia, and Germany have the highest levels of international scientific cooperation.

A visual model was built for each database using VOSviewer software tools to analyze the co-occurrences of keywords. Thus, 20 clusters indicate the research areas in the COVID-19 vaccination campaign.

The results of the bibliometric study could be useful for further investigation of causal relationships and mathematical modeling of the vaccination refusal reasons and predicting different scenarios for a pandemic.

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Бібліометричний аналіз досліджень щодо вакцинаційної кампанії від covid-19 за допомогою vosviewer

У статті проведено бібліометричний аналіз публікацій, що досліджують питання пандемії Covid-19 та превентивних заходів щодо її подолання, зокрема вакцинації. Основною метою дослідження є аналіз, систематизація та побудова кластерів світових наукових шкіл, що у 2020 році змінили свій вектор досліджень у зв'язку пандемією Covid-19. Актуальність вирішення наукової проблеми полягає в тому, що для швидкого відновлення економіки, освіти, туризму та інших сфер життя суспільства, що постраждали від пандемії необхідно якнайшвидше знизити захворюваність, один із дієвих способів є вакцинація, проте у світі зберігається тенденція відмови від щеплень. Дослідження актуальності досліджень науковців світу питання довіри до вакцинаційної кампанії у статті здійснено з використанням програмного забезпечення VOSviewer, інструментів аналізу джерел бази даних Web of Science та Scopus. Вибірку дослідження сформовано за період 2020-2021 роки, мова публікації – англійська, ключові слова – Covid-19 та vaccination, виключені з пошуку медичні та фармацевтичні категорії. Авторами також проаналізовано географію дослідження та визначено, що найбільша кількість робіт була надіслана до науко метричних баз даних Web of Science та Scopus з американською, англійською, китайською, німецькою та італійською афіліаціями. Візуалізація результатів бібліометричного аналізу географії з використанням програмного забезпечення VOSviewer дозволили виокремити дві наукові школи вчені яких досліджують пандемію Covid-19 та перебіг вакцинаційної кампанії. Крім того, дослідження емпірично підтверджує та теоретично доводить, що серед науковців світу існує як мінімум 10 векторів дослідження: пошук причин диференціації намірів вакцинуватись; різне ставлення до щеплень в залежності від гендерної ознаки, віку та соціального становища; прогнозування різних сценаріїв; наслідки інфодемії та боротьби з дезінформацією; ефективність соціального тиску на населення; роль соціальних мереж; достатність використання індивідуальних засобів захисту; відповідальність кожного у створенні колективного імунітету; необхідність проведення роз'яснювальної роботи медичними співробітниками; перевірка ефективності вакцини тощо. Результати проведеного бібліометричного дослідження можуть бути корисними для формування подальших емпіричних досліджень пошуку причинно-наслідкових зв'язків та математичного моделювання причин відмови від вакцинації, а також прогнозування різних сценаріїв розвитку пандемії.

Ключові слова: бібліометричний аналіз, COVID-19, vaccination, пандемія, VOSviewer.