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To cite this article: Francesco Branda, Massimo Ciccozzi & Fabio Scarpa (15 Apr 2025): Managing epidemics in the digital age: the crucial role of social media in information dissemination, Pathogens and Global Health, DOI: [10.1080/20477724.2025.2493854](https://doi.org/10.1080/20477724.2025.2493854)

To link to this article: <https://doi.org/10.1080/20477724.2025.2493854>



Published online: 15 Apr 2025.



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Managing epidemics in the digital age: the crucial role of social media in information dissemination

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KEYWORDS Epidemiology; data analysis; databases; infectious diseases; public health

The 21st century has seen an increase in the frequency and global impact of epidemics, necessitating innovative approaches to public health communication. The interconnectedness of the world, coupled with rapid urbanization and ecological changes, has facilitated the emergence and spread of infectious diseases, posing significant threats to global health security. In this context, social media platforms have the remarkable ability to disseminate information with exceptional speed and across vast geographic distances, often surpassing conventional media channels [1]. Platforms such as Facebook, Twitter (now X), Instagram and WhatsApp boast billions of users worldwide, offering unprecedented reach for public health messaging. Updates can occur in real-time, enabling immediate communication of critical information as soon as it becomes available. For example, during the COVID-19 pandemic, social media facilitated the rapid distribution of information from the onset of the crisis in Wuhan, China, demonstrating their ability to convey the progression of the pandemic across multiple nations [2]. This speed and reach can significantly accelerate public awareness of an epidemic and recommended responses. Sharing scientific articles on platforms such as Facebook and Twitter can lead to increased downloads, queries, and citations, facilitating the rapid dissemination of knowledge, which was particularly advantageous during the COVID-19 pandemic because of reduced editorial time [3]. Social media also enable collaborative research projects, surveys, and multicentre studies. They also support continuing medical education through live and recorded online webinars via platforms such as YouTube, Skype, or Zoom [4]. Social media also help the public maintain communication with friends and family, reducing the isolation associated with quarantine, which can have a positive impact on mental health. Finally, they enable the rapid sharing of treatment protocols, information on personal protective equipment, and proposals for resource allocation at various levels, allowing centers with fewer resources to quickly implement or adapt protocols [5].

Unlike many traditional news sources and academic journals that require a subscription, social media are often free and easily accessible to those with an Internet connection [6]. This accessibility is especially crucial during health crises, when timely information is critical. In addition, health information can be presented in various accessible formats on social media, such as visually appealing infographics, making complex topics more understandable to the general public than dense scientific articles [7]. This democratizes access to health information, potentially reaching disadvantaged populations who may not interact with traditional media. The low barrier to entry, both in terms of cost and ease of use, can help bridge the information gap, especially among young people and those in resource-limited settings [8]. In addition, social media offer an inexpensive and effective means for public health organizations to disseminate essential health communication messages, a particularly significant advantage for nonprofits or campaigns with limited financial resources [9].

While offering numerous advantages, social media also presents significant challenges, most notably the rapid and widespread dissemination of false or misleading information, often referred to as an 'infodemic'. False news tends to spread significantly faster on social media compared to real news, largely due to its novelty factor [10]. This misinformation can lead to incorrect interpretations of health information, increased hesitancy toward vaccinations, delays in seeking appropriate healthcare, and even significant mental distress among the public [11]. Political messaging and the inherent biases of individual users can further contribute to the propagation of inaccurate information. User-generated content on social media often carries a strong emotional undertone, which can inadvertently or intentionally amplify the spread of misinformation and unfounded conspiracy theories [12]. A decline in public trust in traditional institutions and established public health figures can also exacerbate this issue, creating fertile ground for misinformation to take root and spread [13]. The COVID-19 pandemic starkly highlighted the profound dangers that health

misinformation on social media can pose to public health efforts [13]. Social media algorithms, while designed to increase engagement, can sometimes inadvertently amplify popular but potentially inaccurate information, further complicating the landscape [14]. The absence of a rigorous review process on social media platforms, unlike the peer-review system in academic publishing, contributes to the ease with which inaccurate health information can be conveyed as truth. Moreover, automated web-based accounts, known as social bots, have also been identified as contributors to the spread of misinformation during health crises [15]. The very characteristics that make social media a powerful tool for rapid and extensive communication also render it a potent vehicle for the swift and widespread dissemination of harmful misinformation, thereby undermining critical public health initiatives. The absence of stringent editorial oversight and the tendency for sensational or novel content to gain traction quickly create a challenging environment for ensuring the accuracy of public health information. The emotional nature often inherent in user-generated content can further amplify the reach and impact of misinformation.

The utilization of social media for public health communication also raises significant concerns regarding patient privacy and the security of personal data. Sharing personal health information on public platforms carries inherent risks of potential identification and subsequent disclosure [16]. Regulations such as the Health Insurance Portability and Accountability Act (HIPAA) strictly limit the sharing of Protected Health Information (PHI) without obtaining explicit authorization from the individual concerned [17]. Public health organizations must therefore exercise extreme caution and diligently navigate privacy regulations and ethical considerations when employing social media for health-

related communication. This ensures that they do not inadvertently disclose sensitive personal information, which could have serious repercussions for individuals and undermine public trust in health authorities. Maintaining patient confidentiality and data security is paramount in the healthcare domain, and the use of social media must strictly adhere to these principles to avoid potential legal and ethical breaches.

Learning from the past: successful and unsuccessful uses of social media in epidemic outbreaks

Social media data, along with internet search trends, has demonstrated its utility in monitoring and forecasting disease outbreaks, including those of Zika, dengue, Middle East Respiratory Syndrome (MERS), and Ebola viruses [18]. Various tools and Application Programming Interfaces (APIs), such as Tweepy [19] in Python, are available to researchers and public health entities, providing the means to access and analyze data obtained from platforms like Twitter for disease surveillance purposes, as seen in the case of dengue fever monitoring in Brazil using Twitter data [20]. Social listening techniques can also help in identifying emerging health concerns and potential outbreaks at an early stage, even before official reports are released [21]. This capability to provide real-time data significantly enhances disease surveillance and the early detection of outbreaks, acting as a valuable supplement to conventional methods. Analyzing public conversations and search patterns can offer early indicators of disease spread and public health concerns, allowing for more proactive and timely interventions.

As summarized in Table 1, each epidemic demonstrated both the potential and the limitations of social

Table 1. Summary of social media use during past epidemics.

Epidemic	Key successful uses	Key unsuccessful uses	Key insights
H1N1 (2009)	Initial outbreak notification, knowledge translation ("H1N1" vs. "swine flu"), resource sharing, official sources predominated, CDC/DHHS risk communication.	4.5% misinformation, skepticism over vaccine economic benefits (undermined trust).	Potential for rapid initial sharing and knowledge translation, but early challenges in managing misinformation and public trust.
Ebola (2014–2016)	Role in Nigeria's control efforts (anecdotal), documented disease spread, web source for surveillance, CDC message dissemination, clarified misconceptions.	Rumors of cures/prevention, high percentage of misinformation, amplified fear/anxiety (disproportionately in US), exaggerated media reporting.	Potential for rapid sharing but high risk of amplified fear/misinformation, especially with limited digital access in affected areas. Need for targeted, culturally sensitive communication.
Zika (2015–2016)	Forecasted cases (data analysis), association with Dengue cases (early detection potential), disseminated information to young women, CDC activity correlated with case counts, strategic communication by Singapore health agencies, toolkits for information sharing.	Discrepancy between public concern and CDC response on Twitter, highest misleading results on YouTube.	Utility for surveillance and targeted dissemination but challenges in aligning public concerns with official messaging and persistent misinformation on some platforms.
COVID-19 (2020–Present)	Rapid information distribution, dedicated platform sections, government daily updates, protocol/infographic sharing, reduced isolation, facilitated research/webinars, search trends correlated with incidence.	Unprecedented misinformation/disinformation, misuse of public health terms, flawed studies amplified, harmful self-medication, amplified fear/anxiety/mistrust, platform policies not always effective.	Indispensable for dissemination and engagement but exposes profound challenges of widespread misinformation with negative health consequences. Urgent need for effective strategies.

media in public health responses. While the rapid dissemination of information was a key success factor in all cases, the spread of misinformation, amplified fear, and public distrust were significant challenges. In the case of the 2009 H1N1 pandemic, for example, Twitter contributed to the rapid dissemination of information about the risks and facilitated the evolution of the term 'H1N1' replacing 'swine flu' with a more scientific designation [22]. Government agencies such as the CDC leveraged Facebook and Twitter to spread messages about the risk of infection and the importance of vaccination, reaching a wide audience and raising awareness [23]. During the Ebola outbreak (2014–2016), social media were used positively to document the progress of the epidemic in real-time and to inform the public about the risks associated with the disease. In Nigeria, Twitter played a key role in attempts to control the spread of the epidemic [24]. The platforms have also helped correct misinformation regarding the transmission of the virus and strengthen communication by health agencies [25]. During the Zika outbreak (2015–2016), social media were successfully used to monitor the spread of the disease, with analysis of Google search trends and tweets helping to predict the occurrence of new cases [18]. The platforms have also been useful tools for disseminating evidence-based information, particularly to raise awareness among pregnant women about the risks associated with the virus [26]. In countries such as Singapore, social media have also been strategically used to promote prevention behaviors [27]. The COVID-19 pandemic saw even greater use of social media, which became an essential channel for dissemination of updates and guidelines, not only by health authorities, but also as a hub for sharing scientific research [28]. Platforms have played a key role in maintaining contact between people during periods of isolation and fostering international communication between researchers and institutions [29]. In addition, Internet search trends have shown a strong correlation with the incidence of COVID-19 cases, suggesting how people have increasingly turned to the Internet to seek health information [28].

However, despite the undoubted advantages of using social media during health emergencies, there are also negative aspects to consider. During the H1N1 pandemic, for example, a significant percentage of tweets contained misinformation, with the risk of creating confusion among the public [23]. Similarly, the Ebola outbreak highlighted how social media can amplify fear and misinformation, with unsubstantiated rumors suggesting unscientific remedies to prevent or treat Ebola, contributing to greater confusion. Fear and anxiety spread through social media increased panic, especially in countries that were not directly affected by the disease [30]. During the Zika outbreak, platforms such as YouTube

have been particularly problematic, with a significant amount of misleading information further confusing the public. One study critically evaluated 101 Zika virus-related YouTube videos available during the pandemic, categorizing them as informative, misleading, or based on personal experiences. The results showed that 70.3% of the videos were informative, while 23.8% were misleading and 5.9% were about personal experiences. Despite their superior quality, informative videos were viewed, liked and shared less frequently than misleading ones, highlighting the challenge of countering the spread of misinformation on digital platforms [31]. The COVID-19 pandemic showed the intensification of these problems, with the proliferation of misinformation contributing to the spread of conspiracy theories and harmful behaviors, such as the use of unsubstantiated treatments like ivermectin [32]. Despite attempts to regulate content and counter misinformation, platforms such as Facebook have struggled to stop the circulation of false content, which has fueled distrust in health care institutions and public interventions [14]. These examples highlight how, while social media can be powerful tools for emergency management, their uncontrolled use can generate serious risks, especially related to misinformation and poor management of public messages. In addition, investment in a strategic communication capabilities is now an indispensable element of global health preparedness in an increasingly interconnected world where epidemics spread along with the information (and misinformation) that accompanies them. The comprehensive framework provided in Table 2 serves as an essential map for public health organizations, social media platforms, and policymakers to effectively navigate this complex landscape.

GABIE: the new hub for advancing global epidemic monitoring

Our research group has actively contributed to improving the timeliness and accessibility of information during emerging outbreaks, including Ebola [33], avian influenza [34], Mpox [35], and COVID-19 [36]. The choice to focus on X stems from its historical role as a rapid and concise channel for epidemic alerts, widely used by public health authorities and experts worldwide. For instance, during the Ebola outbreak in Uganda, the Ministry of Health (@MinofHealthUG) used X to issue official bulletins and updates, ensuring that critical information reached a global audience. Similarly, in the case of the Chandipura virus, reports from local journalist @BrendanDabhi provided valuable insights, while for the Marburg virus, statements from Rwanda's Minister of Health (@RwandaHealth) helped track the evolving situation. While other platforms such as TikTok or WeChat play an important role

Table 2. Strategies to combat online health misinformation.

	For public health organizations	For social media platforms	For policymakers
Recommendations	• Develop comprehensive and adaptable social media communication strategies that are aligned with overall public health goals and are regularly reviewed and updated. • Invest in training programs for public health staff to enhance their skills in digital communication, social media management, and the identification and debunking of misinformation. • Prioritize the creation of engaging, accessible, and multilingual content that is tailored to the specific needs and cultural contexts of diverse target audiences. • Actively monitor social media platforms for public sentiment, emerging health concerns, and the spread of rumors and misinformation, utilizing social listening tools and techniques. • Build and strengthen partnerships with trusted community leaders, healthcare professionals, and relevant organizations to amplify accurate health messages and enhance credibility within communities. • Integrate social media communication efforts with traditional public health communication channels, such as websites, press releases, and collaborations with traditional media outlets, to ensure a comprehensive and coordinated approach. • Establish clear protocols and workflows for promptly addressing and debunking misinformation circulating on social media, utilizing evidence-based information and working with fact-checking organizations where appropriate. • Continuously evaluate the effectiveness of social media communication efforts using data analytics to track reach, engagement, and impact on public knowledge and behavior, making adjustments to strategies as needed. • Adhere strictly to ethical guidelines and legal regulations regarding patient privacy, data security, and the responsible use of digital communication technologies. • Develop strategies to ensure equitable access to health information for all population segments, recognizing and addressing the digital divide through the use of multiple communication channels.	• Continuously strengthen policies against health misinformation, ensuring that these policies are clearly defined, consistently enforced, and adapted to address emerging threats and deceptive tactics. • Enhance collaboration with public health organizations and health authorities to facilitate the rapid identification, flagging, and removal of harmful and inaccurate health-related content. • Invest in and further develop fact-checking mechanisms, expanding their capacity to review content in multiple languages and across diverse cultural contexts, and ensure transparency in the fact-checking process. • Explore and implement architectural changes and platform features that can limit the spread of misinformation, such as reducing the visibility of unverified claims and promoting authoritative sources, while respecting principles of freedom of expression. • Increase transparency regarding content moderation policies, their enforcement processes, and the criteria used for identifying and addressing misinformation, providing clear information to users about these processes. • Provide users with readily accessible tools and resources to easily identify, report, and understand the context of potentially misleading or false information they encounter on the platform.	• Support and fund research initiatives aimed at better understanding the impact of social media on public health during epidemics and identifying effective communication strategies for the digital age. • Develop clear guidelines and potentially regulations for the responsible and ethical use of social media in public health communication, ensuring accountability and promoting the dissemination of accurate information. • Promote digital literacy and critical thinking skills among the public through educational initiatives, empowering individuals to evaluate online health information and discern credible sources from misinformation. • Facilitate and support ongoing collaboration and information sharing between public health agencies, social media platforms, and relevant research institutions to foster a coordinated response to health crises in the digital environment. • Invest in infrastructure and programs aimed at improving digital access and reducing health inequities related to technology, ensuring that all members of society can access vital health information online.

in social interactions, they are not historically known as primary channels for public health alerts and crisis communication. X remains the preferred platform for identifying early warnings of emerging diseases at a global level.

To improve data accessibility and facilitate real-time monitoring of several infectious diseases, we developed GABIE (<https://gabie-r.web.app/>), a centralized platform designed to follow the evolution of emerging outbreaks. A major challenge in this process is standardizing the data, as sources vary in format, classification

criteria, and level of detail. Official reports, scientific publications, and real-time updates from social media or local news may present inconsistencies in case definitions, reporting structures, and terminologies. Ensuring consistency and comparability across these heterogeneous sources requires rigorous validation and harmonization, often necessitating manual refinement to align epidemiological indicators and improve data reliability for analysis and response planning. To address these challenges, data collection is primarily based on automated scraping techniques, complemented by the use

of ad hoc data dictionaries [37] that we developed to structure a wide range of epidemiological indicators. These include the number of cases and deaths, key dates such as disease onset, hospitalization, and confirmation, as well as geographic distribution and demographic information about the age and sex of cases. However, processing epidemiological bulletins in PDF format introduces additional complexities, as essential information is often embedded within unstructured text rather than organized in standardized tables. In these cases, manual intervention remains critical to ensure both completeness and accuracy. This step is necessary to effectively retrieve, interpret, and integrate vital epidemiological data, preserving its value for meaningful analysis [38,39].

A key aspect of our work is transparency and scientific dissemination. Through careful cross-checking of data we identify inconsistencies and refute false claims, valuing only verified and reliable sources that result in peer-reviewed scientific publications freely available to the public [40,41,42]. This ensures that the findings are verifiable and reproducible, providing both the scientific community and the general public with concrete tools to counter misinformation and improve situational awareness during health crises. In addition, our efforts go beyond simply correcting false narratives – we work to proactively enhance public understanding by providing clear, evidence-based explanations of epidemic dynamics. This includes educational outreach, data visualization, and direct engagement with policymakers and health authorities to ensure that reliable information reaches the right audiences at the right time. Ultimately, our goal is to provide science-based, authoritative content that not only informs but also fosters public trust in official health recommendations. By strengthening the link between scientific research, public health communication, and digital monitoring, we help communities stay prepared to address outbreaks in an informed and effective manner.

Conclusions

Social media have become an indispensable tool in outbreak management, revolutionizing the way information is disseminated during health crises. Their real-time communication capabilities and wide reach have transformed public health responses, enabling the rapid sharing of scientific updates, health guidelines and collaborative research efforts during outbreaks such as COVID-19, Ebola and Zika. However, the power of social media comes with significant challenges, particularly the rapid spread of misinformation, which can undermine public health efforts and erode public trust. The COVID-19 pandemic highlighted how quickly false information can spread, leading to vaccine hesitation, unproven treatments, and unwarranted panic. Addressing these challenges requires

coordinated efforts among health organizations, social media platforms, and policy makers to promote accurate information and counter misinformation. Looking ahead, effective use of social media in epidemic management will depend on promoting digital literacy, adhering to ethical practices in data management, and developing innovative strategies to maintain public trust. As the digital landscape evolves, social media will continue to play a crucial role in global health emergency preparedness. Lessons learned from past epidemics underscore the need for evidence-based communication strategies that leverage the benefits of social media while mitigating its risks. Through collaboration and innovation, we can harness the power of these platforms to build more resilient health systems in the face of future challenges.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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Authors' contribution

Francesco Branda: Conceptualization, Investigation, Visualization, Writing – Original Draft, Writing – Review & Editing. **Massimo Ciccozzi:** Validation, Supervision, Writing – Original Draft, Writing – Review & Editing. **Fabio Scarpa:** Investigation, Writing – Original Draft, Writing – Review & Editing.

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