Systematic Review

Topics and Users' Emotions on Social Media Regarding the COVID-19 Vaccine: A Systematic Review

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Abstract
Background and Aim: *Since the Coronavirus Disease 2019 (COVID-19) pandemic prevailed globally, followed by the provision of its vaccine, social media users worldwide have come to discuss the issue and exchange views accordingly. It seems highly important to understand the nature of the content that users discussing the COVID-19 vaccination regarding the community's general health. Therefore, this systematic review was designed to evaluate the issues and emotions of users on social media regarding the COVID-19 vaccine.*
Material and Methods: *The research data of this systematic review were extracted from the onset of the COVID-19 until November 20, 2021, by employing a proper search strategy in PubMed, Scopus, and Web of Science databases. The original research articles published in English consistent with the study objective were considered the research inclusion criteria. The authors excluded all short articles, letters to the editor, conference proceeding, review articles, and papers whose full texts were not available.*
Results: *The results revealed that most of the users' expressed emotions about the vaccine on social media were positive or neutral, and there were few negative emotions. The most frequent topics in posts and comments shared by social media users included safety and effectiveness, vaccine development and its speed, prevention policies, and health and political authorities.*
Conclusion: *Nowadays, social media can help understand attitudes and behaviors during a public health crisis and promote health messages. Accordingly, it appears crucial to get aware of people's perspectives on social media platforms to assist in designing communication strategies for health policymakers.*

Keywords*: Vaccine, Vaccination, Social media, Emotions, COVID-19.*

Introduction

The Coronavirus Disease 2019 (COVID-19) emerged as an infectious-epidemic disease in Wuhan, China. Since then, the disease has spread in China and other parts of the world (1) and has infected many people worldwide, with a high mortality rate left behind (2). Therefore, the COVID-19 pandemic was announced as a threat to the health of all people in the world (2, 3). Besides the risk of death, COVID-19 has been associated with numerous health, economic, social, and political consequences for all countries (1, 3, 4), and public health measures taken to reduce its effects in various countries have brought huge burden and costs on the relevant governments (5). In the mean-time, the vaccine was introduced as a core and effective solution to prevent COVID-19 (2, 3). Since several vaccines were made available for clinical evaluation, vaccine acceptance by the general public appeared highly important in implementing the vaccination plans among individuals. For instance, the diversity of vaccines may confuse people concerning their safety and effectiveness, leading ultimately to their distrust in the process (2, 3). Doubt about the vaccination plan, defined as a delay in accepting or refusing the vaccine despite its availability, has been announced by the World Health Organization (WHO) as one of the biggest threats to global health (2, 3). According to two surveys conducted in the United States and Canada, 23%

and 76.9% of people were willing to receive COVID-19 vaccines in these countries, respectively (2).

The activity of people on social media such as Facebook, Twitter, and YouTube increased with the global spread of COVID-19; therefore, social networks provided a platform for the development and dissemination of health information (5, 6). On the other hand, the increased number of users in social media has directly influenced their role and effectiveness in shaping public opinions in different social, economic, and political contexts. Therefore, COVID-19, as one of society's special conditions and involvements, cannot be an exception (4). Accordingly, the social media act as a vital communication channel regarding COVID-19. Users on social media show interest in sharing and following their personal experiences, views, and concerns with others (7, 8). The privilege of freedom of speech and sharing of information and data among individuals, regardless of the facts, may provide the ground for sharing incorrect information followed by forming false knowledge among people (9). The repeated use of social media, along with over-reliance on such media as a source of information during the COVID-19 pandemic, has been proven by studies to increase false and wrong views among people and decline participation in preventive health behaviors (5, 10).

According to previous research, the information shared on social media may present a two-way aspect. In other words, such information can be released by reliable and official sources, or in contrast, it may be shared by unreliable and unofficial sources. Therefore, the quality and reliability of the content shared on social media would vary depending on the sharing channel (7, 11). False health information is disseminated similar to the right information, and they even draw more attention due to their attractive nature and utilizing emotions as well as exaggerations (7, 8). Despite all the negative effects related to sharing incorrect information, social media can have positive impacts. Therefore, they may act as a tool to raise people's awareness of different health issues, such as vaccine effectiveness and their consequent positive outcomes for individuals in society (7, 9). According to different surveys, people's uncertainty regarding vaccination is growing with the spread of misinformation in digital media as a mass media. Thus, between 20% and 50% of the US population has been estimated to refuse vaccination despite the availability of the COVID-19 vaccine. This issue can make it difficult for political and health authorities to realize the ultimate aim of public vaccination (8). According to the surveys, the incorrect information shared on social media such as Twitter seems to contradict the policies adopted by policymakers to confront the prevalence of a pandemic such as COVID-19 (12). The release of misinformation and incorrect information regarding COVID-19 has the potential to cause destructive effects as follows:

1. Significant threat to adherence to the vaccintion schedule, especially since the threat can put those at risk who are most affected by the disease.
2. Incoordination in public health measures indealing with the COVID-19 crisis
3. Replacement of announcements published by official health sources with false information published on social media (11)

The most considerable threats of social media may include the dissemination of rumors and unreliable information and the absence of oversight on these networks, which directly influences the decision-making process and measures made by individuals and their behaviors in general (13).

The data and posts that are publicly available on social networks can be used to examine thoughts, emotions, and attitudes in dealing with the COVID-19 crisis (6). The individual's emotions are seen as a core factor in sharing information on the social media platform. This attitude is not limited to sharing, but individuals may, despite the availability of accurate information on social media, publish their views and opinions according to economic, social, etc., conditions in that field (8).

Given that people's emotions and attitudes can have a significant impact on the acceptance or rejection of vaccination, identifying people's emotions and attitudes towards COVID-19 vaccination is of special importance. One way to understand people's emotions towards various topics is through analyzing social networks.

Sentiment analysis is performed with the aim of finding people's opinions and attitudes towards different aspects of products and events on social networks (14).

Sentiment analysis has been extensively studied in previous research, analyzing emotions from various social networking data comprehensively. These studies have examined important events (15), the effects of medication (16), consumer sentiments towards a specific brand (17), and other topics (18).

Furthermore, the study seeks to delve into the emotions expressed by social media users regarding the COVID-19 vaccine. Emotions can significantly influence individuals' attitudes and behaviors towards vaccination, making it crucial to understand the range of emotions expressed and their underlying causes. Exploring these topics and emotions will enable us to identify dominant narratives, prevalent misinformation, or popular concerns that shape public opinion and decision-making processes related to the COVID-19 vaccine. Such findings can pave the way for more targeted and effective communication strategies to address vaccine hesitancy, alleviate concerns, and promote informed decision-making. Therefore, the aim of this article is to

conduct a systematic review of the topics discussed and the emotions expressed by users on social media platforms regarding the COVID-19 vaccine and gain a comprehensive understanding of the public discourse surrounding the vaccine on social media and explore the emotional responses of users. Therefore, the present study aims to answer the question of what are the topics and sentiments of users in social media posts related to the COVID-19 vaccine?

Material and Methods
This systematic review was designed based on the PRISMA guidelines (19) to review and analyze the opinions of social media users regarding the COVID-19 vaccine and vaccination. In this regard, PubMed, Scopus, and Web of Science databases have been searched to retrieve the relevant articles. The keywords used in the search strategy were extracted from the MESH database and also from previous studies and authors' experiences. The strategy presented in Table 1 was used to search for sources on November 20, 2021. Based on this, all the articles related to the study topic that were indexed in PubMed, Scopus, and Web of Science databases until November 21, 2021, were retrieved.

Inclusion criteria
The original articles published in English consistent with the study objective, with the articles' topics dedicated to reviewing users' opinions regarding the COVID-19 vaccination were considered the research inclusion criteria.

Exclusion criteria
The articles published in non-English languages were excluded from the study. Other articles, including review articles, short articles, letters to the editor, and case reports, were excluded as well. Moreover, the authors eliminated the papers whose full texts were unavailable and also the articles that focused on users' comments regarding side effects or about a particular vaccine.

Data selection and extraction
Following the selection of the relevant studies based on inclusion and exclusion criteria, the data was collected using a data mining form according to the study objectives. The titles, abstracts, and full texts of the articles were reviewed independently by two researchers. The possible discrepancies were referred to another person. The data extraction form included the following parts: authors' name and year of the study, social media title, number of the analyzed tweets or posts, geographical area, and the results.

Quality Evaluation
After selecting the relevant studies based on inclusion and exclusion criteria, data collected using a form that aligned with the study objectives. Researchers independently reviewed the titles, abstracts, and full texts of the articles using the STROBE checklist (20). Only articles that met at least 20 out of the 22 checklist items were included in the study. The necessary data were then extracted from the eligible articles and recorded in Excel software. In cases where there were discrepancies, another individual was consulted for a second opinion.

Analysis Data
After collecting the data using the data extraction form, the collected data were analyzed using the content analysis method. This method allowed us to identify recurring patterns, themes, and codes within the data, enabling a comprehensive analysis of the content. For qualitative content analysis, the extracted data was gathered in an Excel file and the results were manually examined, analyzed, and reported.

Results
A total of 1725 papers have been identified and retrieved in the initial search of three databases, then entered into the reference management software End-Note. After removing duplicates and irrelevant items according to evaluating the titles, abstracts, and full texts, the authors ultimately selected 29 articles in line with the study objectives. Figure 1 outlines the process of searching and selecting the articles.
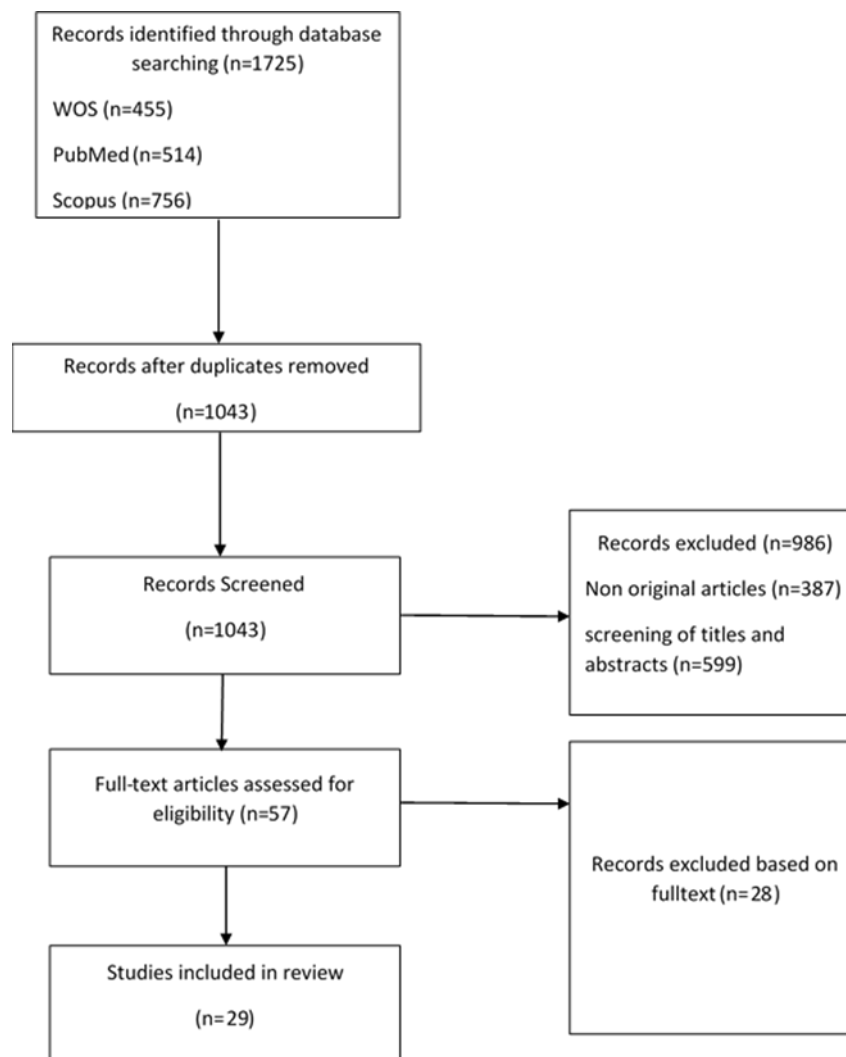
Table 1. Strategy used in searching for sources in the scientific databases

Time limitation	Till November 2021 ,20
Language limitation	English
Database	Web of Science, Scopus, PubMed
Web of science	TS=(COVID 19 Vaccines) OR TS=(COVID-19 Virus Vaccines) OR TS=(COVID 19 Virus Vaccines) OR TS=(COVID-19 Virus Vaccine) OR TS=(COVID 19 Virus Vaccine) OR TS=(COVID19 Virus Vaccines) OR TS=(COVID19 Virus Vaccine) OR TS=(COVID19 Vaccines) OR TS=(COVID19 Vaccine) OR TS=(SARS-CoV-2 Vaccines) OR TS=(SARS CoV 2 Vaccines) OR TS=(SARS-CoV-2 Vaccine) OR TS=(SARS CoV 2 Vaccine) OR TS=(SARS2 Vaccines) OR TS=(SARS2 Vaccine) OR TS=(Coronavirus Disease 2019 Vaccines) OR TS=(Coronavirus Disease 2019 Vaccine) OR TS=(Coronavirus Disease 2019 Virus Vaccine) OR TS=(Coronavirus Disease 2019 Virus Vaccines) OR TS=(Coronavirus Disease-19 Vaccines) OR TS=(Coronavirus Disease 19 Vaccines) OR TS=(Coronavirus Disease-19 Vaccine) OR TS=(Coronavirus Disease 19 Vaccine) OR TS=(COVID 19 Vaccine) OR TS=(2019-nCoV Vaccine) OR TS=(2019 nCoV Vaccine) OR TS=(2019 Novel Coronavirus Vaccines) OR TS=(2019 Novel Coronavirus Vaccine) OR TS=(2019-nCoV Vaccines) OR TS=(2019 nCoV Vaccines) OR TS=(COVID-19 Vaccine) OR TS=(SARS Coronavirus 2 Vaccines)
Scopus	((TITLE-ABS-KEY (covid 19 vaccines) OR TITLE-ABS-KEY (covid-19 AND virus AND vaccines) OR TITLE-ABS-KEY (covid 19 virus AND vaccines) OR TITLE-ABS-KEY (covid-19 AND virus AND vaccine) OR TITLE-ABS-KEY (covid 19 virus AND vaccine) OR TITLE-ABS-KEY (covid19 AND virus AND vaccines) OR TITLE-ABS-KEY (covid19 AND virus AND vaccine) OR TITLE-ABS-KEY (covid19 AND vaccines) OR TITLE-ABS-KEY (covid19 AND vaccine) OR TITLE-ABS-KEY (sars-cov-2 AND vaccines) OR TITLE-ABS-KEY (sars AND cov 2 vaccines) OR TITLE-ABS-KEY (sars-cov-2 AND vaccine) OR TITLE-ABS-KEY (sars AND cov 2 vaccine) OR TITLE-ABS-KEY (sars2 AND vaccines) OR TITLE-ABS-KEY (sars2 AND vaccine) OR TITLE-ABS-KEY (coronavirus AND disease 2019 vaccines) OR TITLE-ABS-KEY (coronavirus AND disease 2019 vaccine) OR TITLE-ABS-KEY (coronavirus AND disease 2019 virus AND vaccine) OR TITLE-ABS-KEY (coronavirus AND disease 2019 virus AND vaccines) OR TITLE-ABS-KEY (coronavirus AND disease-19 AND vaccines) OR TITLE-ABS-KEY (coronavirus AND disease 19 vaccines) OR TITLE-ABS-KEY (coronavirus AND disease-19 AND vaccine) OR TITLE-ABS-KEY (coronavirus AND disease 19 vaccine) OR TITLE-ABS-KEY (covid 19 vaccine) OR TITLE-ABS-KEY (2019-ncov AND vaccine) OR TITLE-ABS-KEY (2019 ncov AND vaccine) OR TITLE-ABS-KEY (2019 novel AND coronavirus AND vaccines) OR TITLE-ABS-KEY (2019 novel AND coronavirus AND vaccine) OR TITLE-ABS-KEY (2019-ncov AND vaccines) OR TITLE-ABS-KEY (2019 ncov AND vaccines) OR TITLE-ABS-KEY (covid-19 AND vaccine) OR TITLE-ABS-KEY (sars AND coronavirus 2 vaccines)) AND (TITLE-ABS-KEY (social AND network) OR TITLE-ABS-KEY (social AND networks) OR TITLE-ABS-KEY (twitter) OR TITLE-ABS-KEY (instagram) OR TITLE-ABS-KEY (whatsapp) OR TITLE-ABS-KEY (telegram) OR TITLE-ABS-KEY (social AND media) OR TITLE-ABS-KEY (social AND medium) OR TITLE-ABS-KEY (web 2.0) OR TITLE-ABS-KEY (web AND 2.0s))) AND TS=(Social media) OR TS=(Social media) OR TS=(Twitter) OR TS=(Instagram) OR TS=(Whatsapp) OR TS=(Telegram) OR TS=(Social Media) OR TS=(Social Medium) OR TS=(Web 2.0) OR TS=(Web 2.0s)
PubMed	(((((((((((((((((((((((((((((COVID 19 Vaccines) OR (COVID-19 Virus Vaccines)) OR (COVID 19 Virus Vaccines)) OR (COVID-19 Virus Vaccine)) OR (COVID 19 Virus Vaccine)) OR (COVID19 Virus Vaccines)) OR (COVID19 Virus Vaccine)) OR (COVID19 Vaccines)) OR (COVID19 Vaccine)) OR (SARS-CoV-2 Vaccines)) OR (SARS CoV 2 Vaccines)) OR (SARS-CoV-2 Vaccine)) OR (SARS CoV 2 Vaccine)) OR (SARS2 Vaccines)) OR (SARS2 Vaccine)) OR (Coronavirus Disease 2019 Vaccines)) OR (Coronavirus Disease 2019 Vaccine)) OR (Coronavirus Disease 2019 Virus Vaccine)) OR (Coronavirus Disease 2019 Virus Vaccines)) OR (Coronavirus Disease-19 Vaccines)) OR (Coronavirus Disease 19 Vaccines)) OR (Coronavirus Disease-19 Vaccine)) OR (Coronavirus Disease 19 Vaccine)) OR (COVID 19 Vaccine)) OR (2019-nCoV Vaccine)) OR (2019 nCoV Vaccine)) OR (2019 Novel Coronavirus Vaccines)) OR (2019 Novel Coronavirus Vaccine)) OR (2019-nCoV Vaccines)) OR (2019 nCoV Vaccines)) OR (COVID-19 Vaccine)) OR (SARS Coronavirus 2 Vaccines)) AND ((((((((((Social media) OR (Social media)) OR (Twitter)) OR (Instagram)) OR (Whatsapp)) OR (Telegram)) OR (Social Media)) OR (Social Medium)) OR (Web 2.0)) OR (Web 2.0s))

Figure 1. Article selection process chart

The features and results of the articles included in the study are summarized in Table 2. According to the data in Table 2, the social media studied in these articles were as follows: Twitter (25 articles), Weibo (2 articles), and Parler-Douban-Reddit (one article for each). The geographical areas of investigated posts were the United States (9 articles), India (4 articles), China (3 articles), Canada (2 articles), and the countries such as Saudi Arabia, Poland, Norway, Pakistan, Sweden, Philippines, South Korea, Australia, the United Kingdom, and Brazil (one article for each). Moreover, no geographical area had been considered for the ten articles for data extraction. The number of posts or comments examined has also differed in different studies. In addition, the time intervals for gathering social media posts for analysis have been varied in various investigations.

Table 2. Results obtained from analyzing the selected studies

Authors and Year of Study	Social Media	Analyzed Posts or Comments	Geographic Area	Results
Alliheibi et al., 2021 (4)	Twitter	A total of n=37,467 tweets were collected during the period of December 15, 2020.	Saudi Arabia	The comments distribution was as follows: Positive (approximately 54%), negative (34%), and neutral (12%). The positive comments included the keywords effective, safe, normal, protection, and caution, pointing to the common concept of reducing the risks associated with COVID-19 through vaccination, especially for the elderly. The negative comments, in turn, involved some words such as rejection, no, infertility, Gates, conspiracy groups, and DNA. These keywords focused on vaccines' ineffectiveness and failure to accurately evaluate the vaccines in clinical trials. They have also mentioned the relationship between the COVID-19 vaccines with infertility and DNA changes in people and a cover for a plan devised and developed by Bill Gates to traceable implant microchips to control people.
Baines et al., 2021 (9)	Parler	Two samples were investigated, including a random sample (n=400) and a larger sample (n=7000) from November 20, 2020, to January 6, 2021.	United States	This research has revealed five main topics among the data shared on this social media: a) reasons for rejecting the COVID-19 vaccine (40%); b) side effects of the COVID-19 vaccine (28%); c) population control through the COVID-19 vaccine (23%); d) the children vaccinated without their parental consent (5%); e) comparing the COVID-19 mortality rate with other diseases (2%).
Baj-Rogowska et al., 2021 (21)	Twitter	A total of n=105,849 Tweets were collected in May 2021 in Poland.	Poland	According to this research, accepting the COVID-19 vaccine mostly depends on two dimensions of awareness (39.4%) and access to the vaccine (27.3%). Based on this study, the most frequently discussed topic on Twitter has been related to awareness and access. People's negative views have prevailed regarding the awareness subject, while positive views have been more than negative views regarding accessibility. There have been other issues in individuals' perspectives; however, no specific classification is assigned to the two groups of awareness and acceptance. Some of them are as follows: the lack of information on the COVID-19 mutations, the need to research and gather data related to the complications of COVID-19 vaccines, and fake news and misinformation regarding the COVID-19 vaccine.

Batra et al., 2021 (1)	Twitter	Two examples in two different periods have been analyzed: n=23,000 tweets collected between January 1, 2020, and March 23, 2020, as well as n=226,668 tweets collected between December 2019 and May 2020. The analyzed tweets have been in the formats of text and images in English.	United States Canada India Norway Pakistan Sweden	Revealed by this research results, the number of tweets shared on Twitter has changed over time. For instance, the growing trend of tweets about the positive and negative emotions concerning vaccination has hit its peak on January 20 with the prevalence of a new mutation of the coronavirus. The changes in people's attitudes and views have occurred more in Asian countries (India and Pakistan) than in other countries. The mean rate of negative views was higher in India than the positive views. Moreover, neighboring countries in each continent show similarities and correlations regarding expressing emotions.
Bi D et al., 2021 (8)	Douban	A total of n=5665 users' comments on Douban were collected from December 2020 to April 2021 with no language limits.	China	The people's views have been varied regarding the COVID-19 vaccination at different times. At first, the number of negative comments about vaccination has shown a rise to a maximum of 44% at some point in time. The users' opinions have changed from neutral to negative at other time intervals. Regarding the analysis of the issues raised on social media, the number of topics with negative and neutral views was the highest and the lowest, respectively.
Bonnevie et al., 2021 (2)	Twitter	This retrospective longitudinal study examined and discussed the information about vaccines against COVID-19 and other diseases over two periods. The first period was from October 15, 2019, to February 14, 2020, and the second was from February 15, 2020, to June 14, 2020. A total of n=799,535 tweets and n=2,514,381 tweets were collected during the first and second periods, respectively.	Without considering any geographical area	The common topics raised in the two periods against vaccines were as follows: Negative effects on health (first period: 22%, second period: 16.9%) Pharmaceutical industry (first period: 11.2%, second period: 10.5%) Requirements and policies (first period: 10.6%, second period: 8.4%) Vaccine ingredients (first period: 10.4%, second period: 9.8%) Federal health authorities (first period: 8.3%, second period: 12%) Clinical research and trials (first period: 7.4%, second period: 7.7%) Religion (first period: 5%, second period: 1.7%) Vaccine safety (first period: 4.5%, second period: 2.7%) Prevalence of the disease (first period: 4.3%, second period: 1.9%) Schools (first period: 3.4%, second period: 1.6%) Family (first period: 3.3%, second period: 1.4%)

Boucher et al., 2021 (22)	Twitter	A total of n=636,516 tweets were collected between November 16, 2020, and November 26, 2020.	Without considering any geographical area	By analyzing the tweets related to distrust of vaccines, the results have demonstrated that people's negative views on Twitter may manifest differently. Thus, people do not consider vaccination an appropriate option to prevent the COVID-19 pandemic since the mass production of vaccines takes much time. Moreover, the political bias of individuals and following the views of political figures can cause a negative view against vaccination. In addition, some proof of the ineffectiveness of vaccines in a series of tests may be a reason for creating negative views in people. Highlighting the side effects of vaccination and creating a haze of ambiguity can affect people and lead them to reject the vaccines. Lack of trust in vaccine-producing pharmaceutical companies has also been identified as a reason for opposing vaccination.
Zhang et al., 2021 (23)	Twitter	A total of n=501,531 tweets were collected from January 1, 2020, to April 30, 2021.	Without considering any geographical area	Twelve topics were extracted by analyzing the tweets according to the results obtained in this study: "vaccine availability," "vaccine effectiveness and unveiling," "vaccine development and public opinion," "vaccination status," "emotions and side effects," "vaccination time," "vaccines availability," "vaccination eligibility," "age and related issues," "preventive measures," "university students," "trust and communication." The results demonstrated that the most attractive tweets for the audience are posted regarding vaccine accessibility, vaccine effectiveness, and vaccine unveiling.
Yousefina-ghani et al., 2021 (24)	Twitter	A total of n=4,552,652 available tweets were collected from January 7, 2020, to January 3, 2021. These tweets were related to the Pfizer, Moderna, AstraZeneca, and Johnson vaccines.	Without considering any geographical area	According to the results, the neutral, positive, and negative categories accounted for 41%, 34%, and 25%, in respective order. Negative emotions covered a broad spectrum of concerns; however, most were concentrated on the time-consuming vaccine production process, doubts about vaccine safety, or the response to governments, political figures, and manufacturers. On the other hand, positive tweets usually focus on scientific advances, medical recommendations, and hope expansion. At the beginning of the year, pro-vaccine tweets prevailed in the media. However, when COVID-19 was declared an epidemic in mid-March, the anti-vaccine posts started to rise and kept their level until the end of May. As July went on, vaccine doubt-containing content increased slightly and remained stable until early November. The most significant authors in pro-vaccine groups were well-known individuals and agencies, including public health institutions, physicians, TV channels, newspapers, international organizations, and health professors.

				For anti-vaccine tweets, many top users had already been suspended by Twitter. However, several Twitter bots were found that were retweeting some tweets automatically. Other users who posted anti-vaccine tweets included political activists, writers, and artists. In this study, political activists were defined as Twitter users; the main topics of their posts were related to politics.
Wang et al., 2021 (25)	Twitter	A total of n=154,978 tweets related to the Coronavirus hashtag were collected from March 20, 2020, to August 9, 2020.	United States	The results of this study have revealed the core topics in tweets on masks and vaccination. The major topics about using masks are as follows: (1) Mask as a new norm (10.8%), (2) Face shield (10.3%), (3) Masks for a living (18.8%), (4) Advertising/Sales (46.8%), and (5) Government criticism (13.3%). Topics for vaccination included (1) Science (25.8%), (2) Vaccine-free control (25.0%), (3) Boosting immunity (14.9%), (4) Vaccine competition (14.3%), and (5) Politics (20.0%). According to the results, Twitter users have reacted more to the positive content about wearing masks (t=2.32, p=0.02). Moreover, negative content about vaccination has been more popular (t=-3.17, p=0.0017). Moreover, the level of popularity and feeling toward each subject have been varied over time.
Villavicencio et al., 2021 (26)	Twitte	A total of n=993 tweets were collected from March 1, 2021, to March 31, 2021	Philippines	Out of the examined tweets, 83.38% were related to positive attitudes. In most of them, users mentioned their vaccination choice to encourage others. Phrases such as "Trust the science," "Vaccination works," and "A dose of hope" have been seen several times. A small number of tweets with a negative perspective were analyzed as well. Some tweets have mentioned adverse side effects. However, some tweets have supported vaccinations despite possible side effects since the benefits of vaccination excel the risk of contracting the virus. Thus, only 8.26% of tweets had a negative concentration. Similarly, 8.36% of tweets were neutral. The process of expressing emotions was also variable in the published tweets over time.

Thelwall et al., 2021 (27)	Twitter	A total of n=446 English tweets regarding the hesitation in getting the COVID-19 vaccine were collected from March 10, 2020, to December 5, 2020	Without considering any geographical area	This research has shown the issue of doubt in half (50.2%) of the tweets. The related topics have been conspiracies (23.5%), development rate (16.1%), and safety (10.5%). Political factions have expressed mainly their doubts regarding the COVID-19 vaccine on Twitter (79%) through a combination of conspiracy theories and plausible concerns about development rate and safety.
Sv et al., 2021 (28)	Twitter	A total of n=189,888 tweets were collected in March and April 2021.	India	According to the results, 33.6% of tweets with negative emotions were about the vaccines' side effects. Moreover, approximately 78.5% of tweets included neutral or positive emotions. According to the findings, positive emotions about the side effects of the COVID-19 vaccine have increased significantly since the second week of April. Besides, the most important concerns of users have been as follows: the fear of the possible effect of COVID-19 vaccination on the performance at work, possible death as a side effect of the COVID-19 vaccine, feeling of risks in getting vaccines, the Covishield bans in countries such as Norway, fear of long-term effects of the COVID-19 vaccine, fear of the occurrence of blood clots, the fear caused by the media, safety measures at the vaccination site, and vaccine efficiency
Shim et al., 2021 (29)	Twitter	A total of n=3509 tweets were collected from February 23, 2021, to March 22, 2021.	South Korea	The results suggested that hesitation in getting vaccines with a relative weight of 14.2% has been the most common tweeted topic. The second and third most frequent topics have been "vaccine development" (13.1%) and "quarantine prevention policy" (13.0%). The other topics were as follows: "Vaccination effectiveness" (12.6%), "Prioritized vaccination of hospital staff" (12.0%), "Media about COVID-19 vaccines" (11.9%), "Medical Association Reaction" (11.8%), and "Side effects" (11.4%). The ratios of positive and negative tweets were similar immediately before and after starting the vaccination; however, the negative tweets were highlighted following the increased number of confirmed COVID-19 infections. People's expectations, frustrations, and fears about the vaccine were reflected in the tweets.

Sattar et al., 2021 (30)	Twitter	A total of n=1,200,000 tweets were collected from April 10, 2021, to May 17, 2021.	United States	.The general emotions expressed in the tweets have been more positive rather than negative despite some side effects found in using some vaccines. Although the majority of tweets (60 to 70%) were considered neutral, the rest portion mainly included positive tweets (20 to 25%).
Praveen et al., 2021 (31)	Twitter	A total of n=18,440 tweets were collected in September, October, November, and December 2020.	India	Almost 47% of the posts in the last four months of 2020 have been focused on vaccines and their effects in a neutral tone, while 35% and 16.6% of the posts about vaccines with a positive tone and a negative tone, respectively. Slight changes have occurred in positive and neutral emotions, and a considerable drop in negative emotions as changes have been made in the number of cases. Positive emotions increased by approximately 1.4% in December compared to the prior four months, and negative emotions decreased by 5.2% in December compared to October. According to the results, tweets have been published on the following topics: Fear of health; Allergic reactions; Fear of death; Hesitations about vaccines; Exaggeration in the COVID-19; Negative emotions towards pharmaceutical companies; Doubts about data; Different vaccines; Hasting in producing vaccines. Fear of health and allergic reactions to the vaccine were also two major issues among Indian citizens' concerns about the COVID-19 vaccines.
Monselise et al., 2021 (32)	Twitter	A total of n=7,948,886 tweets were collected from December 18, 2020, to February 12, 2021.	Without considering any geographical area	The three important topics in this study were identified as follows: "Vaccination of healthcare workers," "Access to vaccines - online registration," and "The South African type." Other topics were mainly related to concerns about vaccines and their supply and distribution. Some topics concerning the profits of pharmaceutical companies and conspiracy theories have also been discussed. The analysis revealed that events reported in the news had affected the peak of the topics, which have been broadcasted through social media. Emotion analysis indicated that 46.9% of tweets were negative, associated with fear emotions, followed by 33.2% of tweets entangled with grief and anger. Positive tweets were associated with emotions of joy and hope. Moreover, 19.9% of tweets were found to be neutral

Mir et al., 2021 (33)	Twitter	A total of n=23,575 tweets were collected from January 12, 2021, to February 13, 2021.	Without considering any geographical area	A gradual drop in tweets has been seen over time. A large portion (47.52%) of tweets were found to express positive emotions with neutral emotions (33.71%) and negative emotions (18.75%) in the following ranks. Moreover, this research revealed a considerable difference between the impacts of tweets sent by approved and unapproved users. The approved users' tweets further affect retweeting (65.91%) and getting likes (84.62%) than the unapproved tweets. Tweets expressing positive emotions show the highest impact in terms of likes (mean=10.48) and retweeting (mean=3.07) compared to the tweets expressing neutral or negative emotions.
Melton et al., 2021 (34)	Reddit	A total of 13 forums were investigated from December 1, 2020, to May 15, 2021.	United States	Five topics for the posts were detected in this study, including vaccine, safety concerns, efficiency, and side effects. The focused analysis of the combined (composite) datasets brought the following results: positive posts (56.68%), negative posts (27.69%), and neutral posts (15.63%). The findings suggested the occurrence of changes in people's emotions over time
Lyu et al., 2021 (35)	Twitter	A total of n=1,499,421 unique tweets were collected from n=583,499 different users from March 11, 2021, to February 31, 2021.	Without considering any geographical area	The results were as follows: the themes of opinions and emotions about vaccines and vaccinations (27.04%), knowledge about vaccines and vaccinations (23.7%), vaccine as a global issue (20.76%), vaccine administration (17.79%), and advances in vaccine development and licensing (10.72%). The vaccine development worldwide became a topic of debate around August 11, 2020, when Russia approved the first COVID-19 vaccine. As vaccine administration progressed, the issue of training on receiving vaccines gradually got more highlighted and turned into the most controversial topic after the first week of January 2021. The mean weekly emotion scores showed that the emotions were increasingly positive despite some fluctuations. Emotion analysis also revealed trust as the most prevailing emotion, followed by expectation, fear, sadness, etc. When Pfizer announced on November 9, 2020, that its vaccine was 90% effective, the feeling of trust reached its peak

Luo et al., 2021 (36)	Twitter and Weibo	Twitter and Weibo were investigated from December 1, 2020, to February 20, 2021.	United States & China	According to emotions analysis, neutral tweets (49.99%) had the highest rate, followed by positive tweets (30.62%) and negative tweets (19.40%). The majority of Weibo posts were positive (40.64%) in comparison with Twitter, followed by neutral posts (37.44%) and negative posts (21.92%). The discussed topics on Twitter were as follows:
				    Promoting vaccines and anti-vaccine discourses
				    Personal vaccination experience
				    Vaccination of priority groups
				    Government vaccination policies
				    Challenges of different types of the COVID-19
				    Vaccination advances around the world
				    The discussed topics on Weibo were as follows:
				    Policies and priority groups
				    Research and development of domestic vaccines
				    Challenges of different types of the COVID-19
				    Global epidemic progression
				    WHO support and evaluation
				    Epidemic development in the United States
				
				According to the results, the social media users of the two countries overlapped on topics related to domestic vaccination policies, priority groups, the challenges of different types of COVID-19, and the status of the global pandemic. However, Twitter users had the potential to disclose individual vaccination experiences and express anti-vaccine attitudes. Weibo users showed obvious respect for the authorities and indicated more positive emotions about the COVID-19 vaccine.

Liu et al., 2021 (37)	Twitter	A total of n=2,678,372 English tweets regarding the COVID-19 vaccine were collected from November 1, 2020, to January 31, 2021, and analyzed.	Without considering any geographical area	with negative emotions (30.3%). Five topics for positive emotion tweets (test results, management, life, information, and efficiency) and five topics for negative emotion tweets (test results, conspiracy, trust, effectiveness, and management) were identified in this study.

Liew et al., 2021 (38	Twitter	. A total of n=672,133 tweets were collected from November 2020 to February 3, 2021.	Without considering any geographical area	Six general topics were recognized for the analyzed tweets as follows: 1. Emotional reactions to COVID-19 vaccines (19.3%) 2. General concerns about COVID-19 vaccines (19.6%) 3. Discussion of vaccines-related news (13.3%) 4. Public health communications about vaccines (10.3%)\ 5. Discussion on vaccination approaches (17.1%) 6. Discussion on vaccine distribution (20.3%) The tweets contacting negative emotions were mostly included the themes of emotional reactions and general concerns related to COVID-19 vaccines. The tweets about vaccination facilitators have revealed time changes over time, while obstacle-related tweets remained largely constant throughout the study period.
Kwok et al., 2021 (39)	Twitter	A total of n=31,100 English tweets were collected from January 22, 2020, to October 20, 2020.	Australia	The results have revealed three topics as follows: 1. Attitudes toward COVID-19 and its vaccination 2. Supporting infection control measures against COVID-19 3. Misconceptions and complaints about the COVID-19 control Almost two-thirds of emotions of all tweets have expressed a positive public opinion about the COVID-19 vaccine, while about a third were negative. Trust and expectation have been two highlighted positive emotions in the tweets out of all emotions expressed, while fear was the highest negative emotion. In addition, the level of emotions in tweets varies over time.
Karami et al., 2021 (40)	Twitter	A total of n=200,000 tweets were collected from November 1, 2020, to February 28, 2021.	United States	The results showed that 33.64% and 66.36% of the tweets were negative and non-negative, respectively. The rate of negative tweets has followed a decreasing trend, while the rate of non-negative tweets has been upward. According to the final analysis, five major topics of negative tweets included vaccination sites, vaccine receiving stories, vaccine effectiveness, information, and management. Moreover, the government, hesitating in getting vaccines, vaccine immunity, vaccines, masks and social distancing, and comparisons of vaccination strategies of governments were identified as the main five topics in non-negative tweets. This study also revealed the change in emotions contained in tweets over time.

Jiang et al., 2021 (41)	Twitter	. A total of n=100,209 tweets were collected from February 20, 2020, to March 31, 2020.	United States	The results of this study have described 26.3% of tweets as news related to the coronavirus and vaccine development, 25.4% as public discussion and searching information on COVID-19, 12.9% as financial concerns, 12.7% as the discharge of negative emotions, and 9.9% as prayers and positive requests. In addition, 8.1% and 4.9% of tweets have focused on vaccine effectiveness, treatment, and conspiracy about the coronavirus and its vaccines. Various topics have changed over time, most closely connected with news or events related to vaccine development. Twitter users busy discussing conspiracy theories, vaccines' effectiveness, treatments, and financial concerns had more followers than people discussing other vaccine topics. The level of interaction - the rate of retweets, quotes, likes, or replies to tweets by other users - was similar among the different themes; however, tweets discharging negative emotions had the lowest interaction rate.
Hou et al., 2021 (42)	Twitter and Weibo	A total of n=7032 posts were collected from June 13, 2020, to July 31, 2020.	New York (USA), London (UK), Mumbai (India), Sao Paulo (Brazil), and Weibo posts from Beijing (China	With the increased risk of COVID-19, more tweets in New York and London were posted as distrusting the vaccine safety, distrust of governments and experts, misinformation, or widespread rumors. Tweeters from Mumbai, Sao Paulo, and Beijing were more concerned about vaccine production and supply, while New York and London tweeters had more concerns about vaccine distribution and inequality. Negative tweets indicating distrust of the vaccine and false information or rumors had more advocators and had attracted more public participation in cyberspace.
Griffith et al., 2021 (43)	Twitter	A total of n=605 tweets about the hesitation in getting the COVID-19 vaccine were collected from December 18, 2020, to December 23, 2020	Canada	The tweets with doubts about the vaccine have originated from the following themes: safety concerns, suspicions about political or economic forces involved in the emergence of the COVID-19 pandemic or vaccine production, lack of knowledge about vaccines, anti-vaccines or confusing messages from authorities, and lack of legal liability on the part of vaccine-producing companies. These themes are classified into five theoretical structures: knowledge, beliefs about consequences, context and environmental resources, social impact, and emotions.

The analyzed articles, given in Table 1, have classified users' emotions and emotions about the COVID-19 vaccine into three positive, negative, and neutral emotions groups. Some other papers have also identified the topics of users' posts and comments on social media regarding the COVID-19 vaccine through analysis.

According to many studies, a large portion of the emotions expressed by users regarding the COVID-19 vaccine on social media has been positive or neutral (4,24, 26, 28, 30, 31, 33, 34, 36, 37, 39, 40). Some studies have also demonstrated a higher frequency of negative emotions over positive emotions in users' posts and comments about the COVID-19 vaccine (1, 8, 29, 32). The occurrence of some changes in the emotions expressed by users in posts and comments about the COVID-19 vaccine on social media have been monitored over time as well (1, 8, 24, 25, 26, 29, 31, 34, 35, 39, 40).

The most frequent topics appearing in posts and com-

ments shared by social media users were as follows: Safety and efficiency (2, 4, 23, 24, 25, 27, 29, 37, 40, 41, 43), vaccine development and its development rate (23, 27, 29, 31, 35, 36, 41), prevention policies and health and political authorities (2, 24, 25, 29, 40, 43). Other topics included vaccine side effects (4, 2, 21, 23), reasons for acceptance or rejection (4, 21, 31), priority groups for receiving vaccines (29, 32, 36), and vaccine-producing companies (2,25,31). Other topics have also involved the discussion of general vaccine information and vaccination.

The conceptual diagram of analyzing the users' emotions about the COVID-19 vaccine on social media according to the present results is illustrated in Figure 2. Conceptual figure 2 has been drawn based on the findings of the studies examined in table 2. Figure 2 illustrates the positive and negative emotions related to COVID-19 vaccination, as well as the topics associated with positive and negative emotions about COVID-19 vaccination.
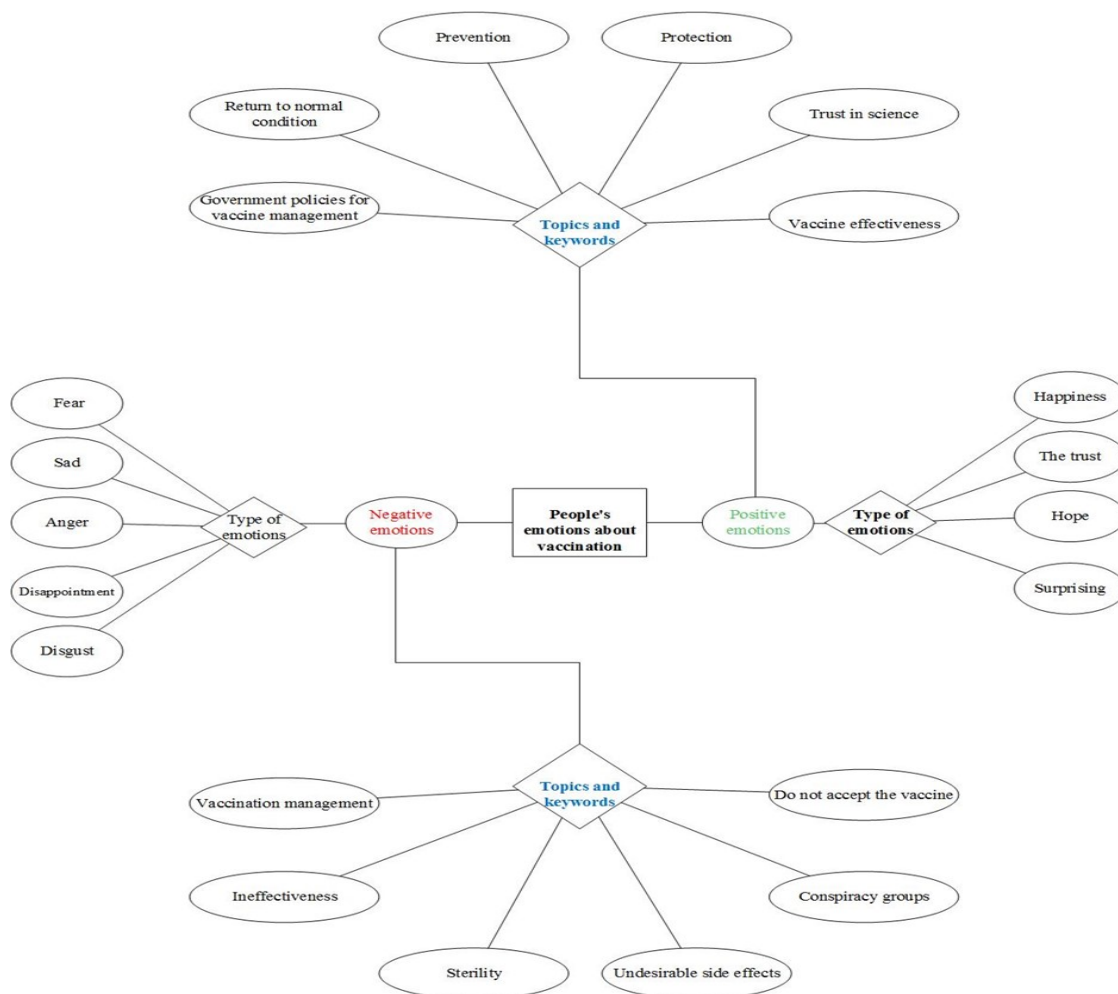

Figure 2. Illustration of emotions expressed by social media users about the COVID-19 vaccine

Discussion

This systematic review was designed to examine and analyze the topic and emotions expressed in comments and posts shared by users on social media regarding the COVID-19 vaccine. According to the findings, most of the emotions and emotions represented by users regarding the COVID-19 vaccine in posts published on social media appeared to be positive or neutral. However, there were negative emotions expressed in these posts at different time intervals.

Positive emotions of people on social media regarding vaccines happen as a reaction to news and information related to the safety and effectiveness of vaccines. In this context, Alliheibi et al. suggested that positive responses and emotions involved the keywords effective, safe, normal, protection, and caution, representing a decrease in the risks related to COVID-19 due to the vaccine efficiency. Moreover, negative reactions and emotions contained words such as rejection, no, infertility, conspiracy groups, and DNA, reflecting the ineffectiveness of vaccines and the failure of accurate evaluation of vaccines in clinical trials (4). Representing negative emotions by individuals happens due to their fears and concerns (44, 45). According to literature, people's activity has grown increasingly on social media in response to the COVID-19 crisis, which would lead to emotional use of social media considering the current situation. The emotional use of social media such as Twitter to share information may cause a considerable challenge for people's health and ongoing efforts to fight the spread of this disease since it may make this information incorrect and part of conspiracy theories (6). Such theories affect people's way of thinking about vaccination and raise doubts about vaccination (9) because people rely on social media to receive up-to-date information in times of crisis (46). In addition, inaccurate information and conspiratorial content can create stronger anti-vaccine beliefs and provoke emotions and changes in people's health behaviors since users fail to pay attention to the validity of the contents.

The findings also revealed that the individuals' emotions about the COVID-19 vaccine have varied during the COVID-19 pandemic and have changed at different time intervals. Since vaccination started at different times in various countries, different reports have been published regarding its side effects and effectiveness worldwide. Accordingly, the number of tweets shared on Twitter has experienced many changes over time. For instance, the increasing trend of tweets with positive and negative emotions about vaccination hit its peak on January 20 with the emergence and spread of a new type (mutation) of the coronavirus. Therefore, it can be said that people's emotional aspects are affected by events related to health issues and can change the direction towards a positive or negative attitude (1). Moreover, the views and emotions of people during the pandemic may come from different factors. For example, they can be originated from media advertising and are related to vaccination policies (8). A long time of mass production, highlighting the side effects of vaccination, and the occurrence of different ambiguities can also influence people's views and emotions regarding the acceptance and rejection of the vaccine (22). The rate of releasing misinformation has been minimized by applying the policies to prevent the dissemination of false information on social media during the COVID-19 pandemic (11), which influences users to express their emotions on social media.

It was also demonstrated that the major topics discussed by users on social media about the vaccine are safety and effectiveness, vaccine development and development rate, prevention policies, and health and political authorities.

Since the safety and effectiveness of the vaccine seem to be core concerns of people influencing individuals' acceptance or rejection of the COVID-19 vaccine (47), it can be said that people on social media look for information related to the COVID-19 vaccine' efficiency and immunogenicity. In addition, due to the ongoing development and production of various vaccines by different companies and countries to fight COVID-19, which has been still in the initial testing and experimenting phase (48), users naturally show different reactions to this issue and follow up on news and information related to the vaccine progress and development.

Social media have been used by users worldwide in the COVID-19 pandemic as a tool to enhance awareness of people regarding various health issues such as vaccine effectiveness and its positive outcomes (9). This issue, in turn, can promote community health programs through familiarity with individuals' views on social media (21). According to previous studies, social media may contribute to further interaction and participation of people in vaccination to prevent mortality and relevant complications as a communication channel by sharing up-to-date and scientific information concerning the safety and effectiveness of vaccines to treat infectious diseases, especially the COVID-19 (10).

Health and political officials and organizations also shared different comments or laws and regulations on social media during the COVID-19 pandemic, which became one of the significant topics discussed among social media users. Individuals, organizations, and governments employ social media to communicate about several issues related to the COVID-19 pandemic (6). The language used by political elites regarding the healthcare area will affect people's opinions and health-related behaviors (49). Therefore,

political leaders can benefit from their influence on public opinion to address health-related issues (15). According to the evidence, political statements have the potential to create remarkable differences in public opinion regarding healthcare measures (50). Additionally, Karami et al. discovered that negative tweets frequently covered vaccination sites, personal accounts of vaccine experiences, vaccine efficacy data, as well as the management of vaccine distribution. On the other hand, non-negative tweets often discussed administrative aspects, vaccine hesitancy, vaccine immunity, the use of masks, social distancing measures, and comparisons of different vaccination strategies (40).

Some other topics that have been discussed on social media concerning vaccines are as follows: vaccine side effects, reasons for acceptance or rejection, priority groups for vaccination, vaccine-producing companies, and general information regarding the vaccines and vaccination.

Based on a survey conducted (51), individuals exhibiting vaccine hesitancy primarily express concerns regarding side effects, emergency approval, and effectiveness of the COVID-19 vaccine. In their analysis, Jun et al. observed that over 1% of COVID-19 vaccine-related tweets mentioned 'side-effects'. They also found a positive correlation between side-effect mentions, death, negative sentiment, and the emotions of fear, sadness, and anger at a preliminary level. These findings suggest that when a larger number of individuals within a country express concerns about vaccine side-effects or primarily focus on adverse vaccination events on social media, it can negatively impact trust and participation in vaccination efforts within that country (52).

Conclusion

Social media have the potential to help understand attitudes and behaviors during a public health crisis and promote health messages. Attitudes toward vaccination are almost formed by information and ideas faced by individuals via social media. Therefore, effective management and use of social media may effectively contribute to improving disease management and crisis management.

According to the results obtained in this study, it can be said that getting aware of people's views on social media platforms matters to policymakers in designing communicative strategies for health communications. In addition, experts and public health organizations should resolve people's concerns and views on vaccine effectiveness to enhance public confidence in vaccines. Accordingly, health policymakers need to pay attention to all the general public's views regarding the COVID-19 vaccination since overlooking those views can cause serious problems in controlling epidemics in different countries and regions. Furthermore, Based on the findings of the present review study, the following suggestions are proposed for researchers and public health policymakers:

-Enhance public health communication
-Monitor social media sentiment
-Identify and address misinformation
• Foster vaccine confidence

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