

Bibliometric analysis of scientific research publications on COVID-19 vaccine hesitancy (2020 – 2021)

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Research Article

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Abstract

Background: Vaccine hesitancy is a real threat to the global efforts to end COVID-19 pandemic. Analysis of literature on COVID-19 vaccine hesitancy helps develop interventional policies to overcome this threat. The objective of the present study was to analyze worldwide research trends and patterns on COVID-19 vaccine hesitancy

Method: This was a descriptive bibliometric study using SciVerse Scopus to retrieve relevant articles. The research was based on the use of specific phrases in the title/abstract of the articles. The study included the years 2020 and 2021. Only research and review articles were included. VOSviewer program was used to map author keywords, terms, and collaborative ties.

Results: The research strategy found 1184 articles with an *h*-index of 55. The vast majority of the retrieved articles were published in 2021 in an open-access format. Analysis showed the following key findings: (1) research was disseminated in journals with a diverse scope, mainly immunology and public health, (2) authors from different geographic regions participated in publishing articles on the topic with those in the United States participating in one-third of the retrieved literature, (3) authors and institutions in the Arab Gulf countries made a noticeable contribution while those from the African region was limited, (4) cross-country collaboration was adequate but little author-author interaction was found, (5) research themes focused on healthcare workers, misinformation, and ethnic/racial variation, (6) *Lancet* and *BMJ* journals in addition to *Vaccine* and *Vaccines* journals were pioneering in the emphasis and emergence of the topic, (7) leading global universities such as Harvard University, Johns Hopkins University, and London School of Hygiene and Tropical Medicine ranked top in publishing articles on the topic, and (8) the bulk of the retrieved articles was multi-authored suggestive of the multidisciplinary nature of the topic.

Conclusion: Research and detailed information on COVID-19 vaccine hesitancy is needed from all countries and regions to help build interventional policies to face the pandemic and the new emerging COVID-19 variants. Collaborative research efforts in the field should be extended to other world regions where research on the topic was limited.

Background

A vaccine against the severe acute respiratory syndrome coronavirus 2 (SARSCoV2) is considered critical to ending the coronavirus disease 2019 (COVID-2019) pandemic [1, 2]. In March 2020, the journey to develop a safe and effective vaccine against COVID-2019 was started by global pharmaceutical companies [3–5]. In December 2020, the FDA approved the first COVID-19 vaccine based on safety and efficacy data provided by pharmaceutical companies [6]. The introduction of the COVID-19 vaccine was a turning point and a key global public health success. At the time of writing the current manuscript, more than nine billion doses of COVID-19 vaccine have been administered worldwide [7]. In low-income countries, less than 10% of people have received at least one dose of the COVID-19 vaccine [7]. The purchase and vaccination programs for COVID-19 vaccines were mainly carried out by high-income countries comprising less than 15% of the world population [8, 9].

The development and authorization of COVID-19 vaccine were made within 12 months of the start of the pandemic in China. This is in contrast to the regular process of developing and authorizing vaccines for an infectious disease. This rapid authorization was made under the umbrella of "Emergency Use Authorization" [6]. The EUA was based on strong evidence of safety and efficacy and high manufacturing quality data received by the FDA and continuous post-marketing safety reports [10–13]. Currently approved COVID-19 vaccines use different technologies including mRNA vaccines and adenovirus vector-based vaccines [14, 15]. These have been tested for safety and efficacy several years before the appearance of COVID-19 pandemic [16, 17]. Despite the safety profile and history of proven efficacy of the novel vaccine technologies, the acceptance rates of COVID-19 vaccines in the general population were less than optimal constituting a

threat to global efforts to eliminate the pandemic [18–20]. Several published studies pointed out the dangers of VH/acceptance in the efforts to combat the COVID-19 pandemic [20–22].

Vaccine hesitancy (VH) is a complex global phenomenon. The World Health Organization (WHO) considered VH as one of the top-ten global health threats in 2019 [23]. According to the WHO, VH threatens to reverse the historic global efforts to stop vaccine-preventable diseases. In its definition of VH, the WHO considers the following factors[24]: (1) "VH is a complex and context-specific varying across time, place and vaccines"; (2) "VH refers to delay in acceptance or refusal of vaccination despite the availability of vaccination services"; (3) VH is influenced by factors such as complacency, convenience, and confidence". Based on this definition, VH is a continuum between full acceptance and complete refusal [25]. The reasons for VH might be religious, cultural, and sometimes based on false information [26]. The WHO hypothesized that three main factors contribute to VH: lack of confidence, perception of no need for the vaccine, and difficulty in accessing the vaccine [27].

Several editorials, research articles, and reviews were published about COVID-19 VH [28–30]. However, due to the importance of COVID-19 vaccine hesitancy as a threat to global health security, the current study was undertaken to investigate the volume, geographical origin, research pattern, scientific disciplines involved in the emergence of this topic, and map the published literature for easy understanding and identification of hot spots in the field. The current study adds to the literature on COVID-19 VH as an individual effort to overcome VH. Policymakers in different countries where vaccination administration is less than optimal need to implement interventional policies to overcome VH. Analysis of existing literature on COVID-19 VH provides information regarding the ongoing global and national efforts to identify factors responsible for the potential failure of COVID-19 vaccination programs in certain countries or among certain ethnic or religious groups. Analysis and mapping of literature on a certain topic are carried out using bibliometric analysis defined as the application of mathematical and statistical analysis on a dataset retrieved from scientific databases. In addition to mathematical and statistical analysis, bibliometric analysis is used to construct a visualization network for co-authorship and country, co-occurrence of author keywords, and citation/co-citation of most important journals involved in publishing documents on the topic.

Method

Research strategy

The current study used Scopus database to retrieve relevant articles on VH. Scopus database was used because it has more than 23 thousand indexed journals in various scientific disciplines. Scopus database has an "analyze" function that allows for data analysis and export to Microsoft Excel and other programs such as VOSviewer used for mapping techniques.

The research strategy was based on combing keywords related to "vaccine", VH, and COVID-19. Keywords related to vaccine included vaccine, vaccination, immunization, and immunization. Keywords related to COVID-19 included covid-19, "COVID*", "novel coronavirus", "2019 novel coronavirus", "coronavirus 2019", "coronavirus disease 2019", "2019-novel CoV", "2019 ncov", "COVID 2019", "COVID19", "corona virus 2019", "nCoV-2019", "nCoV2019", "nCoV 2019", "ncov", "COVID-19", "Severe acute respiratory syndrome coronavirus 2", "SARS-CoV-2", and "corona virus". Keywords related to VH included "vaccin* hesitan*", "vaccin* refusal", "vaccin* opposition", antivacc* groups, antivaxx groups, "willingness to vaccinate", "vaccin* accept*", "vaccin* resist*", "vaccin* uptake", "vaccin* conspiracy", "vaccin* misinformation", "vaccin* skepticism", "accept* of the vaccin*" "accept* of a vaccine*", "mandatory vaccin*", "compulsory vaccin*", "attitude* toward* vaccin*", "attitude toward* COVID-19 vaccin*", "accept* COVID-19 vaccin*", (attitude toward* and vaccin*), (demand and vaccin*), (challenge* and program*), (challenge* and attitude*). In the research strategy, truncated keywords were used with the asterisk to retrieve all possible combination while the quotation marks were used to retrieve the exact phrase. Keywords

related to COVID-19 and vaccine were used in the title search while keywords related to VH were used in the title/abstract search to get a comprehensive result.

The research strategy was filtered by including journal research articles or reviews while editorials, notes, letters, books, and book chapters were excluded. The research strategy was limited to 2020 and 2021 since the approval and administration of COVID-19 took place in the past two years. Finally, the research strategy was filtered by excluding all articles "in press" since they will be published in 2022.

To validate the research strategy, the author asked two volunteers in the medical field to review the title and abstract of the top-50 cited documents to make sure that none was irrelevant or outside the scope of the topic. Based on the review, articles with the following words in the title were excluded (dynamic*, "math* model*", production, hospitalization, delta, "influenza vaccination", "influenza vaccine", "viral clades"). The research strategy retrieved no false-positive results after the exclusion step.

Data export and bibliometric indicators

The refined results were exported to Microsoft Excel and generated the following:

1. Growth pattern
2. Core countries
3. Core journals
4. Core institutions
5. Core authors
6. Map of author keyword co-occurrence
7. Map of co-citation analysis
8. Map cross-country and author-author collaboration
9. Top 10 cited articles

The bibliometric maps were generated using the free online program VOSviewer. In VOSviewer maps, items are presented as nodes. The larger the size of the node the higher the frequency of occurrence of the item. The distance between two items in the map indicates relatedness. Closer items are strongly related and the opposite is true for distantly located items.

Results

The research strategy found 1184 articles related to VH; 1084 (91.6%) research articles and 100 (8.4%) review articles. Of the retrieved articles, 1057 (89.3%) were available as open access. Of the retrieved articles, 71 (6.0%) were published in 2020 while 1113 (94.0%) were published in 2021, a 16-fold increase in the number of publications. Of the retrieved articles, 1156 (97.6%) were unilingual (English only) while 28 (2.4%) were bilingual (English plus another language).

The retrieved articles were disseminated in 435 peer-reviewed journals. Three hundred and eleven journals published one article each while 12 journals published 10 or more articles each. Journals publishing 10 or more articles were considered core journals. The core journals published 505 (42.7%) articles. The *Vaccines* (Switzerland) journal was the major contributor (n = 218, 18.4%) to the retrieved articles. Table 1 shows the list of core journals contributing 10 or more articles each. The *Plos One* and *Vaccine* (Netherlands) ranked second and third with 52 (4.4%) and 48 (4.0%) articles respectively.

Table 1
Core journals publishing at least 10 articles on COVID-19 vaccine hesitancy

Journal	Frequency (%)	Impact Factor*
	N = 1184	
<i>Vaccines</i>	218 (18.4)	4.422
<i>Plos One</i>	52 (4.4)	3.240
<i>Vaccine</i>	48 (4.1)	3.641
<i>International Journal Of Environmental Research And Public Health</i>	46 (3.9)	3.390
<i>Human Vaccines And Immunotherapeutics</i>	34 (2.9)	3.452
<i>Frontiers In Public Health</i>	33 (2.8)	3.709
<i>BMC Public Health</i>	19 (1.6)	3.295
<i>Journal Of Medical Internet Research</i>	12 (1.0)	5.428
<i>BMJ Clinical Research Ed</i>	11 (0.9)	-
<i>Infection And Drug Resistance</i>	11 (0.9)	4.003
<i>JMIR Public Health And Surveillance</i>	11 (0.9)	4.112
<i>Frontiers In Medicine</i>	10 (0.8)	5.091
Impact factors were obtained from the latest Journal Citation Report (2021) published by Clarivate		

Authors from 120 different countries participated in publishing the retrieved articles; more than 60% of the number of States (n = 195) in the United Nations. Authors from the US participated in 402 (36.2%) articles. Table 2 lists core countries (n = 43) with a minimum contribution of 10 articles. China ranked third and Saudi Arabia ranked sixth in the core list. The core list included seven countries in the Eastern Mediterranean region (Saudi Arabia, Jordan, United Arab Emirates, Iran, Qatar, Egypt, and Pakistan) and two in the African region (South Africa and Nigeria).

Table 2
 Core countries publishing at least 10
 articles on COVID-19 vaccine hesitancy

Country	Frequency (%)
	N = 1184
United States	402 (34.0)
United Kingdom	117 (9.9)
China	95 (8.0)
Italy	67 (5.7)
India	52 (4.4)
Saudi Arabia	47 (4.0)
Australia	41 (3.5)
Canada	40 (3.4)
Germany	39 (3.3)
France	34 (2.9)
Bangladesh	29 (2.4)
Hong Kong	27 (2.3)
Pakistan	27 (2.3)
Malaysia	26 (2.2)
Poland	25 (2.1)
Belgium	22 (1.9)
Israel	22 (1.9)
South Korea	22 (1.9)
Spain	22 (1.9)
Taiwan	22 (1.9)
Turkey	21 (1.8)
Ethiopia	20 (1.7)
United Arab Emirates	20 (1.7)
Brazil	19 (1.6)
Indonesia	19 (1.6)
Japan	19 (1.6)
Jordan	19 (1.6)
Switzerland	18 (1.5)
Singapore	17 (1.4)
Greece	15 (1.3)

Country	Frequency (%)
	N = 1184
Qatar	15 (1.3)
Romania	14 (1.2)
Egypt	13 (1.1)
Nigeria	13 (1.1)
South Africa	13 (1.1)
Sweden	13 (1.1)
Denmark	12 (1.0)
Ireland	12 (1.0)
Netherlands	12 (1.0)
Viet Nam	12 (1.0)
Czech Republic	11 (0.9)
Iran	11 (0.9)
Portugal	11 (0.9)

Authors from 41049 institutions/organizations participated in publishing the retrieved articles. Harvard University and Johns Hopkins University were the most active with 34 (2.9%) articles for each. Table 3 lists core institutions (n = 33) with a minimum contribution of 10 articles. The core list included four Chinese institutions/organizations and four institutions/organizations in the Arab region. The remaining institutions in the core list were those mainly present in North America, Europe, the Middle East, and the Western Pacific region.

Table 3
Core institutions/organizations publishing at least 10 articles on COVID-19 vaccine hesitancy

Institutions/Organization	Frequency (%) N = 1184	Country Affiliation
Harvard University	34 (2.9)	US
Johns Hopkins University	34 (2.9)	US
London School of Hygiene & Tropical Medicine	18 (1.5)	UK
University of Pennsylvania	17 (1.4)	US
Yale University	16 (1.4)	US
University of Michigan, Ann Arbor	16 (1.4)	US
University of Toronto	14 (1.2)	Canada
University of California, San Francisco	14 (1.2)	US
Peking University	14 (1.2)	US
Emory University	14 (1.2)	US
University of California, Los Angeles	14 (1.2)	US
Columbia University	13 (1.1)	US
Stanford University	13 (1.1)	US
Chinese University of Hong Kong	12 (1.0)	China
Fudan University	11 (0.9)	China
King Saud University	11 (0.9)	Saudi Arabia
University of Washington	11 (0.9)	US
National University of Singapore	11 (0.9)	Singapore
University College London	11 (0.9)	UK
Al-Qassim University	11 (0.9)	Saudi Arabia
University of Oxford	11 (0.9)	UK
Inserm	10 (0.8)	France
The University of Hong Kong	10 (0.8)	China
University of Dhaka	10 (0.8)	Bangladesh
Indiana University School of Medicine	10 (0.8)	US
Rollins School of Public Health	10 (0.8)	US
Ministry of Health Saudi Arabia	10 (0.8)	Saudi Arabia
The University of Jordan	10 (0.8)	Jordan

In total, 7789 authors participated in publishing the retrieved articles giving an average of 6.6 authors per article. There were 87 (7.3%) single-authored articles, 110 (9.3%) two-authored articles, 140 (11.8%) three-authored articles, 149 (12.6%) four-authored articles, and 698 (59.0%) multi-authored (≥ 5) articles. Gori, D. (Italy) and Wagner A. L. (US) appeared to be the most active in this field. Table 4 lists core authors ($n = 25$) with a minimum contribution of five articles. The core list included authors mainly from the US, Saudi Arabia, Czech Republic, United Arab Emirates, and Italy

Table 4
Core authors publishing at least five articles on COVID-19 vaccine hesitancy

<i>Author name</i>	Frequency (%) N = 1184	Country affiliation in Scopus
<i>Gori, D.</i>	7 (0.6)	Italy
<i>Wagner, A.L.</i>	7 (0.6)	US
<i>Al-Tawfiq, J.A.</i>	6 (0.5)	Saudi Arabia/ US
<i>Omer, S.B.</i>	6 (0.5)	US
<i>Savoia, E.</i>	6 (0.5)	US
<i>Temsah, M.H.</i>	6 (0.5)	Saudi Arabia
<i>Al-Eyadhy, A.</i>	5 (0.4)	Saudi Arabia
<i>Alaraj, A.</i>	5 (0.4)	Saudi Arabia
<i>Alhaboob, A.</i>	5 (0.4)	Saudi Arabia
<i>Alhasan, K.</i>	5 (0.4)	Saudi Arabia
<i>Aljamaan, F.</i>	5 (0.4)	Saudi Arabia
<i>Barry, M.</i>	5 (0.4)	Saudi Arabia
<i>Colebunders, R.</i>	5 (0.4)	Belgium
<i>Halwani, R.</i>	5 (0.4)	United Arab Emirates
<i>Huynh, G.</i>	5 (0.4)	Viet Nam
<i>Jamal, A.</i>	5 (0.4)	Saudi Arabia
<i>Klugar, M.</i>	5 (0.4)	Czech Republic
<i>Larson, H.J.</i>	5 (0.4)	UK
<i>Lau, J.T.F.</i>	5 (0.4)	Hong Kong/ China
<i>Montalti, M.</i>	5 (0.4)	Italy
<i>Pal, S.</i>	5 (0.4)	US
<i>Riad, A.</i>	5 (0.4)	Czech Republic
<i>Saddik, B.</i>	5 (0.4)	United Arab Emirates
<i>Sallam, M.</i>	5 (0.4)	Jordan
<i>Sheikh, A.B.</i>	5 (0.4)	US
<i>Shekhar, R.</i>	5 (0.4)	US

Figure 1 is a network visualization map of author keywords with a minimum occurrence of 10 times. Of the 1764 author keywords present in the dataset 53 met the minimum threshold of 10 occurrences and were processed. The two largest nodes in the map were "COVID-19" and "Vaccine Hesitancy". Keywords other than COVID-19 and VH included misinformation/trust, healthcare workers, safety, and pregnancy.

Figure 2 is a network visualization of terms in the titles/abstracts with a minimum occurrence of 10 times. Of the 18772 terms, 730 terms met the threshold of minimum occurrences of 10 times. Of the 730 terms, only the top 60% related terms (n = 438 terms) were processed. The most frequently encountered terms were questionnaire, SARS-COV2, immunity, challenge, and healthcare worker. The largest cluster (red) in the map appeared to focus on questionnaire-based cross-sectional studies on VH among healthcare workers. The second-largest cluster (green) in the map appeared to focus on misinformation/access/ social media as a challenge for vaccination programs. The third-largest cluster (blue) appeared to focus on review articles and the role of the type of vaccine as well as safety on VH. The smallest cluster (yellow) appeared to focus on VH based on ethnicity, gender, color, and culture.

Figure 3 is a co-citation mapping of journals that received at least 50 citations (n = 80). The size of the nodes in the map reflect the number of co-citation relationship with other journals in the cluster having one color. Journals with larger node sizes are the ones having the most important role in the emergence of the field of COVID-19 VH. The map shows four clusters. The largest nodes in each cluster represented journals that played a significant role in this field: *Vaccine* (Netherlands), *Vaccines* (Switzerland), *Lancet*, and *BMJ* journals.

Figure 4 is a map of cross-country collaboration. The map included countries (n = 43) with a minimum contribution of 10 articles. The map shows that the US and the UK occupy the center of the map with collaborative links with most countries on the map. Colors in the map represented countries with close research collaborative ties. The largest cluster (red cluster) represented the US and many European countries in one cluster. The blue cluster included several Arab countries while the green cluster included countries from Southeastern Asia and Western Pacific regions.

Figure 5 is a map showing collaborative links among authors (n = 26) with a minimum contribution of five articles. The map included 11 clusters. There was only one cluster having five or more authors each. The largest author network (red cluster) included 10 authors (eight from Saudi Arabia and two from the United Arab Emirates). The largest network is in close research collaboration with an international group consisting of authors from Saudi Arabia and the USA (Omer, S. B., and Temsah, M. H.)

The retrieved articles received 13383 citations; an average of 11.3 citations per article, and an h-index of 55.

Table 5 shows the top 10 cited articles [19, 20, 31–38]. The list included eight research articles and two review articles. Seven of the top 10 cited articles were published in 2020 and three were published in 2021. Two of the top-cited articles discussed factors behind VH. The top 10 cited articles were published in journals in diverse medical fields including internal medicine, public health, epidemiology, and immunology/microbiology.

Table 5
Top ten cited articles on COVID-19 vaccine hesitancy

Title	Year	Source title	Cited by
A global survey of potential acceptance of a COVID-19 vaccine	2021	Nature Medicine	523
Vaccine hesitancy: the next challenge in the fight against COVID-19	2020	European Journal of Epidemiology	393
Attitudes toward a potential SARS-CoV-2 vaccine: A survey of U.S. adults	2020	Annals of Internal Medicine	348
Determinants of COVID-19 vaccine acceptance in the US	2020	EClinical Medicine	313
Acceptability of a COVID-19 vaccine among adults in the United States: How many people would get vaccinated?	2020	Vaccine	286
Covid-19 vaccine hesitancy worldwide: A concise systematic review of vaccine acceptance rates	2021	Vaccines	263
Acceptance of covid-19 vaccination during the covid-19 pandemic in china	2020	Vaccines	225
Psychological characteristics associated with COVID-19 vaccine hesitancy and resistance in Ireland and the United Kingdom	2021	Nature Communications	213
Factors Associated With US Adults' Likelihood of Accepting COVID-19 Vaccination	2020	JAMA network open	202
The use of the health belief model to assess predictors of intent to receive the COVID-19 vaccine and willingness to pay	2020	Human Vaccines and Immunotherapeutics	188

Discussion

The current study aimed to analyze research patterns and trends of published scientific articles on COVID-19 VH as part of the global efforts to achieve adequate vaccination to protect against coronavirus 2019. In the past two years, a large number of articles on the topic were produced and disseminated in a large number of journals indicative of the importance of the topic at both national and global levels. Authors from different world regions participated in publishing the retrieved articles, with noticeable contributions from Arab countries in the Middle East. Mapping of the literature pointed to the presence of major research themes on the topic including the role of healthcare workers in the context of VH, misinformation spread through social media and its impact on VH, and the impact of race, color, culture, and ethnicity on VH. The retrieved articles had higher visibility and readability as indicated by the high H-index. The current study showed that the topic is globally critical for scholars across the globe as indicated by the findings. First, approximately 40% of the articles were published in leading scientific journals with high impact factors. Second, approximately 60% of countries worldwide participated in publishing the retrieved articles. Third, approximately 60% of the retrieved articles were multi-authored indicating that scholars are keen and willing to participate in publishing on the topic. Fourth, a noticeable number of countries have good contributions to the topic despite that these countries are usually lagging in research activity in the medical field [39]. Fifth, several multidisciplinary leading journals such as *Plos One* ranked second and made a good contribution to the topic. Sixth, The high citations and the high H-index value are indicative of high visibility and readership.

Research on VH in any country with subsequent implementation of interventional strategies is believed to overcome VH and increase vaccine acceptance and uptake. A recently published article on VH, in general, indicated that the US and countries in the European region were among the top 10 in the number of publications on VH in general [40]. However, in the current study, countries such as China, Saudi Arabia, and India were among the top 10 in the number of publications

on COVID-19 VH. The difference cannot be attributed to a sudden scientific revolution. Rather, such a leading role is mainly attributed to governmental policies that encourage vaccination as one important means to overcome the pandemic and return to economic growth.

Traditionally, VH is a problem of high-income countries since several events played a role in the emergence of this phenomenon. The claim of the false potential association between vaccination and autism [41, 42] and the anti-vaccination groups started in high-income countries [43, 44]. However, the current study indicated that fear from vaccination is a global phenomenon and many countries tried to establish a scientific research momentum to combat this phenomenon. One of the potential causes of this global fear of vaccination is the fast spread of fake news, misinformation, and conspiracy theory regarding the COVID-19 vaccine through various types of social media [45, 46].

At the regional level, the contribution of the African region to research on VH was limited compared to that of other world regions. It is not clear that this limited contribution is related to limited research capacity or the low rates of VH in the African region. A study indicated variable acceptance rates of COVID-19 Vaccine [30]. In African countries, the acceptance rates range from 15–94.0%. Similar rates were found in Arab countries in the Middle East. This raises a hypothesis that countries such as the United Arab Emirates and Saudi Arabia are involved in VH research for reasons related to the economy, international trade, and religious tourism in Saudi Arabia. It has been reported that VH affects countries and regions in high-income countries more than low- and middle-income countries [47, 48].

The current study indicated that journals outside the field of immunology/microbiology have made a good contribution to the topic and helped in the emergence of the topic in scientific literature. Most of these journals were in the field of medicine/public health such as the *Lancet*, *JAMA*, *BMJ*, *BMC Public Health* journals, and others. Vaccination is considered one of the most important medical interventions to overcome vaccine-preventable infections and save lives and the economy. Therefore, VH is of a special public health concern, and several leading public health journals gave this topic a priority during the pandemic. Certain public health journals such as the *International Journal of Environmental Research and Public Health* launched a special issue on VH under the section "Infectious Disease Epidemiology".

The current study indicated that VH and healthcare workers were an important research theme. Healthcare workers have a higher risk of being affected by COVID-19 due to their working environment [49]. Vaccine hesitancy has a triple-negative effect, by affecting the workforce in the health system, exposing themselves to disease risk, and negatively affecting public opinion about vaccines. Therefore, focusing VH research on HCW was not surprising given previous reports of low uptake rates of vaccines among HCW [50–52]. A survey study on medical students indicated less than optimal response regarding willingness to vaccinate against COVID-19 [28]. The authors suggested more awareness and education materials about vaccine safety among medical students.

Policy implications

The current study and the findings obtained should be translated into interventional and strategic plans to overcome VH. First, poor or low research contribution from any country or region does not mean that the uptake or acceptance rate of the vaccine is high. Therefore, research studies on the topic are highly needed in every country and among all minority groups to direct efforts correctly. Second, HCWs are at the frontline in combating infectious disease outbreaks. Therefore, the educational curricula for medical and non-medical students should include evidence-based materials regarding the safety, efficacy, and tolerability of vaccination in general. Third, collaborative efforts among researchers in different countries should be encouraged and funded on VH in the context of COVID-19. Fourth, medical journals need to launch a call for papers on the special issue of VH to encourage researchers from different scientific disciplines to participate in research on this topic. Fifth, special attention should be given to cultural and religious minorities and investigate their access to the COVID-19 vaccine to overcome VH. Finally, research on VH should not be limited by a period. There must be a continuous effort through all communications means to disprove anti-vaccine groups' efforts.

Limitations

All bibliometric studies have inherent limitations related to the perfectness of the research strategy and the comprehensiveness of the database used. Therefore, the author acknowledges these limitations which make the findings accurate within the context of the methodology used.

Conclusion

Research analysis of global scientific publications on COVID-19 VH showed a steep rise in 2021. Despite that, the US contributed to approximately one-third of the literature on the topic, the contribution of other world regions, especially certain Arab Gulf countries was adequately noticeable. There was wide dissemination of literature on the topic in leading journals in the field of immunology and public health. To overcome factors behind VH, more research is needed to shed light on the role of HCWs, social media, access, and minority groups in the context of VH.

Abbreviations

VH: Vaccine Hesitancy

WHO: World Health Organization

HCWs: Healthcare Workers

Declarations

Ethics Approval and Consent to Participate:

Not applicable

IRB at An-Najah National University, Palestine requires no approval for bibliometric studies

Consent for publication:

Not applicable

Availability of data and materials:

all data presented in this manuscript are available on Scopus database using the search query listed in the methodology section.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions:

W.S started the idea, designed the methodology; did the data analysis, graphics, and data interpretation; wrote and submitted the manuscript. This was a single-authored manuscript.

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Figures

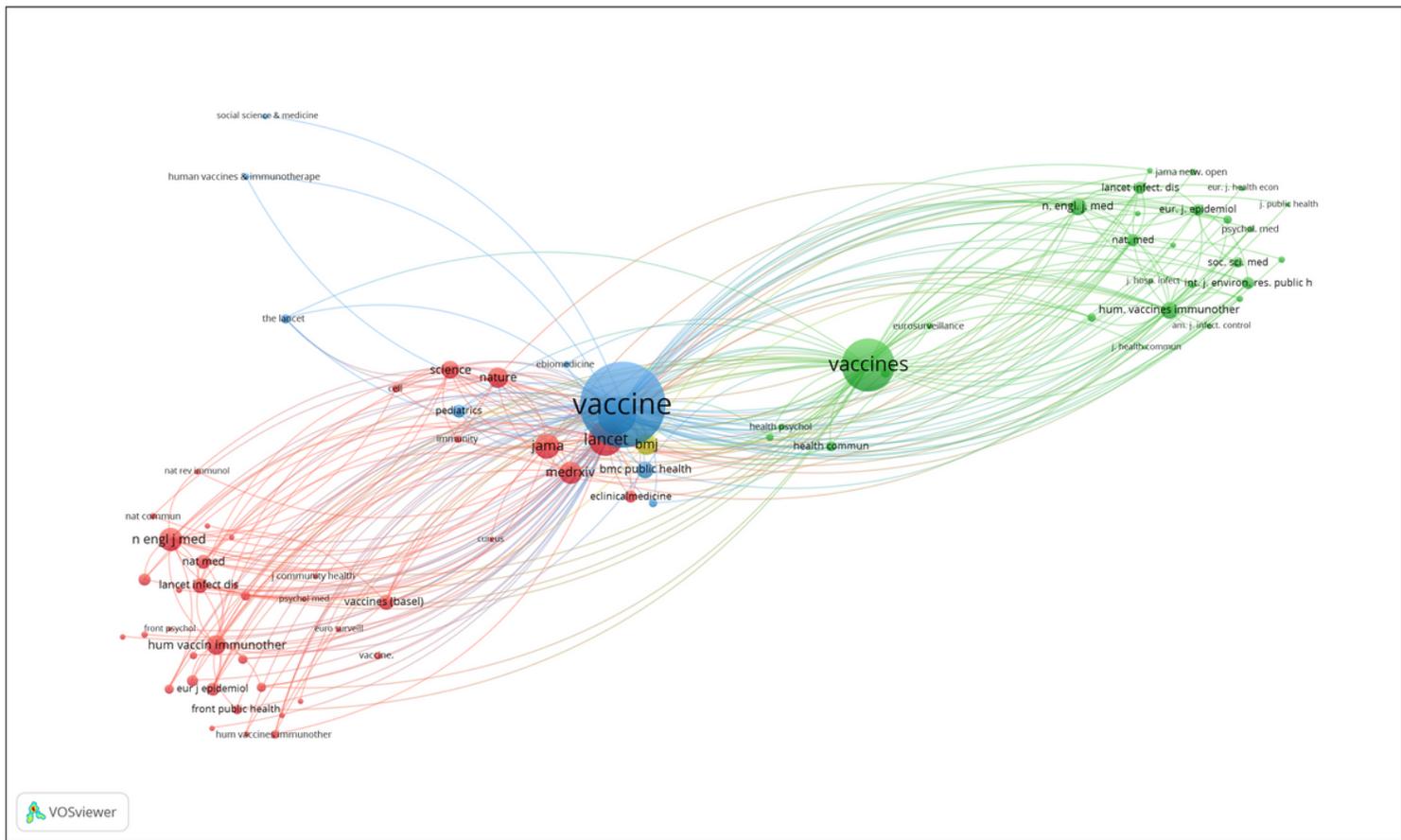


Figure 3

Cocitation analysis of journals with minimum citations of 50. Large nodes represent journals that helped in the emergence of the COVID-19 VH.

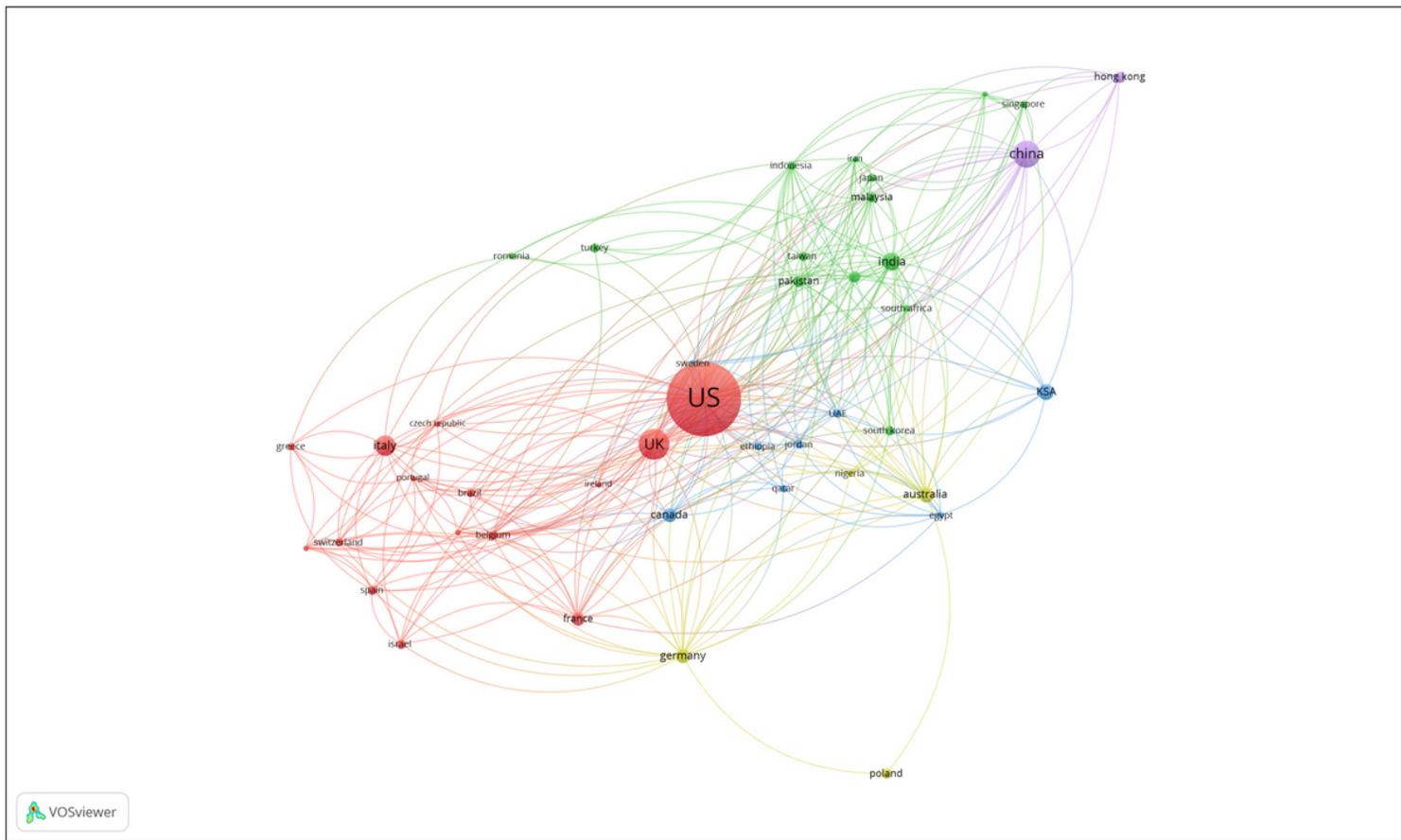


Figure 4

Network visualization map of cross-country collaboration with a minimum contribution of 10 articles

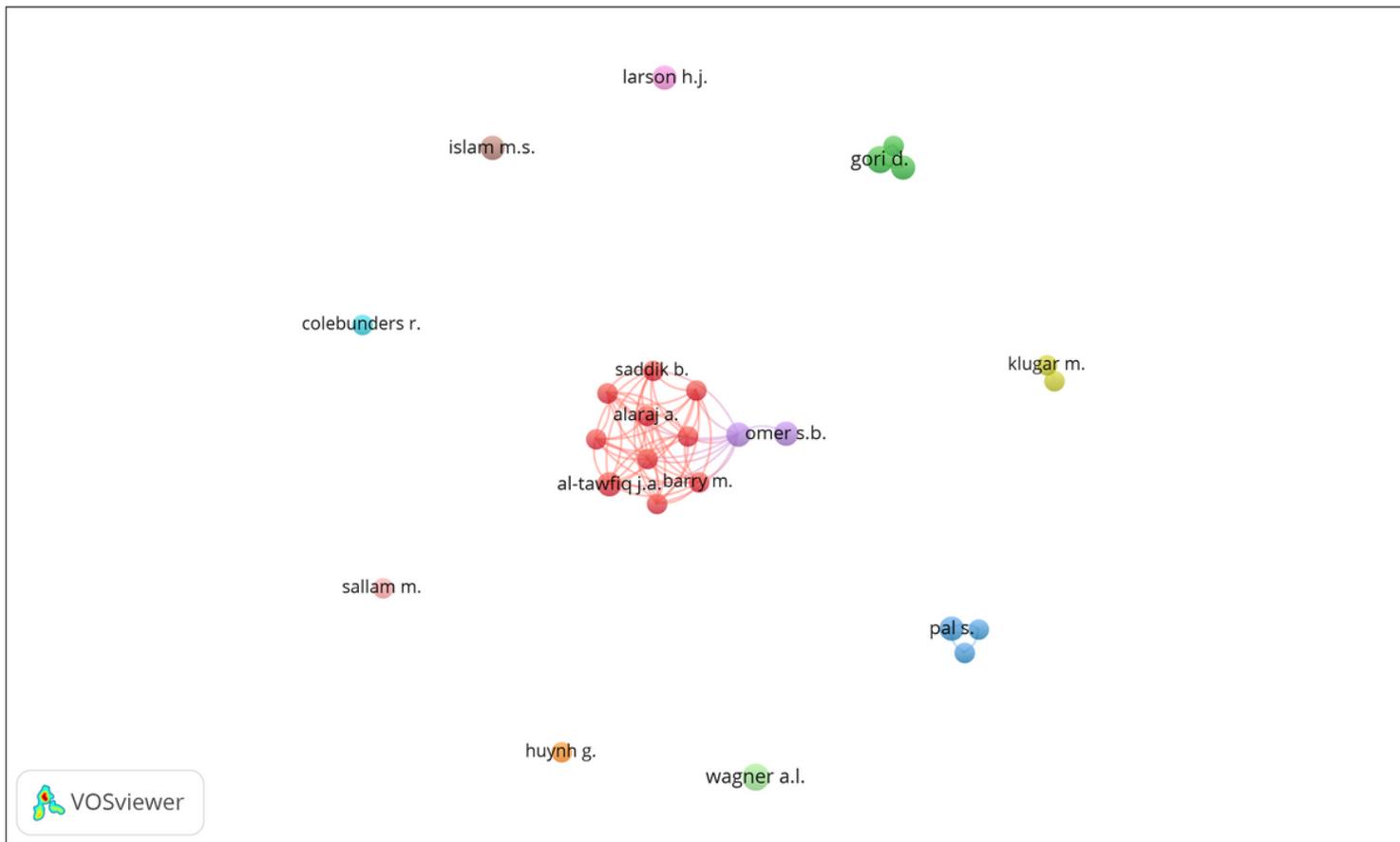


Figure 5

Network visualization map of research networks of authors with a minimum of 5 articles on COVID-19 vaccine hesitancy (2020 - 2021).