



Social media applications in biomedical research

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Abstract

Information and communication technologies (ICTs) have transformed global connectivity, offering significant support to underserved populations and small businesses in developing nations. The integration of social media into the ICT landscape has further revolutionized communication and information sharing worldwide. However, despite its widespread adoption, the precise impact of social media on biomedical research remains uncertain. This manuscript seeks to examine the multifaceted roles of social media in healthcare, focusing on its applications in patient care, professional networking, education, organizational promotion, and public health programs. Additionally, it investigates social media's significance in research, particularly its potential for data collection and analysis. A comprehensive literature review was undertaken to consolidate existing knowledge on social media's utilization in healthcare and research. Various platforms, including social networking sites and academic networking sites, were assessed, along with their respective applications and consequences. Social media platforms have become essential tools in healthcare, facilitating professional networking, patient education, organizational promotion, and public health initiatives. In the realm of research, social media provides extensive opportunities for data collection, analysis, and collaboration, although challenges persist regarding privacy, data accuracy, and ethical considerations. The pervasive influence of social media in healthcare and research highlights its potential to enhance communication, engagement, and knowledge dissemination. However, careful adherence to ethical guidelines and privacy concerns is essential to maximize its benefits while minimizing risks. As social media continues to evolve, its role in shaping biomedical research and healthcare practices is anticipated to grow, necessitating ongoing exploration and adaptation by stakeholders.

Keywords

Clinical trials, data, LinkedIn, social media, Twitter



Introduction

Information and communication technologies (ICTs) have a significant influence on how developed nations progress. In many developing countries, people living in remote locations have access to the Internet, which means they may get helpful knowledge and conduct international business. ICTs can aid in the growth of those from less fortunate circumstances, such as female entrepreneurs in underdeveloped countries and those with lower levels of knowledge. There are multifaceted roles of ICTs, for instance, assist women in poor nations in starting small companies [1, 2]. ICTs are employed in India to boost the earnings of farmers [3]. Young businessmen in Malaysia's countryside launch their modest companies with the use of ICTs [4]. Mobile phones are being utilized in Africa to provide instructive films to farmers [5]. Entrepreneurs may readily access different kinds of data and engage with customers and suppliers thanks to the quick growth of ICTs on an international level particularly for small businesses in underdeveloped nations, ICTs provide excellent commercial potential [2].

The Internet's quick development over the last decade has given users numerous alternatives. In addition to the obvious benefits of information-seeking and cross-border communication, social media these days also makes it achievable to communicate emotions and ideas. Social media are "a category of Internet-based applications based on the scientific and technological foundations of Web 2.0 and enable the generation as well as sharing of User Generated Content", according to Kaplan and Haenlein. Social media have grown rapidly in the past few years since its inception, becoming the preferred form of media all over the globe [6]. Social media platforms are becoming more and more popular, and many businesses, from start-ups to small and medium-sized enterprises, are using them in their daily operations. The precise influence that these advancements in technology have on biomedical research is unknown, despite the widespread usage of social media [7].

Social media is increasingly being used for personal and health-related purposes. This reflects the rising understanding that social media may offer a forum for individuals to learn about their alternatives, consider them, and express their own experiences. Social media offers online forums for conversations about a range of health-related issues, including patient education, health promotion, public relations, and crisis communication [8]. Social media refers to a wide range of technology tools, including blogs, microblogging services like Twitter, social networking services like Facebook and Patients Like Me, and file-and video-sharing websites like YouTube, electronic games, and wikis. Although, the advantages of social media in enhancing patient care have not yet been widely recognized, it is impossible to overlook their effects given that more than 80% of Americans look online for medical information [9]. Physicians in practice and healthcare delivery organizations must comprehend this phenomenon and how it may be utilized advantageously to engage with people considering social media's continuing rise. The types, applications, and effects of social media are beyond the scope of this article, but a quick review that covers the fundamentals of how social media are utilized in health care and elsewhere is provided. The word "social media" refers to a group of technological instruments that, as its name implies, provide chances for social interaction, networking, and dialogic communication. The four different social media kinds are shown in Table 1. The distinctions between these categories, however, have become hazier recently, particularly with the availability of the capacity to synchronize material across numerous websites [10].

Biomedical research denotes scientific inquiries aimed at advancing our comprehension of biological processes, ailments, and medical interventions to enhance human well-being. It spans a diverse array of fields, encompassing molecular biology, genetics, physiology, pharmacology, and epidemiology. Biomedical investigations can encompass fundamental laboratory investigations, clinical trials, epidemiological inquiries, and translational research aimed at connecting scientific breakthroughs with clinical applications [11–13]. The breadth and complexity of biomedical research extend across various facets of human health and illness. This encompasses investigations into normal physiological functions, mechanisms underlying disease development, identification of predisposing factors and markers, creation of diagnostic methodologies, and assessment of therapeutic strategies [14]. Biomedical exploration also encompasses scrutiny of societal, environmental, and genetic influences on health, alongside endeavors to mitigate health

Table 1. Social media platforms according to their usage and function

Type	Description	Examples
Blogs	Online publications where individuals discuss their thoughts and/or views on a range of subjects. Blogs can be private, much like an online journal, or they can be professional, featuring comments about a particular field of expertise. Viewers can leave comments on postings, and entries range in length (typically 200–1,000 words) and frequency (some bloggers publish regularly or several times per day, whilst some publish 2–3 times/week). Photos and audio/video files can be submitted as entries.	Blogger, WordPress, etc.
Microblogging and presence applications	A blog of some kind. More frequently and with significantly shorter postings. Twitter only allows posts of 140 characters or less, yet many users publish numerous times daily. Posts may be transmitted by text message or mobile phone and can contain both picture and audio/video assets.	Twitter, Tumblr, etc.
Photo/video/file sharing sites	Sites where users may exchange data, photographs, and videos. Uploads may frequently be downloaded and shared by connecting to them in the other three forms of social media, and they are accessible. A movie or picture that is linked to might have an exponentially greater audience and become “viral”.	YouTube, SlideShare, etc.
Social networking sites	Websites, where users may create online profiles, update information about themselves, images, links, and other content, and remark on the changes of people. Joining with different profiles is a crucial feature for expanding one’s social network on a website.	Facebook, LinkedIn, etc.

inequities and promote public health initiatives [15]. In essence, biomedical research assumes a pivotal role in advancing medical understanding, fostering the development of novel therapies, and ultimately enhancing patient outcomes.

Methodology

To explore the utilization of social media in biomedical research, an extensive review of the literature was undertaken. Various databases, such as PubMed, Scopus, Web of Science, and Google Scholar, were systematically queried utilizing pertinent terms such as “social media”, “biomedical research”, “healthcare”, “medicine”, “public health”, and “data analysis”. Furthermore, the reference sections of pertinent articles and reviews were meticulously examined to uncover supplementary studies.

Social networking

Nowadays, social networking has emerged as one of the most dynamic platforms for communication. Social media sites are present on websites on the Internet where millions of individuals share similar passions in particular fields. Participants of these connections can access a variety of shared files, photos, and videos, as well as develop blog posts, deliver communications, and have in-person conversations. These networks are referred to be social since they enable contact with friends and colleagues while fostering relationships among them in the online community. The most well-known social media platforms are Facebook ([Facebook.com](https://www.facebook.com)), Instagram ([Instagram.com](https://www.instagram.com)), TikTok ([TikTok.com](https://www.tiktok.com)), Twitter ([Twitter.com](https://www.twitter.com)), WhatsApp ([WhatsApp.com](https://www.whatsapp.com)), and others. Digital social media platforms like Instagram, TikTok, and Facebook have become very well-known very quickly. It has grown outmoded to use the web as a decentralized search engine to look for data or interact with people [16]. One of the most significant services provided by social networks is blogging, where users can get involved and share ideas and engage in discussion with one another. These websites and online communities provide channels for direct social and media engagement with other people. They are actively participating in decision-making at international levels in the financial, political, community, and academic spheres.

The purpose and layout of the Internet are significantly changing as a result of the growing social media phenomenon. The emergence of social networks has transformed the Internet from what we previously thought of as an archive of knowledge into a tool for bringing individuals together. The widespread use of social media platforms of all sizes and forms is a sign that human social interaction is evolving [17].

Social media in healthcare

Social media usage is rising steadily over the world, notably in situations related to healthcare. It is helpful to first describe the broad features of social media before concentrating on social media for healthcare outreach [18]. Since a lot of patients depend on social media, the healthcare sector must determine if and to what extent social media has an impact on patient care. Some experts claim that the impact is obvious. According to David Perlmutter, Ph.D., head of the School of Journalism and Mass Communication at the University of Iowa, scholar of social media and blogging, "The Internet broad and social media, in particular, are transforming the field of healthcare". On the one hand, today's medical professionals were brought up to prefer texting and iPhones for data delivery over conferences and textbooks. However, never has it been so simple for the general public to take in and act upon medical information, incorrect data, and sometimes false information [9].

The benefits of using contemporary technology for communication and information in the healthcare industry are widely known. The scientific literature has also demonstrated that social media platforms within this broad area of recent advances in healthcare grasp significant potential worth as they allow innovative methods of obtaining and exchanging knowledge, encourage social interaction, emphasize collaboration and participation of the stakeholders who are involved, boost oneself interaction, and allow users' involvement directly. But limited information is available about the motivations driving patients' and healthcare professionals (HCPs) use of social media for medical purposes, let alone about potential discrepancies between the two groups [19]. Table 2 lists several online resources and provides examples of how they might be used to promote health [20].

Table 2. Social media resources for promoting and educating on health

Serial no.	Tools	Definition/use
1	Content syndication/RSS feeds	Users may subscribe to and receive online articles, videos, and other content feeds via RSS feeds.
2	e-Games	Interactive games can be executed on a video game console, the Internet, or a mobile device.
3	Message boards	Platforms that allow users to publish comments and queries and then receive answers from other people.
4	Microblogs	Restricted-length blogs.
5	Short message service (SMS)/texting	Anyone with a mobile phone may send and receive SMS, sometimes known as texting.
6	Social networking sites: general	A tool that allows users to add friends, send messages, and share material in online groups.
7	Social networking sites: health specific	Users can exchange information and personal experiences with other people online on websites that are focused on their well-being and issues.
8	Video file sharing	To share and comment on videos, users make and submit them.
9	Weblogs (blogs)	Online diaries where one can post about any subject of curiosity, get feedback, and share content across several platforms.
10	widgets	Web apps called widgets show highlighted material from one website on a user's homepage or a different website.
11	wikis	Enabling a community of individuals to publish and generate material.

Uses

HCPs may discuss healthcare policy and practice problems, encourage healthy behaviors, communicate with the general population, and train and collaborate with individuals, carers, students, and co-workers via social media. HCPs may utilize social media to inspire people, build a professional network, become more informed of news and scientific advancements, and disseminate health information to the public [21].

Professional networking

The most well-liked social media platforms for doctors are those that allow them to engage in online societies, attend to professionals, connect with peers, and discuss patient concerns [22]. Pharmacy

professionals commonly utilize social media to communicate with one another [23]. The social media platforms that are utilized for business networking are frequently only available to those who are employed in these occupations [24]. Conversations on these forums go beyond clinical matters to cover a wide range of issues, including politics, career plans, practice management, morality, as well as relationships in a medical setting [25].

Professional education

Social media communication tools are also being utilized to enhance medical training [26]. The clinical curriculum has been modified to accommodate the shifting preferences and customs of young learners considering the increased percentage of social media activity among 18- to 29-year-olds [23]. Many research investigations have discussed the application of social media resources to improve clinical students' comprehension of ethical behavior, professionalism, and interactions. Institutions are also embracing social media to expand access to educational archives, enroll students, provide virtual office hours, and generate other interesting learning opportunities [27]. Additionally, social media is being used extensively in pharmacy curricula for undergrads [23]. According to a survey, 53% of nursing schools currently use online social networking platforms, which have an impact on nursing students' educational experiences. For instance, Twitter has been utilized to help nursing students in critical care settings improve their clinical decision-making abilities [27].

Organizational promotion

Medical centers, healthcare organizations, professional associations, drug manufacturers, patient advocacy groups, and pharmacy benefit firms are among the organizations in the healthcare industry that use social media for a variety of functions [28, 29]. Among the purposes are connecting with the general population and clients, promoting organizational visibility, marketing goods, and services, creating a forum for learning about events, promotions, and fundraising, offering a means for patient education and resources, and aiding clients [30–32].

Patient care

The use of social networking sites for personalized patient treatment has been met with resistance among HCPs, but physicians and healthcare institutions are gradually coming around to it [29]. For instance, Georgia Health Sciences University has made an application called WebView available to its patients, enabling them to contact their physician and ask about concerns or get refills on medicines [33]. Recent research has revealed that doctors are becoming more interested in communicating with their patients electronically [22]. Some doctors are improving patient communication through social media, such as Twitter and Facebook [33].

Patient education

Social media can facilitate individuals' availability of instructional materials and information about healthcare [24]. Eight out of ten Internet users in the United States (US) look for medical advice online, and 74% of them utilize social media [26, 34]. Individuals can join online groups, take an active role in the investigation, get material or emotional assistance, create objectives, and monitor their success using social media [31, 34]. Additionally, doctors are promoting patient health awareness on social media. They tweet, write blogs, produce films, and take part in disease-specific forums with a patient education focus. These forums give medical professionals a crucial chance to disseminate fact-based information in opposition to misleading data on the web [29].

Public health programs

Massive global communities that can swiftly disseminate knowledge and mobilize millions of individuals have been made possible by social media and can help public health objectives advance more rapidly [31]. As a result, social media may be a potent instrument for healthcare promotion and instruction [35]. Twitter along with other online platforms is being used for these reasons by certain national health departments. In

addition, public health organizations use location-tracking techniques in conjunction with keyword information from Twitter and various other social media platforms to swiftly react to catastrophes and track the well-being and assistance of communities. The Center for Disease Control (CDC) actively monitors “tweets” that could point to a viral breakout and shares notifications about such occurrences on Facebook and Twitter [31]. The CDC has also utilized social networking sites to track sources, possible infections, and disease outbreaks [22].

Social media now plays a crucial role in the healthcare sector and offers several advantages to both patients and HCPs. It provides a forum for patients to communicate with medical professionals, share their stories, and discover more about a range of health issues. Social media may be used by HCPs to share knowledge, connect with peers, and interact with individuals. Social media may, however, also have undesirable effects, such as the dissemination of false information and the invasion of patient confidentiality. To guarantee that social media is utilized efficiently and morally in the context of healthcare, healthcare organizations and experts need to create rules and best practices.

Social media in research

Social media platforms have completely changed how individuals communicate and engage in contemporary culture. Social media networks offer a lot of data that may be analyzed to produce insights on numerous study topics, ensuring that researchers are not left behind. Social media is gaining popularity in research because it makes it possible to gather and analyze massive amounts of data instantly [20, 36]. Social media in research offers an opportunity for data collection from a vast and diverse audience, which is one of its advantages. Millions of people from various age groups, ethnicities, and socioeconomic classes utilize social media sites like Facebook, Twitter, and Instagram [37]. Social media may be used by researchers to acquire information on a variety of subjects, such as politics, consumer behavior, and healthcare. Social media sites also offer real-time data, enabling investigators to keep track of patterns and shifts as they evolve [38, 39].

Social media is useful for research since it makes data collection more affordable. Traditional research techniques like surveys and interviews may take a lot of time and money [40, 41]. An alternate, productive, and affordable technique of data collecting is made possible by social media sites. For instance, to gather information on certain issues or themes, investigators might utilize hashtags on Twitter or Facebook groups [42]. Social media may be useful for research, but some drawbacks should be considered. Social media data could not be reflective of the general public, which is one of the drawbacks. Social media users typically have higher levels of education and younger demographics, which may not be typical of the general population. Social media statistics may also be skewed since people sometimes only share things that are favorable to them [43]. Social media has developed into a useful tool for scholars to gather information, share their results, and work together with others in the field. However, while using social media in the studies, investigators must be mindful of the restrictions and ethical issues. Researchers must adjust their methods considering the likelihood that social media will keep influencing how it is used in research [44, 45].

Academic social networking sites (ASNS) like Academia.edu and ResearchGate have recently emerged on the Internet. Users can assess interest in published papers, submit academic publications, abstracts, and links to published articles, connect with other individuals in professional forums, and ask and answer queries. The websites are a significant contribution to scientific media and are utilized by millions of people [46]. Table 3 includes social media platforms that are popular in academic and scientific communities.

Social media in science and medicine

The use of social media as a communication tool in medicine has grown significantly. Clinicians and professionals in the field of healthcare now often communicate on social media, particularly Twitter. Patients, the general public, healthcare journalists, as well as business and financial organizations, pay close attention to their interactions [47]. The capacity of social media to raise awareness of research and medical

Table 3. Social networking sites used in the field of academia and research

Network	Description
Academia.edu	Academia.edu is a website where researchers may share their study findings to promote global research.
Frontiers Research Network	For investigators, researchers, scholars, and anybody else interested in learning more about the most recent scientific advancements, there is an online social network called Frontiers Research Network.
LinkedIn	LinkedIn is a social media site that is largely utilized for professional connections and job finding.
Mendeley	Mendeley is a free referencing management and social network for academia that may assist you in planning your study, working together with others, and connecting to the most recent scientific publications.
OpenWetWare	The goal of OpenWetWare is to encourage the exchange of knowledge, skills, and insight among academics and teams engaged with biology and biological engineering.
ResearchGate	ResearchGate is a social network where scientists from different professions may communicate and work together.
ResearcherID	A system known as ResearcherID serves to monitor and handle the research output and citation data for specific scholars.
Sage Bionetworks	The goal of Sage Bionetworks is to direct the creation of an open-source forum where computational biologists may create and evaluate biological science models.
Zotero	Research materials including papers, books, websites, and various other online materials are gathered, organized, and cited using the free and open-source referencing manager program Zotero.

practices is one of the key benefits for science and medicine. Social media platforms give researchers and medical professionals a chance to publicize their work, expand their audience, and interact with the general public. According to one investigation, utilizing Twitter raised the number of citations for scientific papers by 43%, proving that social media may support scientific study and interaction [48]. Social media may also assist make medical practices more visible, enabling people to learn more about the amenities provided by medical experts.

Social media's capacity to increase public interaction is another advantage for research and medicine. Social media platforms give researchers and medical professionals the chance to share their discoveries and studies with a wider range of people. Social media may also be used by medical providers to interact with their patients and share health and wellness-related content with them. For instance, the researchers discovered that communicating with patients via social media increased their overall pleasure and engagement [49, 50]. Social media is an important tool in the fields of health and science because it helps researchers become more visible, communicate with the general population more effectively, and spread their discoveries more quickly. But it is crucial to use social media sensibly and to be mindful of the dangers it may pose.

Web-based tools to predict and track disease outbreaks

In the contemporary era of technological advancements, web-based tools have grown in favor of surveillance and epidemic prediction. These programs enable the monitoring and analysis of epidemics in real time utilizing data from a range of sources, such as social media, news articles, and public health agencies. Daily, millions of individuals globally look for health-related details on the internet, making web search queries an important source of data on general health trends [51]. Although the CDC was always crucial in tracking disease outbreaks, not only in the US but globally. Google Inc. and the CDC recently collaborated on research to see if their search engine might identify regions in which an influenza outbreak could be imminent [52, 53]. The study analyzed keyword searches conducted on the Google website using any influenza-related terms. They were able to track regions that could be experiencing an influenza outbreak using this method. In parallel research, their findings were compared with those obtained using the CDC's standard techniques to see which one could identify impacted regions more quickly and accurately. Google's algorithm won out. Google online search logs may offer one of the most effective and up-to-date disease surveillance methods available. Google's estimations were accessible every day, in contrast to standard monitoring methods employed by the CDC and government agencies, which take 1–2 weeks to collect and analyze the information [54]. Currently, Google and the CDC collaborate to develop web tools that can aid governments in monitoring outbreaks.

The H1N1 virus was tracked using Google searches in a non-seasonal flu pandemic in 2009, and a similar methodology has been used frequently for health-seeking behavior [52]. Google Trends (GT) is a brand-new tool offered by Google that analyses anonymized, pooled online search data to generate real-time projections on any form of influenza activity throughout the globe (Table 4) [53]. Google collaborates closely with professionals in the public and private healthcare sectors to enhance tools like GT, which may be used as a model for tracking infectious illnesses [54]. GT, however, is still in the early stages of its evolution and requires enhancements, to perform better in the future.

Table 4. Internet firms' general social networks and web-based technologies that have been utilized to monitor and control illnesses

Company	Tool(s)
Causes	The greatest philanthropic platform in the entire globe, particularly when it comes to diseases, is Causes. Among other compassionate uses, this social network may be a useful instrument for increasing knowledge of and funds for those affected by diseases.
Facebook	Facebook does not employ a specific method, but with approximately 3 billion users, it might be used to monitor illness and epidemic patterns identically to Google Trends. The latest launch of an organ donor status option by Facebook for its members may help with organ donation and transplantation in the medical industry.
Google	Google Trends is a program that estimates the global epidemic activity of several infectious illnesses in real-time using aggregated Google search results.
Twitter	Twitter does not utilize a specific technology, but with more than 350 million users, the website's trends and hashtags may be able to aid with the real-time detection of viral epidemics.

The Epidemic Intelligence Service (EIS) represents one of the most widely utilized web-based resources for forecasting and monitoring disease epidemics. The CDC's EIS program educates and assists public health specialists in detecting and managing epidemics of illness. Public health professionals can respond promptly and efficiently because of EIS's continuous surveillance of disease outbreaks across the world [55]. HealthMap is another well-liked online resource that was created by Boston Children's Hospital experts. To deliver continuous surveillance of illness breakouts throughout the world, HealthMap gathers data from a variety of sources, including news outlets, government health organizations, and social media [56]. Several outbreaks have been monitored by HealthMap, such as the Zika virus epidemic in 2016 and the Ebola outbreak in West Africa in 2014 [57, 58].

There are numerous additional internet-based applications for forecasting and monitoring disease outbreaks alongside these. A web-based program like the Global Public Health Intelligence Network (GPHIN), for instance, gathers and analyses data from numerous sources to enable continuous surveillance of illness outbreaks all over the world [59]. Several incidents, such as the spread of SARS in 2003 and the global pandemic of H1N1 influenza in 2009, have been monitored using GPHIN [60]. People may register their flu symptoms and follow the progress of the virus in their local areas using another application called Flu Near You. To produce live visualizations of the flu movement, the system combines the data, giving public health professionals crucial information for focusing efforts [61–63]. Web-based services are useful for forecasting and monitoring epidemics of diseases. For HCPs to react swiftly and successfully to epidemics, they offer continuous surveillance and evaluation of those epidemics. Web-based tools are expected to grow much more complex as technology develops, offering data that is more precise and frequent.

Social media and the clinical researcher: concerns and considerations

Social media has completely changed how we exchange knowledge and interact, involving the area of clinical research [64]. Social media is being used more often by clinical investigators to interact with the general population, distribute outcomes of studies, and identify research subjects [65]. Even though the possibility for utilization of social media in research has been shown, researchers have highlighted concerns about participant integrity, confidentiality, permission, and secrecy [66]. Concerns have also been raised about whether and how online networks reflect offline or real-world societies [67], particularly given that older and less advantaged people might not have broadband access or be acquainted with social

media platforms. This imbalance is known as the “digital gap” [68]. Additionally, as new social media sites continue to appear, they have a constantly shifting influence on researchers and their subjects while additionally altering how developed tools are used [69].

Recruiting participants via social media presents multifaceted challenges that extend beyond the conventional concerns. While it offers a vast pool of potential candidates, ensuring compliance with age requirements becomes a pertinent issue due to limited means for verification. Moreover, the absence of immediate guidance or a designated individual to address queries arising from the consent form may leave participants feeling uninformed or uncertain. Compounding these challenges is the tendency for online forms to be glossed over hastily, potentially leading to overlooked details or misunderstandings. Addressing these nuanced issues requires a thoughtful approach that balances the convenience of digital recruitment with the necessity for thorough participant engagement and comprehension [70].

The possibility of prejudice and misleading data is one of the key worries. The reliability of clinical research may be harmed by the spread of misleading information and unconfirmed findings on social networking sites [71, 72]. The study perspective may also be distorted by social media algorithms that favor sensational or information that is contentious [73]. Therefore, clinical investigators should exercise caution when using social media and make sure that their posts are factual and supported by data.

The secrecy and privacy of research participants is further issues. There is a chance of unintentional exposure of private data on social networking sites, which are not intended to safeguard private medical data [74, 75]. Clinical investigators must be aware of their responsibilities to safeguard study participants’ security and anonymity and take the necessary precautions to reduce the likelihood of data being compromised [76]. The implementation of social networking sites in clinical research also carries the possibility of conflicts of interest [77]. Clinical scientists’ social media messaging may be influenced by their monetary or other connections to business or advocacy organizations. Investigators must be open about their conflicts of interest and make sure that no outside influences are unfairly influencing their communication. Despite these reservations, clinical investigators can use social media as a potent tool to interact with individuals as well as the general public. Clinical researchers may promote confidence and cooperation among patients by interacting with them on social media and sharing their study conclusions, which will eventually improve the health of patients.

Social media platforms for public health responses before and during the COVID-19 pandemic

Public health responses to the coronavirus disease 2019 (COVID-19) epidemic have benefited greatly from the use of social media. Public health organizations have utilized social media channels to provide information, enlighten the public, and address worries and inquiries [78]. Since the discovery of COVID-19, the public has been subjected to an unmatched amount of scientific (and non-scientific) messaging, which has left many people perplexed about the actions required to lower personal risk and contain the pandemic at the community level. This condition has been dubbed an infodemic by the World Health Organization (WHO), which defines it as “an excess of knowledge—good or bad—that renders it challenging for individuals to make choices for their wellbeing”. A surplus of knowledge may make people confused, encourage risky behavior, and erode public confidence in science. Social media sites like Facebook, Twitter, and Instagram, which enable the quick transmission of knowledge without reviewing its accuracy, are partially to blame for this infodemic. Social media makes it easy for false data to proliferate fast, displacing information with a scientific basis. Disinformation is a message that is explicitly intended to hide the truth, whereas misinformation is erroneous information that is offered as reality, despite the purpose of the deception [79, 80].

Before the global epidemic, public health organizations used social networking sites like Twitter and Facebook to share knowledge and interact with people throughout epidemics of infections. HCPs used social media much more during the COVID-19 pandemic [81]. Live coverage of news talks, press events, and town hall discussions has helped worldwide and local news channels raise the public’s consciousness and

reduce concern amid the virus's emergence. On internet pages, in journals, in magazines, and on social networking sites like Facebook, Instagram, and Twitter, health professionals and many others have shared and discussed health recommendations and official directives [82]. Health-related organizations have made substantial use of Facebook in addition to Twitter to notify the public about available tools and services during the COVID-19 epidemic [83]. For instance, the US CDC has utilized Facebook to issue educational materials, answer queries from readers, and offer updates on the COVID-19 epidemic [84, 85]. Healthcare organizations have found that Twitter especially has been a useful tool for sharing information and responding to questions and worries from the general public. For instance, the WHO has utilized Twitter to respond to inquiries from citizens, dispel rumors, and offer updated information on the COVID-19 outbreak [86–88].

However, there are difficulties and restrictions associated with using social media platforms for public health responses. One issue is the possibility of misleading material circulating on social media sites and causing disinformation. Misinformation and conspiracy theories have been widely disseminated during the COVID-19 epidemic, which might jeopardize efforts by the government to limit the worldwide outbreak [84, 88]. A further limitation is the likelihood that social media sites fuel public worry and terror. Public health organizations must be cautious to offer correct information without raising unwarranted anxiety due to the continual flow of information and updates on social networking sites [79].

Conclusions

Social media has emerged as a transformative tool in healthcare, fostering a dynamic platform where individuals, medical professionals, and the general public can engage in discussions about various health-related topics. This interconnectedness offers unprecedented opportunities for knowledge sharing, support networks, and awareness campaigns, ultimately contributing to enhanced health outcomes. Patients can access valuable information, seek advice from peers or professionals, and participate in online communities tailored to specific health conditions. Medical professionals utilize social media to disseminate accurate health information, engage in professional development, and collaborate with peers globally. Furthermore, the general public benefits from increased health literacy and awareness, leading to more informed healthcare decisions and proactive preventive measures. By facilitating open dialogue and collaboration, social media serves as a catalyst for empowering individuals and promoting collective efforts towards better health outcomes. It encourages user involvement and is an effective tool for continual education and social engagement.

To sum up, social media has been extremely important for biological research and the effort to combat the COVID-19 epidemic. Collaboration, information sharing, and interaction with the general public, medical experts, and policymakers have all been aided by it. Social media sites have been crucial for monitoring the virus's progress, encouraging vaccination, and combating disinformation. Social media has also made it possible for investigators to communicate with individuals and trial subjects, hastening the creation of efficient drugs and vaccinations.

As we continue to harness the power of social networking sites for advancing public health and scientific research objectives, it is imperative to maintain a balanced approach that acknowledges both the benefits and potential hazards associated with these platforms. While social media offers unparalleled opportunities for disseminating health information, engaging diverse communities, and facilitating research collaborations, it also presents ethical challenges and risks that must be addressed proactively. Issues such as privacy concerns, data security, misinformation dissemination, and potential biases in participant recruitment are among the ethical considerations that require careful attention. Additionally, the rapid spread of false or misleading information on social media platforms can undermine public trust and pose significant public health risks. Therefore, it is essential for researchers, HCPs, and policymakers to implement robust safeguards, ethical guidelines, and transparency measures to mitigate these risks while maximizing the potential benefits of social networking sites for public health and scientific research endeavors. All things considered, social media has shown to be an effective weapon in the war against COVID-19 and has an opportunity to make major advances in scientific study in the years ahead.

Abbreviations

CDC: Center for Disease Control

COVID-19: coronavirus disease 2019

EIS: Epidemic Intelligence Service

GPHIN: Global Public Health Intelligence Network

GT: Google Trends

HCPs: healthcare professionals

ICTs: information and communication technologies

US: United States

WHO: World Health Organization

Declarations

Author contributions

MSH: Data curation, Investigation, Methodology, Project administration, Resources, Software, Writing—original draft, Writing—review & editing. DT: Conceptualization, Formal analysis, Methodology, Supervision, Validation, Visualization, Writing—review & editing.

Conflicts of interest

Author D.T. is Editorial Board member of *Exploration of Digital Health Technologies*, but he had no involvement in the peer-review of this article and had no access to information regarding its peer-review. The other author declares that he has no conflicts of interest.

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