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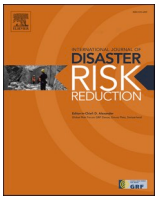

Social media data for disaster risk management and research

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ABSTRACT

The rise of social media has revolutionized disaster risk reduction (DRR) by offering real-time, large-scale data collection and fostering dynamic community engagement. This study explores the potential of social media analytics as a vital resource in understanding population responses during disasters. By harnessing social media data, researchers and policymakers can gain insights into public sentiment, immediate needs, and reactions to risk reduction measures. The study presents case studies on major disasters, including earthquakes and pandemics, demonstrating the efficacy and challenges of social media as a tool for DRR. Despite its advantages, such as immediacy and broad reach, the study addresses significant concerns like data accuracy, privacy, and misinformation. Drawing from the Horizon Europe initiatives, this research offers a comprehensive analysis of how social media can enhance disaster preparedness and response, while proposing future avenues for optimizing the integration of social media data in DRR strategies.

1. Introduction

The advent of social media has not only transformed how individuals interact with each other but has also significantly altered the landscape of data availability and its application across various sectors. In the early 2010s, social media was a novel but rapidly growing field whose potential in disaster management was just beginning to be realized – with applications ranging from monitoring public sentiment and extending emergency management to fostering community cohesion and supporting research [1]. Today, it has become an important element in understanding and responding to crises [2]. In the age dominated by digital communication, social media platforms are powerful tools that offer real-time data and facilitate widespread community engagement. The immediacy and broad reach of these platforms allow for quick dissemination of information and efficient gathering of community feedback during crises [3,4]. This dynamic interaction provides researchers and policymakers with a pulse on evolving situations and enables more responsive and adaptive approaches to disaster management.

This study seeks to unravel the complexities of utilizing social media for disaster risk reduction. By harnessing social media analytics, researchers and policymakers can extract nuanced information about how populations react to and recover from disasters, what their immediate needs are, and how they perceive various risk reduction measures. This data is crucial not only for immediate response efforts but also for planning long-term recovery and resilience-building initiatives. However, despite the promising opportunities offered by social media, there are inherent challenges and limitations that need to be addressed. Issues such as data accuracy, privacy concerns, and the digital divide [5] can significantly impede the effectiveness of using social media data in this context. The study discusses these challenges in depth and explores both technical and ethical dimensions of social media data utilization in disaster

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risk management and research.

Building on the outcomes of the research conducted by the authors within the Horizon Europe Initiatives[1] on disaster risk resilience and climate change adaptation – particularly studies on major earthquakes [6,7], COVID-19 [8], monkeypox [9], and critical issues such as GMOs [10], migration [11], and the global challenge of climate change [12] – the authors aim to give a comprehensive overview of how social media data can be leveraged for management and research in disaster risk reduction, in particular, to illustrate successful applications of social media data in different disaster scenarios and to highlight how researchers and practitioners have navigated the challenges and capitalized on the opportunities inherent in this data source.

Furthermore, the paper reflects on the findings from these case studies to draw broader conclusions about the role of social media in enhancing disaster risk management and research. It identifies key factors that contribute to the success or failure of using social media data in this context and offers guidance for future research and practice. By doing so, the study not only enriches the academic literature on disaster management and research but also provides valuable lessons for practitioners seeking to implement more inclusive and effective disaster risk reduction strategies.

The paper is structured as follows. Section 2 outlines the narrative review methodology used to gather insights from existing literature on social media and DRR. Section 3 discusses the various approaches and techniques used in social media data analysis, such as sentiment analysis and natural language processing. Section 4 presents case studies on the use of social media in different disaster scenarios. Section 5 delves into the challenges and limitations of using social media data. Section 6 focuses on disaster risk reduction strategies informed by social media data and offers examples of community co-creation efforts. Section 7 highlights the critical impact of misinformation on DRR, while Section 8 examines how social media data can be integrated into traditional disaster management systems. Section 9 looks at technological innovations and future trends in disaster risk reduction, and Section 10 offers policy recommendations and suggests areas for future research to further optimize the role of social media in DRR. Finally, Section 11 concludes.

2. Methodology

To investigate the role of social media in disaster risk reduction, we adopted a narrative review methodology [13–15]. This approach is well-suited for providing a comprehensive overview of a broad topic, allowing for a flexible synthesis of diverse sources without the constraints of systematic review protocols. A narrative review enables the integration of findings from various studies to develop a holistic understanding of complex issues, which is essential in the interdisciplinary field of disaster risk management and research.

Building upon our prior expertise and research in this area, we identified key themes, challenges, and opportunities related to the utilization of social media in disaster risk management and research. To substantiate and enrich these insights, we conducted a targeted literature search. This search aimed to locate articles that support, challenge, or expand upon our perspectives, ensuring a balanced and comprehensive discussion.

Our literature search employed a flexible and iterative approach, focusing on articles, case studies, and reports from both peer-reviewed journals and grey literature. The selection of sources was guided by the following criteria.

- Relevance: We selected literature aligned with the thematic areas identified, including social media analytics, disaster management practices, and risk reduction strategies.
- Diversity of perspectives: Both supporting and contrasting viewpoints were included to provide a balanced analysis of the topic.
- Illustrative case studies: Practical examples of social media applications in disaster contexts were prioritized to substantiate theoretical discussions.

We conducted searches using academic databases such as Scopus, Web of Science, and Google Scholar. While no strict inclusion or exclusion criteria regarding publication dates were imposed, emphasis was placed on literature that offered significant insights or added nuance to our analysis. Keywords used in the search included “social media”, “disaster risk reduction”, “emergency management”, “social media analytics”, and “crisis communication”.

The findings from the selected literature were synthesized to highlight key points and emergent themes in our discussion. By integrating insights from various sources, we aimed to construct an integrated overview that reflects both practical experiences and theoretical advancements in the field. This narrative synthesis allowed us to explore patterns and relationships within the literature, contributing to a nuanced understanding of the role of social media in disaster risk reduction. While not a systematic review, this approach ensured that our analysis remained grounded in evidence and diverse perspectives, enhancing the robustness of our conclusions.

[1] The critical importance of social media in disaster risk reduction is underscored by its central role in several Horizon Europe initiatives. Notably, projects such as LINKS (Strengthening Links between Technologies and Society for European Disaster Resilience), ENGAGE (Engage Society for Risk Awareness and Resilience), CORE (Science and Human Factor for Resilient Society), and I-REACT (Improving Resilience to Emergencies through Advanced Cyber Technologies) highlight the emphasis on integrating social media technologies to enhance disaster resilience and societal risk awareness across Europe.

3. Approaches and techniques in social media data analysis

In examining approaches and techniques employed across various case studies that utilize social media data to understand disaster risk reduction, we see a pattern in approaches and tools. The primary methodologies involve data collection via social media application programming interfaces (APIs), analysis through advanced natural language processing (NLP) tools, and various analytical techniques like sentiment analysis and content analysis. Each of these methodologies offers distinct advantages and faces specific limitations, which can significantly influence the research outcomes and implications.

3.1. Data collection methods

The foundation of these methods is the use of APIs provided by social media platforms, particularly X (earlier Twitter).[2] Social media APIs offer researchers valuable tools for collecting real-time data on public sentiment and discourse, particularly during crises or emergencies [16]. These interfaces enable the gathering of large datasets efficiently, providing insights into user activity and responses to events as they unfold [17].

The advantages include the ability to handle large data sets and stream data in real time, which is crucial for timely analysis during unfolding events [18,19]. APIs provide structured data that are relatively easy to analyze with appropriate tools, allowing researchers to focus more on analysis rather than data cleaning [20].

However, this method comes with limitations such as selection bias, where the data collected may not represent the entire population since not all demographic groups are equally active or present on social media platforms [21]. Additionally, changes in API policies or limitations in query parameters can restrict access to data and potentially bias the sample [22]. These policy shifts also highlight the power dynamics between governing bodies and private platform providers, suggesting an area for critical analysis regarding their impact on data accessibility and research methodologies.

3.2. Analytical techniques

Techniques such as sentiment analysis, content analysis, and the use of advanced NLP tools like RoBERTa are central to extracting meaningful insights from the collected data [7,9]. Sentiment analysis helps in gauging the emotional tone behind posts, which can indicate public sentiment during crises. Content analysis allows for the identification of recurring themes and provides deeper insights into the subjects being discussed.

These techniques offer a depth of understanding by allowing researchers to parse large datasets to find trends, patterns, and outliers, which can inform disaster response and risk reduction strategies [23,24]. They also provide scalability and automation, as NLP and machine learning models can process data at a scale unmanageable by human researchers and thus offer faster insights.

However, these methods face challenges such as the potential for missing contextual and linguistic nuances, including sarcasm, irony, or cultural contexts, which can lead to misinterpretations [25]. Additionally, machine learning models, including NLP tools, can perpetuate or amplify biases present in the training data or algorithms [26].

4. Case studies and insights

In this section, we present a series of case studies from our research that examine the utilization of social media data in disaster risk reduction. These studies offer detailed analyses of specific events, employing methodologies such as sentiment analysis, content analysis, and advanced natural language processing tools. By sharing insights from our work, we aim to contribute to a deeper understanding of the dynamics of information dissemination, public engagement, and the challenges posed by misinformation during crises.

Our first case study investigates the spread of misinformation during the COVID-19 pandemic through an analysis of Twitter data [8]. Utilizing sentiment analysis and natural language processing techniques, we identified prevalent conspiracy theories and false narratives circulating on the platform. The findings revealed that misinformation significantly influenced public perceptions and behaviors, leading to decreased adherence to health guidelines and diminished trust in health authorities. This underscores the critical impact of misinformation on public health responses and highlights the need for effective strategies to counteract false information.

The second case study examines public engagement on social media following a major natural disaster, specifically analyzing data from Twitter after a significant earthquake [6,7,27]. Through content analysis, we explored how affected communities used social media to share real-time information, request assistance, and offer support. The study observed dramatic fluctuations in public sentiment and discussion volumes in response to specific events related to the disaster. This reactive engagement illustrates both the potential of social media as a tool for rapid communication and coordination, and the challenges in managing the spread of unverified information during such times.

Collectively, these case studies provide valuable insights from our work into the complexities of social media use during crises:

Firstly, the analysis of COVID-19 misinformation highlights the profound influence that false information can have on public behavior and the importance of timely fact-checking and public education efforts. The rapid dissemination of conspiracy theories

[2] It is to note that the recent changes in X policy and pricing have complicated its use for research purposes.

necessitates proactive measures by health authorities to maintain public trust and ensure compliance with health guidelines.

Secondly, the examination of social media engagement following a natural disaster reveals the dual nature of these platforms as both valuable communication tools and potential sources of misinformation. The intense spikes in activity underscore the need for authorities to harness social media effectively to disseminate accurate information swiftly while implementing strategies to mitigate the spread of rumors and unverified content.

5. Challenges and limitations of using social media data

The utilization of social media data for research purposes, particularly in areas critical like disaster risk reduction, comes with a set of inherent challenges and limitations. These issues span from biases embedded within the data, concerns about privacy and ethical considerations, to inherent limitations in data analysis and interpretation. Understanding and addressing these challenges is pivotal for researchers aiming to leverage social media data effectively and responsibly.

Social media data are susceptible to various biases that can substantially impact the validity and generalizability of research findings. One primary concern is selection bias [28], where not all demographic groups use social media platforms uniformly. This may skew data towards the views and behaviors of more present demographics. Additionally, each social media platform tends to attract specific user bases [29], which may not reflect the broader population accurately. There is also the issue of self-selection bias, where individuals choose to engage with content that aligns with their existing beliefs, which reinforces echo chambers [30]. Moreover, activity bias can lead to data being dominated by hyperactive users [31,32] who post content much more frequently than the average user and potentially distort perceived public opinion.

Privacy and ethical issues are also significant when dealing with social media data [33,34]. Users posting on public platforms do not typically anticipate their content being used for research purposes. This raises concerns about privacy even when data is publicly accessible. This brings to the forefront the importance of informed consent, which is seldom feasible in large-scale social media analysis. Ethical considerations extend to the potential harm that could arise from data misuse or the implications of sensitive findings being made public. Another challenge is the veracity of social media data [35], which can be questionable, as misinformation or manipulated content can skew perceptions of public sentiment.

The technical challenges involved in analyzing and interpreting social activity are considerable. Social media data, vast in volume and unstructured in nature, demand sophisticated analytical tools and methodologies. Despite the power of advanced analytics and machine learning models to process such large datasets, these technologies introduce their own limitations. For instance, they often struggle to interpret the nuances of language used in social media posts, such as slang or irony [36], which can lead to incorrect interpretations of public sentiment or behavior. Furthermore, the relevance of social media data can diminish rapidly as online conversations evolve. This necessitates ongoing data collection and analysis to keep findings current (see Erokhin et al. [8] on how the discussion of various COVID-19 related conspiracy theories changes over time). Another critical issue is algorithmic bias – algorithms can perpetuate or amplify existing biases in the data or introduce new biases depending on their design and training [37,38].

To navigate these challenges effectively, researchers should implement robust ethical guidelines and privacy protection measures, such as anonymizing data to prevent individual identification. They also need to employ rigorous methodologies and continuously refine their analytical techniques to ensure accuracy and fairness. This might involve model validation with real-world data, hybrid approaches that combine machine learning with human analysis to better capture context, and transparency about the methods and limitations of the study.

6. Disaster risk reduction strategies

With the expansive reach and real-time communication capabilities of social media, researchers and practitioners now have access to a unique and extensive dataset from which valuable insights can be drawn to inform and enhance DRR strategies [39,40]. This section explores how insights gleaned from social media data can guide DRR efforts.

Social media platforms serve as a dynamic pulse-check on community needs, concerns, and perceptions and offer continuous streams of data invaluable for disaster preparedness and response [41]. Properly analyzed, this data can provide several benefits [42]. For instance, real-time monitoring of social media allows for the immediate understanding of situations as they unfold during disasters [43]. People often turn to these platforms to report occurrences, share experiences, and seek help. Analyzing these posts [44] can provide first responders with real-time insights into where resources are most urgently needed. Sentiment analysis of posts can reveal the community's emotional state [45], which is crucial for adjusting the tone and content of public communications to maintain calm and build trust. Additionally, social media can help detect emerging trends [46] that might impact disaster management, such as sudden spikes in discussion around specific topics related to a disaster and allow responders to quickly address these areas and ensure that correct and helpful information is widely disseminated.

Several successful initiatives demonstrate how social media facilitates the co-creation of DRR strategies by incorporating community input. During the 2010–2011 floods in Queensland, Australia, for example, community-initiated Facebook groups quickly emerged and gained a substantial following from both local residents within the affected areas and their friends and family outside the impacted zones [47]. Administrators of these groups sourced their data from various official agencies, including the Bureau of Meteorology, State Emergency Service, Queensland and Victorian Police Departments, local councils, and news media. More importantly, these administrators published real-time information from the general public and allowed Facebook members to post information and questions, seek help and advice, and update others on road closures and flooding conditions. The effectiveness of these groups was evident as they became vital platforms for local residents to engage with each other, request assistance, and provide

on-the-ground updates. This community-driven interaction played a crucial role in facilitating a coordinated response to the floods. Bird et al. [47] leveraged this engagement by using Facebook to distribute a survey to members of these groups to understand how people used these platforms during the disaster. The survey results showed that most respondents began using the groups to obtain information about their community and found the platform useful and effective for communicating with family and friends. This underscores the role of social media in gathering community input and feedback, which is essential for developing robust DRR strategies. Moreover, these Facebook groups were largely self-regulating, with moderators and members swiftly verifying and correcting any inaccurate information. The Queensland Police Service also used their Facebook page to debunk rumors and provide accurate updates, which further enhanced the reliability of the information shared. This combination of immediate, crowd-sourced updates and official data helped create a comprehensive and effective communication network during the floods.

In response to the 2012 Waldo Canyon wildfire in Colorado Springs, public officials used Twitter to disseminate critical information and engage with the community [48]. This engagement allowed for the rapid exchange of up-to-date information, which is crucial during disaster events. The thematic content of tweets, such as evacuation guidance and hazard impact information, significantly affected the likelihood of retweeting. Messages that included clear and specific guidance were more likely to be retweeted and helped to spread crucial information more effectively. Additionally, tweets that were imperative in nature (giving direct commands) were also more likely to be retweeted. The inclusion of hashtags and mentions of other users further increased the retweet likelihood by making the tweets more visible and engaging within the community.

The February 2023 earthquake in Syria provides a comprehensive example of how social media facilitated the community input [49]. In the immediate aftermath of the earthquake, social media platforms played a pivotal role in mobilizing community engagement and crowdsourcing to support search and rescue (SAR) efforts. The researchers distributed a Google form through various social media channels, including Facebook, Twitter, and Instagram, to collect data from individuals in the affected areas. This form gathered information about collapsed buildings, the number of people trapped, and specific needs for assistance. The widespread use of these platforms, particularly Facebook, allowed the form to reach a broad audience quickly and enabled a rapid collection of valuable data. Within the first 24 h, 1259 reports were received, which detailed affected locations and collapsed buildings. This community-sourced data was then mapped using Google Earth, which resulted in the identification of 129 confirmed locations with 1083 collapsed buildings, primarily in Aleppo and Idlib. The real-time data collected from the community helped direct SAR operations to the most critical locations and ensure that resources were allocated efficiently and that rescue efforts were focused where they were most needed. By engaging the local population through social media, the response teams were able to gather timely and accurate information, validate it through a network of volunteers, and communicate the results effectively to both civil defense organizations and the broader community.

7. Impact of misinformation on DRR

Despite the numerous advantages, integrating social media data into DRR strategies also presents several challenges and ethical considerations, as discussed in Section 5. One significant challenge is ensuring the accuracy of the data and combating the spread of misinformation, which can proliferate rapidly during a disaster.

In the realm of DRR, accurate and timely dissemination of information is paramount. However, the rise of digital platforms, while facilitating rapid communication, has also enabled the widespread dissemination of misinformation [8]. This misinformation can significantly alter public perceptions and behaviors during crises, complicate emergency response efforts and undermine trust in authorities. The role of automated bots in disseminating misinformation further complicates the landscape and makes it crucial for DRR strategies to address and mitigate these challenges effectively [6].

Social media bots, which are automated accounts that can generate or spread content, amplify the reach and impact of misinformation. These bots can quickly disseminate misleading information across platforms and potentially influence public behavior based on falsehoods. During natural disasters bots have been used to spread false information about the scale of damage or the direction of the threat [6]. Health crises, such as the COVID-19 pandemic, have seen bots contributing to the spread of conspiracy theories and unverified treatments [50].

Bots exploit the algorithms of social media platforms that prioritize content based on engagement metrics such as likes, shares, and comments [51]. Since misinformation often evokes strong emotional responses, it garners high engagement, which further amplifies its reach and gives it an appearance of credibility. This creates a feedback loop where false information not only reaches wide audiences but also appears trustworthy to users unfamiliar with the nuances of content dissemination on social media [52].

To combat the adverse effects of misinformation on disaster risk reduction, a comprehensive and proactive approach is necessary. This involves implementing advanced monitoring tools that can detect the spread of misinformation in real-time. Such systems analyze trends and patterns to identify potential misinformation campaigns before they gain traction, use artificial intelligence to detect suspicious content and flag it for further verification [53].

Collaboration with technology companies is essential to mitigate the spread of misinformation [54]. By working with social media platforms to improve algorithmic transparency and adjust content ranking systems to prioritize verified information, the visibility of misleading content can be reduced.

Educating the public about the risks of misinformation and how to identify credible sources is another critical strategy [11]. Media literacy initiatives teach critical thinking skills to make the public less susceptible to misinformation. Public awareness campaigns that explain the specific tactics used by bots and misinformation campaigns empower individuals to critically assess the content they encounter online.

Establishing dedicated response teams within emergency management agencies that focus on countering misinformation during

disasters can improve public safety [55]. These teams provide rapid clarifications and updates and ensure that the public receives accurate and timely information. They can also work directly with social media platforms to label false information as it appears.

Leveraging influencers and respected community leaders can also play a crucial role in amplifying accurate information during a crisis [56]. These individuals often have large followings and can help reach audiences that official agencies may not. By providing these influencers with accurate information and resources, they can help counteract misinformation directly within their communities.

To enhance the reliability of communication in disaster scenarios, authorities must ensure that their messaging is not only accurate but also accessible. This involves using clear, concise language and avoiding technical jargon that might be misunderstood [57]. It also means disseminating information through multiple channels to reach as broad an audience as possible, including those who may not have access to the internet or social media [58].

Furthermore, establishing trust with the public before disasters strike is crucial [59,60]. Trust can be built through consistent and transparent communication practices, community engagement, and visible preparedness activities. When the public trusts the sources of their information, they are less likely to turn to unverified content and more likely to comply with safety directives during emergencies.

8. Integration with traditional disaster management systems

The integration of social media data into traditional disaster management systems represents a significant evolution in how societies prepare for, respond to, and recover from emergencies. By merging digital insights with established protocols, a more robust and dynamic approach to disaster risk reduction is achieved [61]. It enhances both the efficacy and reach of traditional systems such as early warning signals, emergency broadcasting, and on-ground response coordination.

Social media's real-time data flow allows for the rapid dissemination of information, which is crucial during the onset of disasters. When integrated with early warning systems, social media can amplify reach and speed and ensure that warnings reach not only those directly connected to traditional alert systems but also the wider public through platforms they frequently use. For example, meteorological agencies can use social media platforms to post updates and warnings directly from their early warning systems and thus effectively increase the timeliness and penetration of critical safety information [62].

Moreover, emergency broadcasting can benefit significantly from the integration of social media [63,64]. Traditionally, emergency broadcasting has relied on radio and television to alert the public about impending or ongoing disasters. However, with the advent of social media, emergency information can be broadcast across multiple platforms and reach different demographic groups through tailored messages. This method ensures broader coverage and caters to the diversifying media consumption habits across different age groups and social backgrounds.

The role of social media in on-ground response coordination cannot be overstated. Platforms such as Twitter and Facebook have been used in various disaster scenarios to coordinate volunteer activities, manage logistics, and mobilize resources [65,66]. For instance, in the case of the Camp Fire in Paradise, California, Facebook helped in several key ways [67]. Numerous Camp Fire Facebook Groups (CFFGs) facilitated the formation of a network where survivors could connect, share experiences, and support each other. These groups provided a sense of community and belonging and helped to alleviate the isolation many felt after the disaster. Survivors used these groups to share their recovery journeys, including rebuilding homes and lives. This sharing of experiences was therapeutic and offered practical advice and emotional support to others going through similar challenges. During and after the Camp Fire, CFFGs became crucial for disseminating real-time information about the fire, evacuation routes, and the status of homes and neighborhoods. This information was often timelier and more detailed than what was available through official channels. The groups were used to publicize information about available resources, such as locations for free food, clothing, and shelter. This helped survivors quickly find the assistance they needed. CFFGs enabled the exchange of direct assistance, including monetary donations, goods, and services. For example, many survivors received help through family adoption programs where families in need were matched with those who could offer sustained support. The groups were instrumental in reuniting people with their missing family members and pets, which provided emotional relief and practical support during the chaotic aftermath of the fire. While the groups were largely beneficial, there were also challenges such as the spread of misinformation and incidents of scamming. Some individuals posed as survivors to receive aid, which undermined trust and made it harder for genuine survivors to get help. The groups sometimes became platforms for negative interactions and complaints, which could be detrimental to the mental health of members. Additionally, the focus on constant assistance sometimes fostered a victim mentality, which was not conducive to long-term recovery.

Hybrid models that blend digital and traditional disaster management approaches have shown enhanced resilience and adaptability. The use of combined systems provides real-time updates and significantly aids the traditional efforts of emergency responders and community preparedness initiatives. Messaging apps and social media platforms can alert citizens immediately when an earthquake is detected [68]. This system not only warns residents about potential aftershocks but also guides them on immediate actions to take via the integration of traditional seismic monitoring systems with modern communication tools.

Furthermore, the integration of these systems has facilitated the development of community-based monitoring programs, where local residents contribute to data collection and sharing [69]. For example, in flood-prone areas, community members use social media to report rising water levels, which is then integrated into national monitoring systems to enhance the accuracy and timeliness of flood forecasts and warnings.

The effectiveness of these hybrid models hinges on the seamless integration of data flows and communication channels between traditional disaster management infrastructures and modern digital platforms [70]. Ensuring interoperability, data accuracy, and security are paramount, as is maintaining public trust in these integrated systems [71]. Regular drills and public education campaigns can familiarize residents with these tools and ensure they understand how to access and use the information provided during disasters

effectively.

As we continue to witness the merging of digital and traditional disaster management systems, ongoing evaluation and adaptation of these hybrid models are necessary to address emerging challenges and exploit new technological advancements. This dynamic approach not only enhances current disaster management capabilities but also prepares systems to better handle future emergencies in an increasingly interconnected world.

9. Technological innovations and future trends in disaster risk reduction

As we venture further into the 21st century, the application of emerging technologies such as artificial intelligence (AI) and machine learning (ML), alongside advancements in augmented reality (AR) and virtual reality (VR), holds promising potential to revolutionize disaster risk reduction strategies [72,73]. These technologies are redefining the paradigms of data gathering, analysis, and implementation in mitigating disaster impacts and could enhance community engagement and bolster preparedness and response mechanisms.

Artificial intelligence and machine learning are spearheading significant advancements in disaster risk management by leveraging social media. AI's capability to process extensive data sets rapidly enables the extraction of insights at scales and speeds that were once beyond human reach. For instance, predictive analytics powered by AI can sift through historical and real-time social media data to identify emerging disaster trends and potential impacts before they occur [74]. This allows for timely interventions that can mitigate or even prevent certain disasters.

Moreover, machine learning models have become increasingly adept at interpreting sentiments expressed across social media platforms [75]. This capability is crucial for emergency response teams to gauge public sentiment, address specific concerns effectively, and counteract misinformation to maintain public calm and trust during crises. Automated alerts generated by AI from specific triggers in social media streams, such as increases in keywords related to natural events [76], enable rapid dissemination of warnings and guidance to the public and facilitate immediate awareness and action.

In terms of damage assessment, ML models are instrumental in analyzing images and videos from social media to evaluate the extent of disaster impacts [77]. This immediate analysis helps map affected areas accurately and swiftly and guide the allocation of resources and aid where they are needed most.

Shifting focus to augmented reality and virtual reality, these technologies offer immersive experiences that can significantly alter disaster preparedness and community training [78]. Virtual reality, in particular, can simulate detailed disaster scenarios within a controlled environment and provides an experiential learning platform for individuals and emergency teams [79]. Such training enhances understanding and preparedness for real-world emergencies, can reduce potential panic and improve safety protocols.

Augmented reality enhances operational planning by overlaying critical real-time information, such as escape routes and safe zones, onto real-world environments [80]. This technology can prove indispensable during an emergency and help individuals navigate chaotic situations safely. Furthermore, AR and VR can foster greater public engagement by allowing communities to visualize potential disaster impacts vividly and tangibly and thereby enhance public understanding of risks and the importance of preparedness [81].

Looking towards future trends, the integration of AI, AR, VR, and social media is expected to develop into smart disaster management systems that not only predict and respond to emergencies more efficiently but also build more resilient and informed communities. As these technological innovations continue to evolve, it is crucial to address the accompanying ethical implications, particularly concerning privacy, data security, and the potential for technological disparity. Ensuring that these innovations are accessible and beneficial, especially to the most vulnerable populations, will be essential in fully realizing their potential for disaster risk reduction. The future of disaster management lies in the ethical and inclusive application of these advanced technologies to ensure they serve as vital tools in our collective resilience and preparedness strategies.

10. Policy recommendations and future directions

In the evolving landscape of disaster risk reduction, the integration of insights from social media analysis into policymaking is becoming increasingly essential. Social media platforms offer real-time data that can be instrumental in shaping effective disaster response and preparedness strategies. The papers discussed highlight the significant impact of misinformation on public safety and the importance of crafting informed policies that can effectively leverage social media's extensive reach.

10.1. Recommendations for policymakers

Based on the findings from various studies analyzing social media content, several recommendations emerge for policymakers. First, there is a critical need for the development of more sophisticated monitoring tools that can detect and mitigate the spread of misinformation effectively. These tools should be capable of real-time analysis to quickly ascertain the validity of widely circulated information and respond accordingly.

Policymakers should also consider forming strategic partnerships with social media platforms to ensure that accurate information is promoted during crises. These partnerships can facilitate quicker responses to misinformation, which includes the removal of harmful content and the promotion of accurate, authoritative information. Additionally, there is a need for policies that encourage social media platforms to implement more transparent algorithms to prevent the amplification of false information.

Public education campaigns that enhance media literacy are essential. Such initiatives can empower individuals to critically

evaluate the information they encounter online. Policymakers can support the development of educational programs that focus on understanding social media landscapes, recognizing credible sources, and debunking common misinformation tactics.

Social media can serve as a platform for engaging communities in disaster preparedness and response planning. Policies that support community-led discussions and feedback mechanisms via social media can enhance the resilience of communities and the effectiveness of disaster response strategies.

10.2. Suggested areas for further research

The exploration of methods and tools in disaster risk reduction can benefit significantly from further research, particularly in the context of enhancing the use of social media. One potential area of study is the development of predictive analytics tools that utilize social media data to forecast disaster impacts. Such tools could analyze historical data and real-time inputs from social media to predict the paths of storms, the spread of misinformation during public health emergencies, or community needs during evacuations.

Another area for research is the exploration of the psychological impacts of misinformation on disaster preparedness and response. Understanding how misinformation affects public behavior could inform more targeted communication strategies that address specific fears or misconceptions prevalent during disasters.

Additionally, studies could focus on the efficacy of different types of messaging during crises. For instance, comparing the responses to official communications versus grassroots messages on social media could provide insights into how trust and source credibility affect public compliance with safety instructions.

Exploring the role of artificial intelligence in managing social media data during disasters could also yield valuable insights. AI could help automate the detection of emerging trends and misinformation and potentially offer a scalable solution that supports more responsive disaster risk reduction strategies.

11. Conclusion

The conclusion of this paper underscores the transformative potential of social media data in enhancing disaster risk reduction strategies. This study, anchored in the robust framework of the Horizon Europe initiatives, delves into how the expansive digital landscape of social media provides invaluable insights into the perceptions, needs, and reactions of populations during disasters. These insights not only enable real-time responses but also facilitate the co-creation of strategies that are both inclusive and effective and align with community needs and expectations.

Our investigation reveals that social media platforms serve as critical conduits for capturing a wide array of voices from affected communities and provide a real-time pulse on societal impacts during crises. This capability is crucial for developing disaster risk reduction strategies that are responsive and adaptive to the evolving dynamics of disaster scenarios. The data derived from social media enhances situational awareness, informs decision-making, and supports the implementation of targeted interventions that can mitigate risk and augment community resilience.

Social media's role in disaster risk reduction is multifaceted and potent. As a tool for data collection, it offers unprecedented access to real-time, user-generated content that reflects community sentiment and identifies emergent needs during crises. This immediacy can significantly enhance the speed and appropriateness of responses by disaster management teams. Moreover, social media facilitates broader engagement of community members, who can share critical information, participate in problem-solving, and disseminate official communications, which amplifies their reach and impact.

Furthermore, social media platforms can be instrumental in countering misinformation, a critical aspect of managing public perceptions and behaviors during disasters. Through strategic use of these platforms, authorities and organizations can provide accurate, timely information that is crucial in shaping public responses in crisis situations.

While the potential of social media is undeniable, this research also highlights significant challenges that must be addressed. Issues such as data reliability, privacy concerns, and the digital divide pose substantial obstacles to the effective use of social media data. Future research must continue to develop methods that can filter and verify the vast amounts of data generated during disasters to ensure accuracy and reliability.

Additionally, ethical considerations around the use of social media data, particularly in terms of privacy and consent, remain paramount. As researchers, we must strive to develop frameworks that respect individual rights while still leveraging the capabilities of social media to benefit public safety and disaster preparedness.

CRediT authorship contribution statement

Dmitry Erokhin: Writing – review & editing, Writing – original draft, Methodology, Investigation, Conceptualization. **Nadejda Komendantova:** Writing – review & editing, Validation, Supervision.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

No data was used for the research described in the article.

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