Analyzing the Use of Social Media Data to Understand Long-Term Crisis Management Challenges of COVID-19

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Abstract

In the past three years, social media has had a significant impact on our lives, including crisis management. The COVID-19 pandemic highlighted the importance of accurate information and exposed the spread of false information. This paper specifically examines the COVID-19 crisis and analyzes relevant literature to provide insights for national authorities and organizations. Utilizing social media data for crisis management poses challenges due to its unstructured nature. To overcome this, the paper proposes a comprehensive method that addresses all aspects of long-term crisis management. This method relies on labeled and structured information for accurate sentiment analysis and classification. An automated approach is presented to annotate and classify tweet texts, reducing manual labeling and improving classifier accuracy. The framework involves generating topics using Latent Dirichlet Allocation (LDA) and ranking them with a new algorithm for data annotation. The labeled text is transformed into feature representation using Bert embeddings, which can be utilized in deep learning models for categorizing textual data. The primary aim of this paper is to offer valuable insights and resources to researchers studying crisis management through social media literature, with a specific focus on high-accuracy sentiment analysis.

Keywords: COVID-19 pandemic; Social Medias; Long-Lasting Crisis Management.

1. Introduction

Long-term crisis management involves addressing ongoing challenges and impacts after the initial crisis has happened. Social media plays a crucial role in this problem by enabling rapid dissemination of information, real-time communication, and addressing concerns and misinformation[1, 2] They can be utilized to provide updates on the vaccination process, share success stories, address concerns, and offer supports. It is a vital tool for organizations, health authorities, and governments to engage with the public, manage expectations, and ensures accurate information is widely available. Ultimately building trust and confidence in the vaccination process and pandemic response efforts [3].

Crisis management pertains to how an organization or government manages an emergency [4, 5], and it is commonly structured into four stages: minimise damage, get ready (before a crisis happens), react, and get back on your feet [4, 5].Preventing a catastrophe and reducing identified socioeconomic flaws in systems are the objectives of the remediation step. Being well-prepared means having the resources that first officers and crisis controllers need to do their jobs well. [6]. During the response phase, responders strive to limit additional harm from ongoing issues, whereas the recovery phase centres on reinstating the state preceding the crisis [6].

Social Media is increasingly being utilized within the domain of crisis response in particular [7, 8]. It has grown an integral part of crisis communication, enabling the instantaneous transmission of vital information [9, 11]. To better manage crises, emergency services are beginning to see the use of social media as an exchange transmit

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[12, 13]. During times of crisis, people often turn to their social networks for help with things like information collection, alertness to circumstances, relationship maintenance, emotional support, volunteer coordination, distributing relevant details, and counsel and direction [14-22]. During the flood catastrophe, for instance, social media was very influential.in Queensland in 2011 [23].

In this research, social media is defined as a socially and technological that helps save people's lives and possessions during disasters by providing real-time information about the circumstances at hand [24, 25]. Situational awareness is described as the awareness of unfolding events and the comprehension of the significance of potentially relevant information in the present and future[26, 27]. An important element of situational awareness involves crisis managers gathering data from numerous sources [28, 29].

One area where social media has proven useful in crisis management is during the COVID-19 pandemic. Quick information may be shared, questions can be answered, and false information can be countered. The COVID-19 vaccine notification relies heavily on social media for information dissemination, problem resolution, and consumer expectation control [30, 31]. Officials in the public and private sectors can utilize social media to control the flow of information, respond to questions, and regulate public opinion. Organizations must comprehend the significance of social media in crisis management and establish strategies to leverage these channels in the post-vaccination period of a pandemic [32, 33]. It is critical to examine how methods for managing crises might incorporate social media after discussing the role of these platforms in crisis interaction. Using social media as an example, this review post will quickly go over the three stages of crisis management. Rethinking decision-making to include data from social media examination is necessary when incorporating social media into emergency preparedness protocols, as previously stated. In addition, businesses can use social media technologies for crowdsourcing, which involves collecting new ideas and opinions from internet users in order to better manage a problem. By incorporating and refining social media tools, numerous federal agencies and international organisations have improved their crisis management methods. In the event of a national emergency, for example, the Dutch government notifies its population through a dedicated website, crisis.nl. One of the map-based apps that crisis managers use to examine the crisis's spatial and temporal progression while filtering data gathered from people is SensePlace2.[34-38].

The importance of social media in crisis communication strategies and how to use these tools successfully during crisis management were emphasised in this part of our article. This in-depth analysis will revolve around a prominent case study, the COVID-19 pandemic, which is seen as distinct by numerous academics because of the extensive utilisation of social media by individuals, groups, and government agencies. To assess the perspectives of individuals engaged and summarise important results, the study will undertake an extensive literature analysis of relevant materials. To help national authorities and organisations deal with the COVID-19 situation and its long-term effects, an investigation is being conducted. We will start by comparing how the COVID-19 crisis was handled with prior health emergencies and how social media was used at those times. The next section will analyse the case study by looking at related studies and identifying the most effective methods.

2. Related Work

2.1. The effect of emergency situation on social media

Crisis managers must devise methods to incorporate social media into their plans, making use of these tools in all three phases of crisis management [39]. In the time leading up to a possible catastrophe, the public is educated and prepared through the dissemination of educational content and messages through social media platforms. The efficiency of sharing information greatly depends on the accessibility of social media, making the first phase vital for preventive and decreasing the impact when the crisis happens [40]. It is also possible to use social media in the pre-crisis phase to spot developing problems and early warning signals of a crisis [41]. Government bodies and organisations can keep tabs on online issues and potential crises by using analytical tools and social media monitoring on a regular basis. Social media tools can help identify urgent situations by analysing remarks and online feelings, so crisis managers can prioritise and prevent the escalation of emergent issues. But just in case stopping the crisis from happening isn't possible, the crisis management group should be ready. Social media platforms can be utilised to create a crisis simulation during staff training and crisis planning. This way, the team's efficiency can be evaluated along with the public's and stakeholders' reactions. To respond effectively to the quickly developing crisis, the preparedness phase is of the utmost importance. Consequently, all potential outcomes should be addressed and protocols laid forth in the pre-crisis strategy. [41].

During a crisis, managers are taking advantage of social media to quickly gather important information across numerous web sources and get a better picture of the situation. This helps with resolving issues and making decisions. [42]. In addition, the online evolution of the problem and the sentiments of the public, individuals engaged, and stakeholders are gauged through the utilisation of social media platforms. Thus, crisis management teams must include public relations experts and social media managers to coordinate the selection of the best

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communication plan, which should be uniform across both traditional and social media platforms [43]. The message that organisations seek to express should guide their choice of platform. Even though there is a length restriction on tweets, platforms like LinkedIn, Facebook, and Twitter are ideal for sending brief, targeted messages to many people at once. Official and formal messages are best communicated by organisations through their websites or more conventional forms of media. As a result, organisations will have to manage a recovery period that is either shorter or longer, depending on how quickly a crisis is resolved. Analysing public's reaction to the company's response and gathering participant comments on crisis management are key steps in evaluating the organization's online reputation management during the crisis in the post-crisis phase [44, 45]. Furthermore, in order to start learning, the crisis management team should evaluate how well social media mitigated the issue. Social media technologies, like the traditional processes in the crisis management plan, can provide useful insights that can be incorporated into future plans. During the recovery period, social media is still a vital tool for keeping in touch with everyone and assuring them that the organisation is back to normal. Although social media has been an invaluable resource for crisis management, it is important to remember that it is not a panacea [45]. The ever-changing nature of social media platforms and the myriad ways in which people engage with them means that there are still unanswered questions about this kind of crisis communication that necessitate additional study.

Table 1. Features of literature review of the effect of emergency on social media

Features	Description of features
F1	Importance of social media in crisis management strategies.
F2	Utilization of social media in all three stages of crisis management.
F3	Role of social media in the pre-crisis phase for distributing information and preparing the public.
F4	Use of social media for identifying early signs of a crisis and detecting emerging issues.
F5	Simulation of crisis through social media for personnel training and crisis planning.
F6	Utilization of social media in the response phase to streamline problem-solving and decision-making processes.
F7	Assessment of social media's role in managing online reputation and lessening the impact of a crisis in the post-crisis phase.
F8	Recognition of challenges and issues associated with using social media for crisis communication, necessitating further research due to the evolving nature of social media technology.

- **Conclusion of features of F1 to F8 and research gaps (Table 1)**

Throughout the entire crisis management process, the extensive role of social media is apparent. When it comes to spreading information and getting people ready for possible disasters, social media is indispensable in the pre-crisis period. It is also utilized for identifying early signs of a crisis and detecting emerging issues, as well as simulating crisis scenarios for personnel training and crisis planning. During the response phase, social media is leveraged to streamline problem-solving and decision-making processes. In the post-crisis phase, the assessment of social media's role is focused on managing online reputation and lessening the impact of a crisis. However, challenges and issues associated with using social media for crisis communication are recognized, necessitating further research due to the evolving nature of social media technology.

2.2. Public health crisis and social media

While this research does focus on the COVID-19 example, there is an extensive amount of public health emergencies that made good use of social media for crisis communication in the literature. Similar to earlier worldwide pandemic crises, but with a wider reach and more powerful effects [46]. Crisis management and social media have thus been the subjects of substantial academic analysis of past health catastrophes. Because of the unique characteristics of public health emergencies, such as their elevated effect and inherent unpredictability, it is essential to examine crisis communication strategies in such situations [47]. Specifically, the goal of crisis communication is to safeguard citizens against infection and stop the illness from spreading. To equip people to evaluate their own risk and take appropriate measures, national authorities must provide information regarding the disease to the public. During a public health emergency, there is a risk of confusion and noncompliance with expert recommendations due to a lack of accurate and comprehensive information. The public has more faith in institutions because they believe information from government agencies to be

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trustworthy and true. As social media has grown in popularity, crisis management teams have begun to use it more and more in their outreach efforts [47]. A few organisations have set up a two-way communication channel with the public in response to the public's greater use of social media amid public health crises. Social media allows people to stay informed about what's happening and make connections with others going through the same thing, whereas online platforms help crisis management share details and limit the harm. More individuals can learn about the situation and help with the response thanks to social media.

In this context, assistance is provided in two ways: practical guidance derived from official and trustworthy information on managing the health crisis, and emotional support through connecting with others and sharing similar experiences[48]. The development of online communities to address health concerns during and after pandemics has been made possible by these platforms. A growing number of medical social media accounts, maintained by patients, family members, or other healthcare providers, post regularly about health and medicine [49]. Even though this feature of social media facilitates communication and disease awareness, it also poses the threat of false or inaccurate information reaching a larger audience. This is by no means an exhaustive list of all the potential social media features for crisis communication. When thinking about how to handle the COVID-19 pandemic, it is helpful to look at how institutions handled similar crises in the past. Studies examining health emergencies have shown how important it is to monitor public health by analysing social media. To avoid the spread of an imminent disease, organisations can use monitoring methods to detect its early warning indications. Crisis managers can benefit from public health alerts disseminated through social media and other new technology. Institutions may examine social media for disease-related terms and content using alerting systems and analytic tools. Then, they can analyse the data to find crucial data for crisis management.[50].

This method is especially helpful in times of global health crises since it analyses content in several languages, which allows it to transcend national boundaries. Institutions and organisations conduct monitoring on a continuous basis, and social media espionage is only one component of it. To comprehend the feelings of those impacted, find out what information is needed for operational crisis management, and spot early warning indications of a crisis, social media content is continuously watched [51]. Within this paradigm, specialists employ "epidemic intelligence" to scour social media for data and augment conventional surveillance systems with web-based tools that keep an eye on online mediums for new problems. In addition, digital epidemiology allows national authorities to evaluate the health of the population even when no crisis is underway. During an epidemic, people's stories on how the disease has progressed from their own unique vantage points might be shared on social media. Private sources first reported the crisis spreading on social media; later, medical experts verified the reports and provided more details regarding the disease's development. Public health officials' reliance on social media to disseminate up-to-date information regarding illnesses is critically important, as shown by the CDC's efficacy during the H1N1 flu pandemic [51]. The Centres for Disease Control and Prevention (CDC) made effective use of social media for educating people regarding safety precautions, and their emergency feed provides recent data, safeguards, and wellness warnings throughout medical incidents or crises caused by environment. During a public health emergency, getting the word out is key to helping people assess the situation and make educated decisions. Information from both government sources and internet users can be quickly disseminated due to the decentralised nature of social media.[51].

Public health workers comb through social media posts for the relevant data about the current crisis so they may give accurate reports to crisis management that combine empirical evidence, practical information, and the actual experiences of those affected. People use several different types of social media during a health crisis, and each one has its own specific function [52]. Figure 1 shows the most popular social media sites and how they help with crisis communication. Among numerous platforms for social media used by crisis managers to develop strategies, Twitter stands out for its unique features, such as brief posts (up to 280 characters), the ability to use hashtags for concepts, and its massive accessibility. In times of crisis, Twitter's data analytic capabilities can shed light on previously unknown factors. Local news and advice are shared based on people's emotionally and physically proximity, in addition to governmental places, national authorities, health specialists, and traditional media profiles. Many people want to help with crisis management by volunteering during public health situations. Platforms like Facebook enable individuals to indicate their availability to assist during emergencies in their profile's status section, allowing crisis responders to identify willing participants and swiftly contact them [51-53].

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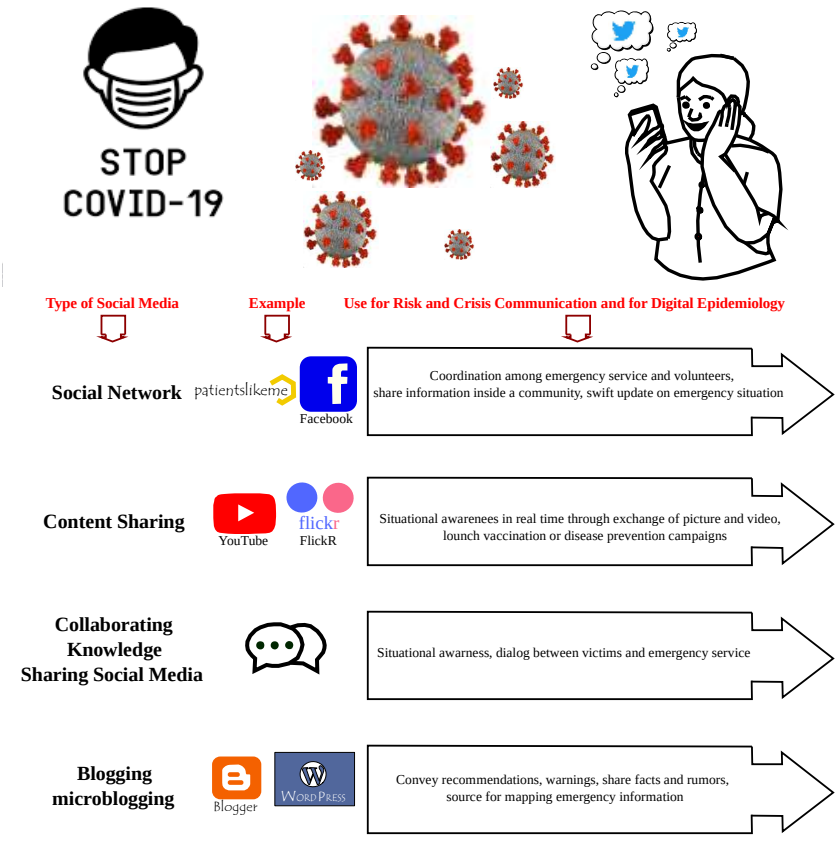

Figure 1: Types of social media and their use for health crisis communication

Hashtags pertaining to diseases, location-based searches, and keyword analysis in tweets all contribute to the simplicity of monitoring on Twitter. Information dissemination, opinion expression, and issue reporting are the three primary uses of tweets. Public and official awareness can be greatly enhanced by informative messages sent during a health crisis [52]. However, monitoring systems may find it difficult to detect improper keyword use or the propagation of false information when internet users frequently share their ideas through social media. Crisis managers may proactively engage with people through personal issues tweeted, which helps them gain credibility and trust—both of which are vital during emergencies. On the other hand, academics have pointed out problems with relying on Twitter for online crisis communication [53]. Misunderstandings could arise due to the frequent use of acronyms, short sentences, or keywords in tweets. When dealing with a health crisis, it becomes quite difficult to understand and analyse the message content. Despite Twitter's undeniable utility, crisis managers must consider the platform's advantages and disadvantages. When thinking about the potential outcomes of using any kind of social media, the same factors come into play. In times of public health emergency, when decisions made at the national level can have a profound effect on the spread of illness, the accuracy and trustworthiness of data collected online are of the utmost importance. There could be serious financial and reputational consequences if we don't find misleading information and use it to inform our decisions. Public health professionals and national authorities should also work to dispel myths and misconceptions that restrict the public from getting the facts they need to stay healthy [54]. For this reason, it is critical to have authorities and medical professionals available online during emergencies so that people can get answers to their questions and feel better. People in the Zika health crisis sought solutions through online forums because there were no trusted sources available, leading to acute confusion induced by crisis management. Additionally, health professionals need strong technology to sift through the mountain of social media content created during a crisis to find the pertinent and useful information. Furthermore, analytical systems have it tough when trying to get reliable information for in crisis management from social media posts owing to language ambiguity or the misuse of medical terminology. The crisis team has to be mindful of privacy concerns associated with keeping personal data during monitoring, and this could cause false alarms that impede their job. It is necessary to define the research scope, people involved, and application area before developing an online application for illness detection. Considering the disparity in social media penetration between wealthy and

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developing nations, particularly in the case of worldwide pandemics, universal standards are required for the efficient use of these platforms to handle public health emergencies [54]. Although COVID-19 is a completely new pandemic, it follows nearly identical pathways to earlier ones; thus, the research presented here will be considered when analysing this case study. To effectively handle future public health emergencies including comparable elements, it is crucial to consider the consequences induced by the COVID-19 pandemic.

Table 2: Features of literature review of public health crisis and social media

Features	Description of features
F9	Extensive use of social media in crisis communication during public health crises.
F10	Two-way communication stream between crisis managers and the public through social media
F11	Role of social media in providing practical guidance and emotional support during health crises
F12	Rise of medical social media for sharing health-related content from patients, loved ones, and healthcare professionals
F13	Utilization of social media for public health surveillance and early detection of impending diseases
F14	Importance of social media in disseminating timely and accurate disease-related information during health crises
F15	Use of Twitter as a potent tool for data analysis and crisis management during public health emergencies
F16	Challenges in monitoring and interpreting social media content during health crises, including the spread of misinformation
F17	Need for reliable sources and the presence of authorities and medical experts online to provide accurate information during crises
F18	Challenges in interpreting social media content and addressing privacy issues related to retaining personal data during surveillance.

- **Conclusion of features of F9 to F18 and research gaps (Table 2)**

Social media plays an extensive role in crisis communication during public health crises, facilitating a two-way communication stream between crisis managers and the public. It also serves as a platform for providing practical guidance, emotional support, and sharing health-related content from patients, loved ones, and healthcare professionals. Additionally, social media is utilized for public health surveillance, early disease detection, and disseminating timely and accurate disease-related information. Twitter is recognized as a potent tool for data analysis and crisis management during public health emergencies. However, challenges exist in monitoring and interpreting social media content, including the spread of misinformation, underscoring the need for reliable sources and the presence of authorities and medical experts online to provide accurate information during crises. Moreover, challenges in interpreting social media content and addressing privacy issues related to retaining personal data during surveillance are also acknowledged.

2.3. impact of social media on public mental health and crisis management

People who were living in isolation during the COVID-19 epidemic relied heavily on social media to stay informed about the virus, government actions, and mental health resources. To help academics and policymakers understand public perspectives and mental health status, the website also allowed users to share knowledge, attitudes, and behaviours. Researchers also looked at the moral implications of exploiting social media users' personal information for public good, which could help with pandemic response efforts and resource allocation. Research in this field has also looked at how social media has affected public mental health and disaster management, providing information on how individuals react and cope and what this means for policymakers.

Using Weibo data, Ma et al. [55] examined public sentiment during the COVID-19 epidemic. Using deep learning and issue clustering, the authors tracked how public opinion changed over time and found that unfavourable comments sparked lively debates. Additionally, they discovered that experts had little sway over the public's perception and that individual posts or users did not affect it. Public opinion monitoring and intervention tactics can be enhanced by implementing the study's findings.

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Table 3: Features of literature review of impact of social media on public mental health and crisis management

Features	Description of features
F19	Utilization of social media as a crucial communication tool during the COVID-19 pandemic, providing information on the virus, government measures, and mental health support.
F20	Exploration of the ethical use of private data collected on social media for public benefit, including allocating resources and supporting pandemic response efforts.
F21	Analysis of public sentiment during the COVID-19 outbreak using deep learning and topic clustering, providing insights into public opinion management and intervention strategies.
F22	Examination of the impact of COVID-19 stress, social media use, and coping strategies on individuals' mental health, highlighting the crucial role of social media in psychological adjustment and stress coping during public health crises.
F23	Study of how government information transparency influences the adoption of COVID-19 related information on social media, providing valuable insights for combating false information and enhancing social media's response to public health events.

- **Conclusion of features of F19 to F23 and research gaps (Table 3)**

A key means of exchange during the COVID-19 outbreak, social media has disseminated crucial data on the virus, government conduct, and mental health support. Additionally, there has been exploration into the ethical use of private data collected on social media for public benefit, such as resource allocation and supporting pandemic response efforts. Furthermore, analysis using deep learning and topic clustering has been conducted to gauge public sentiment during the outbreak, offering insights into public opinion management and intervention strategies. Examining the effects of COVID-19 anxiety, social media usage, and coping mechanisms on people's mental health has also been spurred by the epidemic. This study highlights the vital importance of social media in behavioral adaptation and managing stress throughout public health emergencies. Lastly, research has explored the relationship between governmental openness and the spread of COVID-19-related content on social media. Providing valuable insights for combating false information and enhancing social media's response to public health events.

2.4. public sentiment characteristics on social media for public opinion management

Findings from the study stress the need of utilizing social media data for immediate examination of public opinions [60-62], since conventional surveys were inadequate in gauging popular feelings and views during the unexpected outbreak of COVID-19. During the epidemic, it highlights the significance of using social media to better respond to emergencies, spread accurate information, increase awareness of one's and monitor misrepresentation. To address public issues and improve ways to interact, governments should collect important data from social media, as highlighted by Abbas et al. [30]. Public unhappiness and conformity to safety standards may result from the unknown spread of COVID-19. Government message and emotionally charged content impact public attitude, according to study that uses emotional analysis of social media posts. When dealing with crises like the COVID-19 epidemic, it is essential to understand and monitor public opinions to regulate public opinion [63–65].

The use of social media during the COVID-19 pandemic has influenced public sentiments, with discussions reflecting anxiety, negative attitudes towards remote work, and concerns about vaccines. Scholars have utilized machine learning and text-mining techniques to analyse social media data, extract topics, and classify public sentiments, enabling accurate responses based on public needs. Research has also focused on sentiment tendencies, trends, and descriptive statistical analysis of public posts, emphasizing the importance of understanding, and responding to public sentiments during a crisis[66-68].

Sun et al. [56] studied the impact of COVID-19 stress, social media use, and coping strategies on people's mental health during the epidemic. By showing how important these platforms are for mental wellness and stress coping, the study's results illuminate the impact of social media on mental health during medical emergencies.

The authors Steinberger and Kim [57] investigated how dependent people are on social networks and how it relates to their overall happiness. The authors found that subjective wellbeing and social network addiction are mediated by social comparison and FOMO. They found that interpersonal comparison of abilities, rather than opinions, was the most important factor in social network addiction, and that comparing abilities was the primary

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means by which FOMO was induced. Recognising dependence on social media and encouraging healthy practices among social media users are both aided by the study's findings.

Researchers Mensah et al. [58] looked at how the openness of government data affected the spread of COVID-19-related content online. Based on their research of 516 participants' survey responses, they found that the implementation of pandemic-related data on social media was greatly affected by information quality, trustworthiness, and utility. Furthermore, these effects were tempered positively by the perception of government information transparency. Findings from this study can help strengthen public health emergency response systems, improve the way social media handles public health crises, and fight misinformation.

In their qualitative study, Alon-Tirosh and Meir [59] looked at the ways in which teenagers on the autistic spectrum who also had trouble communicating used social media. Using semi-structured interviews, the authors looked at ten diagnosed teenagers' social media use, why they used it, when they used it, and how their autism manifested itself. Adolescents on the autistic spectrum rely heavily on social networks, and this study's results highlight the importance of the interpersonal communication that occurs on social media for this population.

Table 4: Features of literature review of public sentiment characteristics on social media for public opinion management

Features	Description of features
F24	Limitations of traditional questionnaires in measuring public sentiments during the sudden onset of COVID-19.
F25	Emphasizing the value of using social media data for real-time analysis of public opinions.
F26	Importance of leveraging social media to improve emergency response and disseminate accurate information.
F27	Monitoring misinformation during the COVID-19 pandemic.
F28	Influence of social media discussions on public sentiments, including anxiety, negative attitudes towards remote work, and concerns about vaccines.
F29	Limitations of traditional questionnaires in measuring public sentiments during the sudden onset of COVID-19.

Table 5. Research Gaps of literature review

	Research Gap	Concept
Aoun and Aoun Barakat[69]	Social media increased public scrutiny of institutions.	qualitative approach
Abbas et al.[30]	Social media educates to mitigate COVID-19's impact.	non-pharmaceutical interventions (NPIs)
Chon and Kim[70]	Analyze 360,861 tweets using attribution theory framework.	machine learning
Zhou et al.[71]	Manage pandemic impacts with resilience and agility.	NPI interventions (non-pharmaceutical intervention)
Li et al.[72]	Address information asymmetry issues.	latent Dirichlet allocation (LDA) topic modeling
Bukar et al.[73]	Social media aids public resilience during crises.	PLS-SEM algorithm
Van Dijck and Alinejad [74]	Scientists, government, media, citizens exchange Covid-19 information.	qualitative approach
Yu et al.[75]	Tourism, media, quarantine, and discrimination effects dynamically changed.	-

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Park [76]	Identify priorities in crisis management in Saudi Arabia.	data mining technique
Cheng et al.[77]	COVID-19 crisis intervention through social media peer support.	qualitative approach

- **Conclusion of features of F24 to F29 and research gaps (Table 4 and 5)**

An emphasis on the utility of leveraging social media data for real-time analysis of public attitudes was prompted by the unexpected onset of COVID-19, which showed the restrictions of traditional surveys in capturing public feelings. During the pandemic, social media has grown in importance as a tool for tracking and countering deception, as well as for enhancing emergency response and spreading information. Furthermore, the influence of social media discussions on public sentiments, including anxiety, negative attitudes towards remote work, and concerns about vaccines, has underscored the need to rely on dynamic and real-time data sources to capture the evolving public mood effectively.

2.5. Text classification methods

Present part of research provided text showcase various approaches to automatically tag and categorize training data for event extraction, particularly in the context of crisis response and social media analysis. These techniques effectively handle and organise massive amounts of textual data by utilising a mix of linguistic expertise, semantic understanding of the world, and automated methodologies. Tag training data automatically for event extraction with the help of Freebase's semantic world knowledge and FrameNet's language knowledge, according to Chen and colleagues [78]. This method entailed classifying tweets according to clusters of related data. Karami and colleagues [79] employed LIWC, a language analysis tool, to classify data into different sentiments based on contextual information gathered during a crisis. To facilitate the speedy retrieval of massive text datasets spanning several disciplines, Xin et al. [80] suggested an automatic labelling method dependent on the number of identified entities in text datasets. To automate the process of tagging large Twitter datasets for crisis response, Alrashdi and O'Keefe [81] presented an approach that uses distant supervision. This approach used the preexisting language knowledge base FrameNet and the first set of keywords. By combining several datasets of the same kind of disaster into one extensive lexicon, Win et al. [82] created an annotation model that makes use of expanded disaster lexicons. Using the clustering technique known Gupta and Joshi [83] suggested an automated labelling method that would group data according to common patterns and classify tweets appropriately. From responding to crises and social media analysis perspective, these approaches show how different the methodologies and tools are for dynamically tagging and categorising information being trained for event separation.

Table 6. Features of literature review of text classification methods

Features	Description of features
F30	Utilization of Multiple Knowledge Sources: The presented research text demonstrates the use of both semantic world knowledge (Freebase) and linguistic knowledge (FrameNet) to automatically tag training data for event extraction. This approach leverages a combination of different knowledge sources to enhance the accuracy and efficiency of data processing.
F31	Application of Automated Approaches: The text highlights the use of automated approaches to efficiently process and categorize large volumes of textual data. These approaches include automated labeling based on named entities, distant supervision, and k-means clustering, showcasing a variety of automated techniques to handle data categorization.
F32	Focus on Crisis Response and Social Media Analysis: The research emphasizes the application of these techniques in the context of crisis response and social media analysis. This indicates a specific focus on leveraging automated tagging and categorization methods to extract valuable insights from social media data during crisis situations.

- **Conclusion of features of F30 to F32 and research gaps (Table 6)**

The presented research survey demonstrates the utilization of multiple knowledge sources, specifically semantic world knowledge (Freebase) and linguistic knowledge (FrameNet), to automatically tag training data for event extraction. This innovative approach leverages a combination of different knowledge sources to

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enhance the accuracy and efficiency of data processing. Additionally, the survey highlights the application of automated approaches to efficiently process and categorize large volumes of textual data, including automated labeling based on named entities, distant supervision, and k-means clustering, showcasing a variety of automated techniques to handle data categorization. Furthermore, the research emphasizes the application of these techniques in the context of crisis response and social media analysis, indicating a specific focus on leveraging automated tagging and categorization methods to extract valuable insights from social media data during crisis situations.

3. Our Study Achievement

This study examines the pre-, during-, and post-crisis phases of social media's crucial role in crisis management. It highlights the importance of social media for communicating, assessing public opinion, and offering mental health help during public health emergencies, especially the COVID-19 pandemic. The study also emphasizes the ethical use of private data for public benefit and the application of advanced techniques like deep learning and topic clustering for sentiment analysis. It highlights the necessity of reliable sources and authorities to counter misinformation. Findings highlight the need for dynamic, immediate information sources to accurately reflect the changing public mood and show the benefits of using social media for sentiment analysis in real-time. Furthermore, the article suggests an all-encompassing approach to handle the difficulties of utilising social media data for crisis management, focusing on automated labelling to reduce human effort and improve data classification. The framework includes automatic annotation, sentiment analysis, and tweet text classification, utilizing techniques such as Latent Dirichlet Allocation (LDA) for topic generation and a new algorithm for data annotation. The paper aims to offer valuable insights for researchers studying crisis management through social media literature, particularly focusing on high-accuracy sentiment analysis, and emphasizes the knowledge generated through a critical analysis of major gaps and challenges in the field. Figure 2 presents a conceptualization of the analysis, emphasizing knowledge generated from a critical literature review. It proposes a conceptualization of identified concepts, focusing on knowledge from a previous study.

4. The proposed framework

Labelling datasets and using suitable modelling techniques with contextual embeddings are crucial for achieving correct classification results. Automated labelling using LDA topic distributions is where we begin. In natural language processing, the LDA method finds latent topic structures by analysing word distribution; these subjects are referred to as LDA topics. Using this method, we can deduce the overarching themes from a set of documents even when we don't know anything about them beforehand. Applications such as document grouping, topic modelling, and information retrieval greatly benefit from these LDA themes. To sort these subjects into order of importance for dominant topic extraction, we present a novel ranking system. After that, we use Bert embeddings to extract features; these insertions capture words' contextual meaning through the BERT model. Among the many uses of NLP are sentiment analysis, text categorization, including identification of named entities might benefit from these embeddings since they retain contextual data as well as can be used as input features. Figure 4 shows the proposed framework that we will talk about in more depth later on.

4.1. LDA model

In the Latent Dirichlet Allocation (LDA) model, topic proportions θm are generated for each document in a collection using the alpha dirichlet distribution. The LDA model involves selecting topics and words based on these proportions. The α and β hyperparameters determine the prior distributions for the topic and word distributions, respectively. These hyperparameters shape the assignment of topics to words and documents in the LDA model. Latent Dirichlet Allocation (LDA) aims to discover the most effective representation of the Document-Topic and Topic-Word matrices, assuming that documents are amalgams of topics and topics are amalgams of words. The algorithm iteratively assigns topics to words in documents, refining these assignments by computing probabilities and adjusting topic assignments for words. This process continues until a convergence point is reached, providing an optimized representation of the matrices. Without LDA or similar techniques, tokenized words after text preprocessing would result in a larger number of features (Figure 3).

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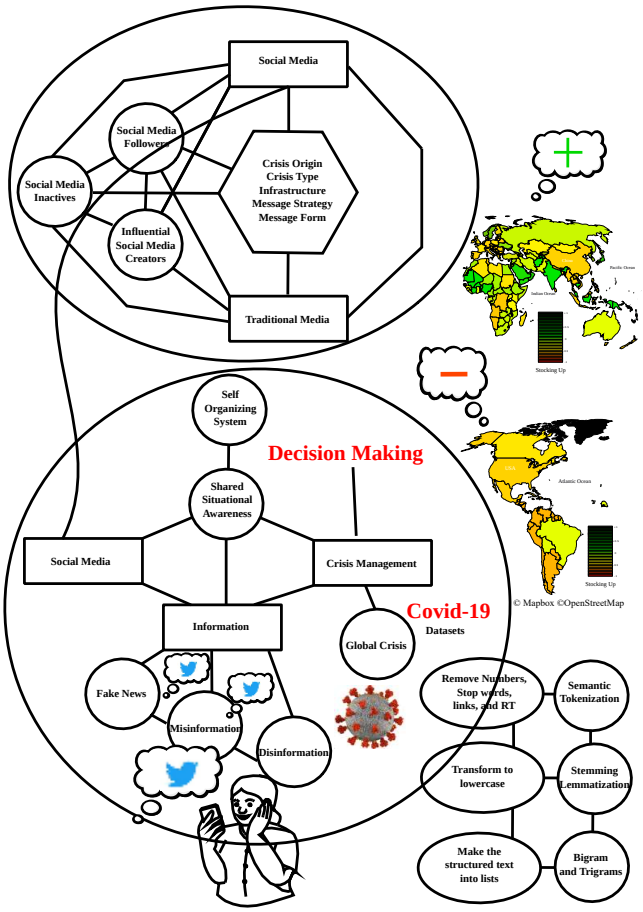

Figure 2: Formulation of the review of literature. A rectangular box reports the paper's core ideas, while circles represent the ideas that contribute to its worth.

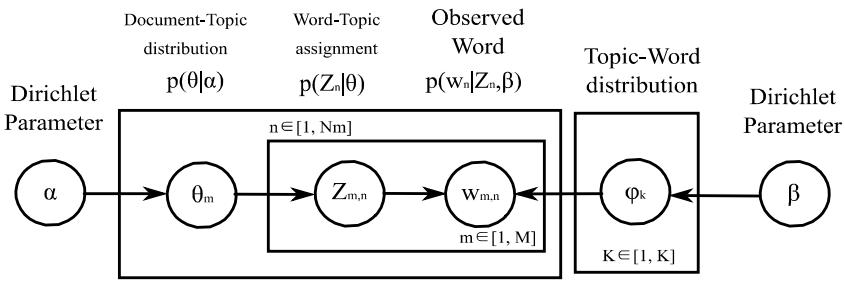

Figure 3: LDA Framework to extract topics

4.2. Tokenization and lemmatization

Tokenization involves dividing a document or tweet into individual words or tokens. We used Spacy for tokenization and lemmatization, which provides detailed part-of-speech information and can handle sentence dependencies. After tokenization, we extracted words in their original forms using lemmatization. Unlike stemming, lemmatization considers the dictionary of the specific language, ensuring valid root forms. We focused on nouns, adjectives, and verbs during lemmatization, which can be beneficial for precise topic modeling using Latent Dirichlet Allocation (LDA).

4.3. Bigrams and trigrams

The term "tokenization" describes the method of breaking down a text or tweet into its component words. Tokenization and lemmatization were carried out using Spacy, a tool that offers comprehensive part-of-speech

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data. By utilising bigrams and trigrams to combine adjectives or nouns with several words, the semantic context of phrases can be preserved in lengthy texts. To implement LDA, we used Gensim's phrases class to aggregate related words into single tokens. "Ice cream" and "united states of america" are two examples of phrases that benefit from this improved analysis. A mixture of unigrams, bigrams, and trigrams is produced by these models as an output. How to use the LDA (Latent Dirichlet Allocation) model for obtaining and label themes was covered in the component on topic modelling. Using metrics like coherence and prevalence scores, we calculated the ideal number of subjects. The LDA model was applied using a glossary and several corpora, such as unigrams, bigrams, and trigrams.

It could be difficult and time-consuming to choose the best number of subjects for an LDA model. Coherence scores and perplexity scores are two popular metrics used to evaluate LDA models. Words in a topic's coherence score indicate how related they are semantically. Phrases within a topic are evaluated for their ability to support one another and be understood within a certain context. Since coherence ratings give subjects that humans can understand, they are ideal for evaluating LDA model performance. Conversely, the accuracy of the model's predictions is measured by complexity scores. Better prediction accuracy is indicated by a lower perplexity score. New research suggests, yet, that confusion scores don't necessarily provide themes that humans can understand. To find the best number of subjects, coherence ratings are usually used. The C_V coherence measure is frequently utilised for the purpose of calculating coherence scores. Slider windows, top-word one-set segmentation, and metrics like cosine similarity and Normalised Pointwise Mutual Information (NPMI) are all part of this metric. To determine the coherence score, the results of word pairs (wi, wj) are added together, where $i < j$, and these words are most likely to appear in the topic. You can choose how many words count towards the final score. Results from employing bigrams with fewer subjects were better and more cohesive when compared to bigrams and trigrams with more themes on COVID-19. This is probably since fewer themes tend to yield better results when dealing with social media data, which is frequently brief, loud, and sparse. Furthermore, when comparing bigrams to trigrams, the results for coherence were clearly better with the former. Subjects with fewer words scored higher on the coherence test, according to additional research. So, it seems that being part of a given topic is more likely when each topic has a small set of words. This is especially important to keep in mind while writing for social media, as sites like Twitter often restrict users to 280 characters. Themes that had high coherence values and high-frequency words gave the most useful information when the analysis was done. As an example, out of the 10 topics in the COVID-19 dataset that included bigrams, the one with the greatest coherence score was topic 4, which included crucial terms pertaining to health, quarantine, lockdown, vaccination, and masks. Finding the sweet spot for topic extraction from the LDA model is the next stage before labelling each tweet with a dominating subject. Announcements, public health, and government initiatives, talks about medical equipment reserves, and hospital conditions are among the pertinent subjects retrieved from the COVID-19 dataset. Finally, considering the unique features of the dataset and assessing coherence scores are essential steps in determining the ideal quantity of themes for an LDA model. Keeping issues short and to the point usually yields better results, particularly when working with social media datasets. You can utilise the subjects that were extracted to label tweets and learn more about the dataset in general.

Table 7: Extracted topics keywords and description details of post-COVID-19 dataset

Topics/classes	Keywords	Description (Post- COVID-19)
Topic 1	Disinformation, narratives, conspiracy, cover-up, new world, order, origins, Media	Conspiracy Theory
Topic 2	Updates, Reliable sources, Misinformation, Fact-checking	COVID-19 information
Topic 3	numbers, Death, Recovery, Vaccination, Variants, Testing	COVID-19 statistics
Topic 4	Economic, recovery, unemployment, growth post-COVID-19, economic, revival, Inflation, economy, Consumer, inequality	Economics
Topic 5	Aware, false, misleading, hydroxychloroquine, Miracle, silver, essential, oils, high-dose, vitamin C, garlic	Fake Treatment
Topic 6	Lockdown, Quarantine, Social distancing, Stay-at-home orders, Travel restrictions, Curfew, Mask mandates, Testing, Contact tracing, Vaccination campaigns, public health guidelines, Economic stimulus packages, Business closures, Remote work policies, School closures	Governmental Measures
Topic 7	Analyzing, responses, Examining, health, vaccination, global,	Politics

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	polarization, recovery, Governance, crisis	
Topic 8	Protocols, Contact, Testing, strategies, isolation, Travel, campaigns	Public health measures
Topic 9	Leadership, Policy, Partisanship, Accountability, International cooperation	Stocking Up
Topic 10	development, Efficacy, safety, distribution, immunity, hesitancy, Long-term effects	Vaccine/Cure

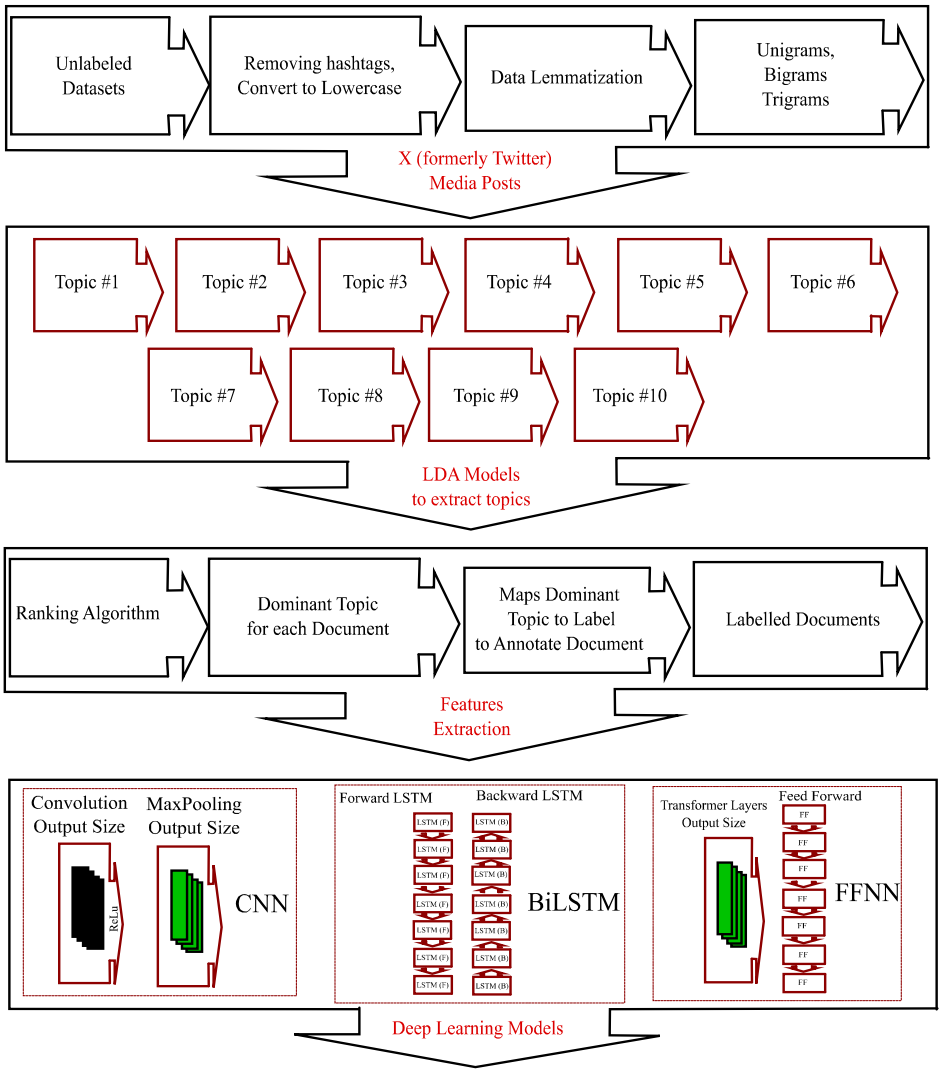

Figure 4: Proposed Framework.

4.4. Dominant topic

After extracting topics from an LDA model, the dominant topic for each document needs to be determined. This can be done by applying the TF-IDF technique to compare the phrases' significance in different texts. To find the TF-IDF score, we group all of the document's themes together and treat them as one the most important topic can be identified based on the probability distributions of its words. Our proposed Algorithm aims to label unlabelled tweets by identifying their main topic. The steps involved are as follows:

- Pre-processing: Prepare the tweet dataset for analysis by performing necessary pre-processing steps.

- Extracting Topics with LDA: Use LDA to extract topics from the pre-processed tweets, determining the optimal number of topics based on coherence scores.

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- Representing Topics: Represent each topic as a set of words with associated probabilities.

- Ranking with T-TF-IDF: Apply the T-TF-IDF ranking algorithm to determine the dominant topic for each tweet in the dataset.

- Labeling and Saving: Assign the dominant topic number as a label to each tweet and save the labeled tweets in a separate file. This creates a dataset of tweets with labels based on the dominant topic extracted from LDA and the ranking algorithm.

5. Conclusions

The results of this literature study highlight the significance of social media in managing long-term emergencies, especially in the unique setting of the COVID-19 pandemic. Recognising the critical significance of social networks in improving situational awareness and enabling successful response efforts during crises, the study emphasises the increasing dependence on these platforms by stakeholders such as crisis managers, communication specialists, and others. The evaluation does, however, note that there are still ongoing problems with making strategic and effective use of social media in a variety of crisis situations. The study sheds light on the challenges and limitations of properly utilising social networks, even if they are becoming more integrated into crisis management techniques. More specifically, the analysis notes that the COVID-19 epidemic highlights the importance of delving into the complexities of social media's role in crisis management. Additionally, the study highlights the importance of delving deeper into sophisticated approaches like deep learning classifiers and topic modelling to improve crisis response strategies. In conclusion, the literature study stresses the need of understanding and utilising social media's complex features in crisis management, especially in the wake of major worldwide occurrences such as the COVID-19 epidemic. To get over the obstacles and get the most of social media for crisis management that lasts, it suggests intensive utilisation research and development.

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