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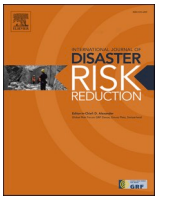

Social media use in disaster recovery: A systematic literature review

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ABSTRACT

Studies on the role of social media in disaster management have so far focused mainly on early phases of the disaster response process. Published evidence regarding the scope and effectiveness of social media use in the recovery phase is limited but promising. There is currently no study that provides a comprehensive picture of the current research landscape that can inform different groups who need to capitalise on social media for disaster recovery. The present study aims to address this research gap by conducting a systematic literature review of social media use in disaster recovery. The review analyses the relevant studies to identify any temporal variations in research activity, the social media platforms most frequently used in disaster recovery, their patterns of use by type of disaster as well as the geographical locations where the studies have focused. Importantly, the paper identifies and summarises research findings relating to social media use in various aspects of disaster recovery, including (1) donations and financial support, (2) solidarity and social cohesion, (3) post-disaster reconstruction and infrastructure services, (4) socioeconomic and physical wellbeing, (5) information support, (6) mental health and emotional support, and (7) business & economic activities. We envisage that this comprehensive review will support the disaster risk reduction community with the requisite knowledge to better explore social media for disaster recovery. Similarly, future research may find the study helpful for understanding the state of knowledge and identifying research gaps around social media use for disaster recovery.

1. Introduction

Natural disasters such as floods, hurricanes and earthquakes are growing in frequency and intensity around the world [1]. These disasters can have devastating impacts on victims and society at large. In the last decade alone (2011–2020), natural disasters have affected 1.6 billion people globally, killing 188,583 people and causing over 1.7 trillion US dollars in damage cost [2]. The physical damage from disasters can directly affect personal property or lifeline infrastructure that serve communities (e.g., transportation systems, electric power, communication networks, water supply, and wastewater systems). Aside from the physical damage, disasters often deliver ruinous impacts to other aspects of human lives, including bodily harm, job loss, homelessness, mental health breakdown, emotional distress, financial strain, and economic downturn [3]. Hence, it is vital that the disaster risk reduction community continuously seek new and improved ways of preparing for, responding to, and recovering from disasters.

Social media has emerged as a vital technology to support disaster risk reduction, including preparedness, response, and recovery

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activities [1]. The remarkable growth in the diversity and richness of time-critical information that is generated on social media sites during disasters provides a great opportunity to harness large-scale spatio-temporal data of enormous value to disaster managers [1]. In times of crises and disasters, social media platforms such as Twitter, Facebook, WeChat, and Weibo are often used by communities to stay connected, share experiences, and access vital information and resources as needed to support disaster response and recovery [3]. These social media platforms have become even more important to help disaster-impacted communities stay connected in the face of lockdowns and social distancing necessitated by the recent COVID-19 global pandemic. Following the 2019–2020 Australian bushfires, for example, social media was used in several ways, including mobilising donations of goods and money, encouraging tourism (e.g., #HolidayHereThisYear), reigniting economic activities (e.g., #buyfromthebush), expressing feelings, seeking assistance, and showing empathy or solidarity for those requiring emotional support [4]. These aforementioned activities can be considered key elements of disaster recovery, based on existing definitions.

1.1. Framing 'disaster recovery'

While disaster recovery has been defined in several ways, most understandings and recovery plans point to the ultimate goal of returning to normalcy [3]. According to the United Nations, "recovery is the restoration, and improvement where appropriate, of facilities, livelihoods and living conditions of disaster-affected communities, including efforts to reduce disaster risk factors" [5]; p.27). This definition not only emphasizes the reconstruction and restoration of the built environment, but it also highlights the need to support the means for disaster victims to lead a normal life. Smith and Wenger [6]; p.237) define disaster recovery as "the differential process of restoring, rebuilding, and reshaping the physical, social, economic, and natural environment through pre-event planning and post-event actions". Disaster recovery can therefore be a lengthy process, starting early on with pre-event planning to ensure adequate arrangements are in place to minimise damage and swiftly restore normalcy. The restoration of normalcy within disaster-impacted communities is what Rouhanizadeh et al. [7] described as short-term recovery, often overlapping with disaster response and lasting for the first few months in the immediate aftermath of the disaster. Whereas the long-term recovery process begins after the emergency response period and can last for several years [7]. The focus of long-term recovery is to help "communities become more resilient so that they are less vulnerable and more capable of dealing with future disasters" [7]; p. 1). Disaster recovery can also be defined as "the process of restoring survivors' living and enhancing the sustainability and resilience of the built environment" [8]; p.41). According to the Federal Emergency Management Agency, "recovery encompasses more than the restoration of a community's physical structures to its pre-disaster conditions. Of equal importance is providing a continuum of care to meet the needs of the affected community members who have experienced the hardships of financial, emotional, or physical impacts as well as positioning the community to meet the needs of the future" [9]; p.5). In essence, disaster recovery comprises various aspects that should be considered, including mental health and emotional support, financial support, economic activities, solidarity and social cohesion, access to vital information and, reconstruction and infrastructure services, etc [7,10,11]. These diverse aspects of disaster recovery can be supported through the use of social media.

1.2. The research landscape

A burgeoning body of literature examines the enormous potential that social media offer for disaster management and response. However, previous research has largely focused on social media use in the emergency management and early phases of disaster response, particularly the communications role of social media in improving situational awareness [12]. Jamali et al. [3] note that although social media applications in disaster preparedness, response, and mitigation have been widely studied, the same cannot be said for social media use in disaster recovery (see also [13]. More recently, Yeo et al. [14] added that in comparison to the other phases of disaster management, recovery still appears to be the least studied, consequently leading to a lack of theories.

While comparatively little work has focused on recovery specifically, prior research has emphasized the value of social media use across all disaster management phases, including recovery [15–18]. A previous review focusing on collective behaviour associated with social media use during disasters, points to some novel phenomena relevant to disaster recovery, beyond information dissemination, particularly digital volunteerism, and digital commemoration [19]. Shibuya [13] highlights the role of social media posts in 'citizen as sensor' approaches to providing both real time and long-term sensing to monitor and assess recovery progress. Houston et al. [17] reviewed the literature and developed a framework of disaster social media users and uses, identifying a number of important uses relevant to the disaster recovery phase, including raising awareness and facilitating donation, the provision and receipt of mental health support as well as general information provision, discussion and storytelling around rebuilding and recovery. A recent review by Zhang et al. [20] also identifies several aspects of social media informatics that may be useful during the disaster recovery phase, including event damage/impact detection, damage assessment and mapping, and assisting with aid-seeking and aid-providing activities. However, as the review only explores the public information and warning role of social media, other potential aspects of social media use for recovery, such as building community cohesion, supporting psycho-emotional healing, and recovery progress tracking were not examined.

Although existing research has started to build understanding around social media for disaster recovery, several important aspects of recovery are under-explored and there remains a need for a more in-depth picture of how specific components of recovery are both supported or hindered by social media use. There is also a need to, more closely, examine patterns in the research landscape around social media for disaster recovery, including which disaster types, aspects of recovery, geographic locations and social media platforms are currently represented. Eismann et al. [19] note that the nature, extent, and relevance of social media functions can shift across disaster types and contexts. Previous work has also pointed to a particular need for more research on social media use for longer-term recovery [13,15]. Long-term recovery is considered to be more protracted recovery, often lasting over several years beyond the rapid recovery in the immediate aftermath of the disaster [7,15]. Better understanding of the role social media can play in relation to

longer-term recovery processes, particularly where certain economic, social, and environmental impacts of disasters may only become apparent after some time, is especially important considering recent unprecedented disaster events including the 2019-20 Australian bushfires and the coronavirus pandemic that have significant long-term consequences. As Tagliacozzo [21] notes, little is known about how social media is used to support long-term recovery from disasters. There are only a few studies exploring social media use for such later stages of disaster recovery. Further, in most of the existent research on long-term recovery, housing and infrastructure reconstruction are emphasized to the exclusion of other aspects of disaster recovery [22].

These gaps in the literature on social media and disaster management provide strong motivation for the present study. Building on existing work we review the literature with the aim of offering a more comprehensive overview of the state of knowledge and remaining gaps around social media use for disaster recovery. We hope that this work will inspire future research to further advance the use of social media in various aspects of disaster recovery. In the following section, we present the methods adopted to conduct the review.

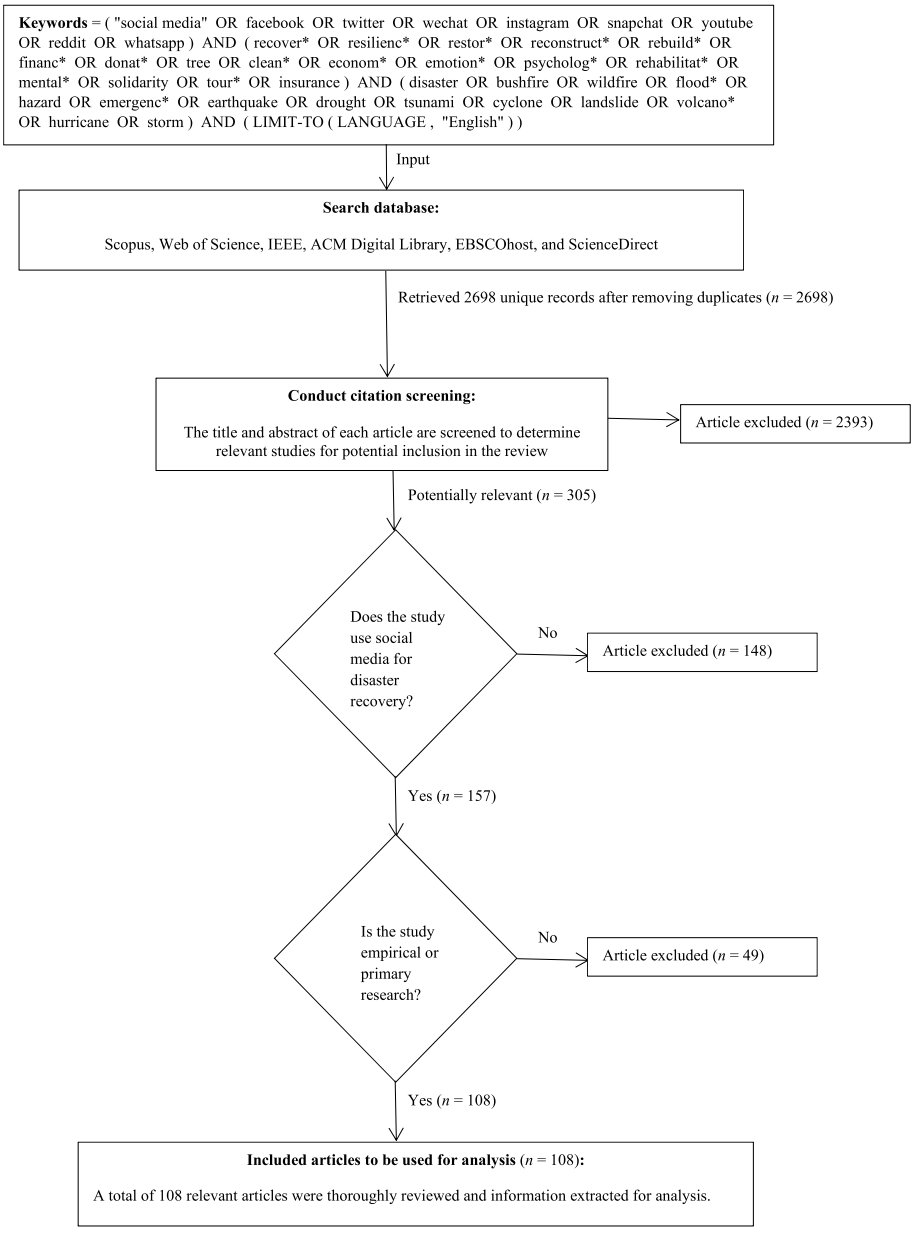

Fig. 1. The systematic process of screening articles.

2. Methods

This research follows a standard, systematic process for identifying and reviewing relevant literature, in this case covering studies that explore social media use for disaster recovery. The review process begins with retrieving articles from relevant academic databases, which in this study included Scopus, Web of Science, IEEE xplore, ACM Digital Library, EBSCOhost, and ScienceDirect, as depicted in Fig. 1. The articles were retrieved by using a combination of keywords as shown in Fig. 1. The keywords used in searching for relevant literature were chosen based on existing understandings of disaster recovery as presented in Section 1.1. The existing literature suggests that there are several aspects to consider in relation to disaster recovery, including mental health and emotional support, financial support, economic activities, information support, reconstruction and infrastructure services. A total of 2698 unique records were retrieved after removing duplicates. These were studies written in English and published online before the cut-off date of July 8, 2021. The 2698 articles were subjected to citation screening [23]. In the citation screening, the title and abstract of each article were examined to identify studies that could potentially be included in the literature review [23]. Articles were included for further screening if they utilised social media in a disaster context. The citation screening resulted in the exclusion of 2393 studies.

The remaining 305 articles were examined to see if they were concerned with social media use for disaster recovery. Articles were considered to be related to disaster recovery if they contributed to one or more aspects of recovery, including, mental health and emotional support, financial support, economic activities, solidarity and social cohesion, access to vital information, reconstruction and infrastructure services, etc. Articles focusing on disaster prevention, preparedness, or response were excluded if they did not also cover recovery. Articles focusing on individual isolated cases of health recovery that were not associated with a crisis (e.g., social media use, to support individual recovery from psychiatric illness) were excluded. Similarly, studies that used social media for business recovery from corporate crises such as personnel or financial crises were not included. Disasters/crises included both natural and man-made but studies focusing on crises that were not tightly tied to a specific geographical location at a specific time, such as the US 'opioid crisis' were excluded. Other broad-scale crises, such as the COVID-19 pandemic, which have clear place-based implications for control and recovery were included. This resulted in the exclusion of a further 148 articles.

The remaining 157 articles were further scrutinised to identify whether they were empirical or primary research. Only those containing significant original empirical research were included in the review. Literature reviews, position papers, book chapters, non-peer reviewed conference papers, conference reviews, letters to the editor, peer-reviewed published abstracts, editorials, and other instructional texts with no significant original empirical component were excluded. The review comprised only peer-reviewed research, including peer-reviewed conference proceedings. This resulted in the exclusion of 49 articles, leaving a total of 108 articles to be included in the review. The included literature utilised a wide range of quantitative or qualitative methods (including, but not limited to, interviews, surveys, geospatial mapping, text mining, corpus methods, automatic or manual text analysis, discourse analysis, ethnographic and other field methods).

Each stage of the systematic literature review process was independently scrutinised by at least two researchers, ensuring that individual subjective bias was minimised. For example, each researcher first reviewed the articles assigned to them and categorised each assigned article to one of seven specific aspects of disaster recovery (discussed later in the Results section). The results were then independently scrutinised by at least two other researchers in the team, ensuring that articles have been correctly categorised. Where there were discrepancies emanating from the independent review, these were highlighted and later discussed amongst the entire research team to reach a consensus on the most appropriate categorisation for the articles. The researchers acknowledge that an article could potentially contain contents that may be relevant to several aspects of disaster recovery. However, the rationale for the

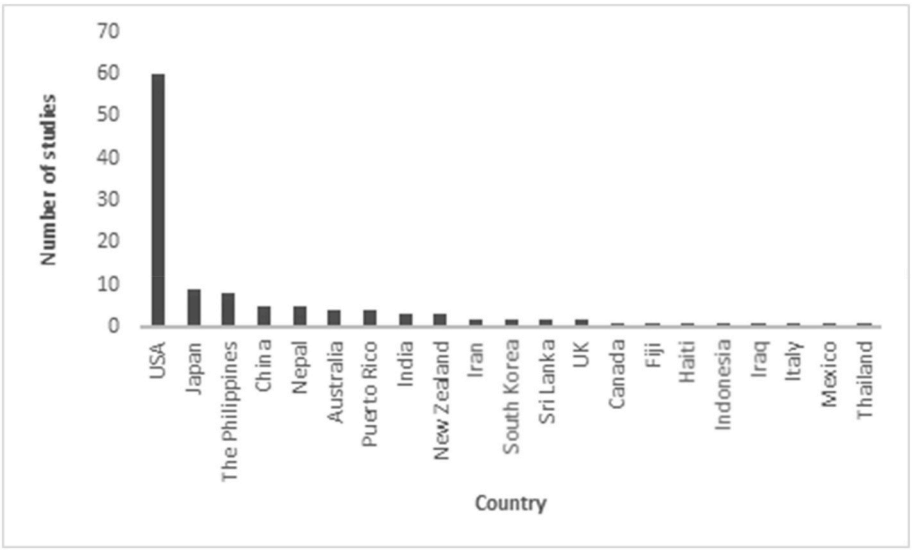

Fig. 2. Geographical spread of literature exploring social media use for disaster recovery.

categorisation is that articles are assigned to just one specific category of disaster recovery, on the basis of the core focus of the study or the aspect to which the results are mostly relevant. This is helpful in understanding where the most research attention has been directed in terms of aspects of recovery being explored. Articles that have a broad focus on social media use in disaster recovery, without focusing on one specific recovery aspect, were assigned to a distinct category referred to as 'recovery (in general)'. In reviewing each article, the researchers also recorded the social media platforms, disaster types, and countries involved in the case study. This enabled the researchers to understand the frequency of occurrence of different social media platforms, disaster types, and geographical representation in the literature. It is not unusual to have an article with a case study involving multiple social media platforms, disaster types, or countries. Hence, it is possible that the total frequency count of the different social media platforms, for example, may exceed the total number of studies (108) investigated. The following section discusses the results of analysing the 108 articles included in this review.

3. Results and discussion

3.1. Summary of research activities

In the last few decades, different countries around the world have been impacted by several types of disasters. The social media platforms used in disaster recovery and how they were used varies across these countries. While an in-depth comparison of different country contexts is beyond the scope of this review, Fig. 2 identifies where research activities have focused over the years. Significantly, more than half (55.6%) of the research has focused on the USA. In considering this geographical bias it is worth noting that this review is limited to articles published in English. While the language limitations are certainly a factor, this level of dominance is still notable considering that a number of other English-speaking countries are also prone to natural hazards.

The disaster types and the social media platforms discussed were also noted in reviewing the articles. As Fig. 3 shows, hurricanes, earthquakes, floods, and typhoons were the most predominant disasters reported in the literature reviewed. These disasters occurred mostly in the USA, Japan, China, and The Philippines. Studies from China relied mostly on WeChat and Weibo for disaster recovery. However, Twitter was by far the dominant social media platform used in other countries for research around disaster recovery, followed by Facebook. Twitter was used in 65% of the articles (see Fig. 4), followed by Facebook at 16%. Some of the articles (15%) discussed social media in general without being specific about the platform. Interestingly, social media apps (e.g., SnapChat, TikTok) that are more common with teenagers and younger cohorts were not reported in the literature. One issue likely impacting platform representation in the literature is the challenge of accessing the data for research. Social media platforms used for private messaging, including WhatsApp and Facebook Messenger, are generally harder to access for the purpose of obtaining research data. This does not mean that these platforms are not increasingly being used in times of crises. As these platforms gain a growing user base, particularly amongst younger generations who would likely be responsible for tackling future disaster risks, it might be important for future research to investigate how such data could be accessed for public good without invading the privacy of the users.

In reviewing the articles, attention was also paid to how the results around social media use for disaster recovery were validated. Social media provides rich data sets for research, but the data often contains a lot of irrelevant content. There is also a chance that social media data may be harvested for research purposes without capturing important contextual factors that were at play when the data was generated by users. These point to an issue of data quality that can potentially affect the accuracy of the research results. Hence, there is a need to validate research results by comparing the findings from social media data with what is indicated by other independent data sources. As Fig. 5 shows, 29% of the studies relied on secondary data sources (e.g., official government reports,

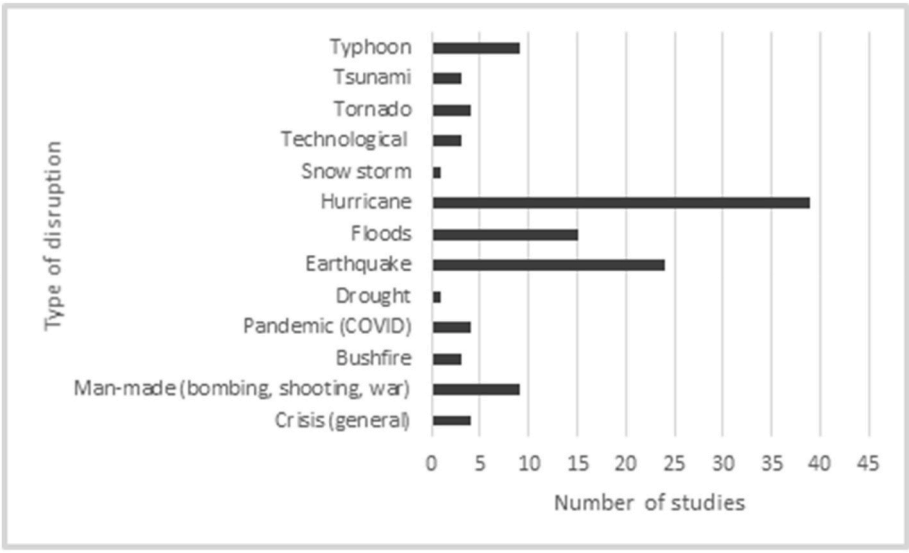

Fig. 3. Disaster types represented in the literature.

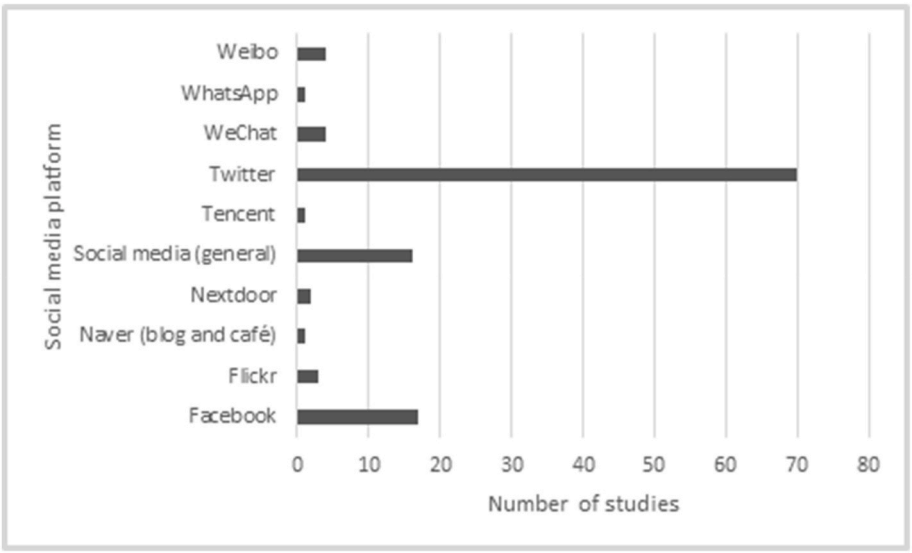

Fig. 4. Social media platforms identified in the literature.

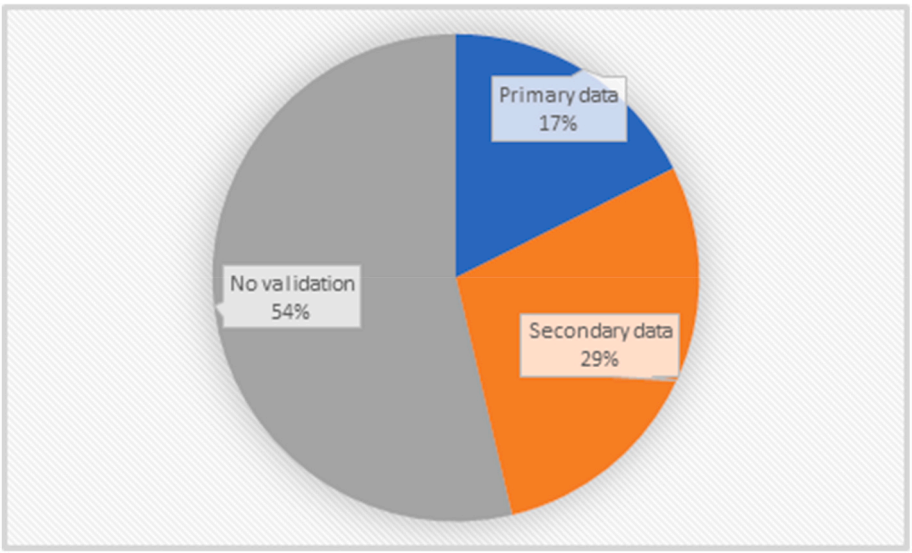

Fig. 5. How research results from social media data analysis were validated.

newspaper articles, web portals, insurance data) to validate the results from social media data analysis. A further 17% of the studies were based on primary data from surveys and interviews. In other words, these studies essentially relied on surveys and/or interviews to ascertain how social media was used in the aftermath of major disasters. Surprisingly, we found that more than half of the studies (54%) which used social media data for disaster recovery did not validate their results. However, in some cases the nature of the data would make validation implausible. There could also be issues with accessing authoritative data sources (eg. census data) to support validation, particularly in developing countries. While this does not, in any way, imply that such studies have inaccurate findings, it does suggest the need for careful consideration of how the results from social media disaster research are interpreted, communicated, and applied in practice. This has become even more important given the growing number of studies (see Fig. 6) that are exploring social media data for disaster recovery.

The studies reviewed in this paper have focused on how social media use relates to several aspects of disaster recovery, as shown in Fig. 7. A number of studies (31%) explored social media use in disaster recovery in general, without focusing on any specific aspect of recovery. When considering more specific aspects of recovery, "reconstruction and infrastructure services" featured most predominantly in the literature, accounting for 16% of the studies. The aspects of disaster recovery that were least represented were "donations & financial support" (6.5%) and "solidarity & social cohesion" (6.5%). The following section discusses these different aspects of disaster recovery in more detail.

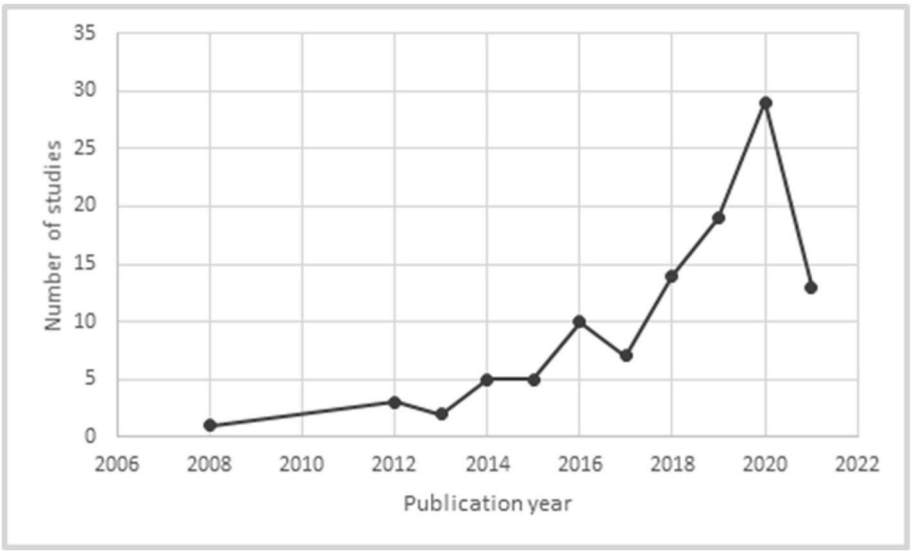

Fig. 6. Yearly record of studies utilising social media for disaster recovery. Cut-off is July 8, 2021- so figures should not be interpreted as indicating a downward trend in 2021.

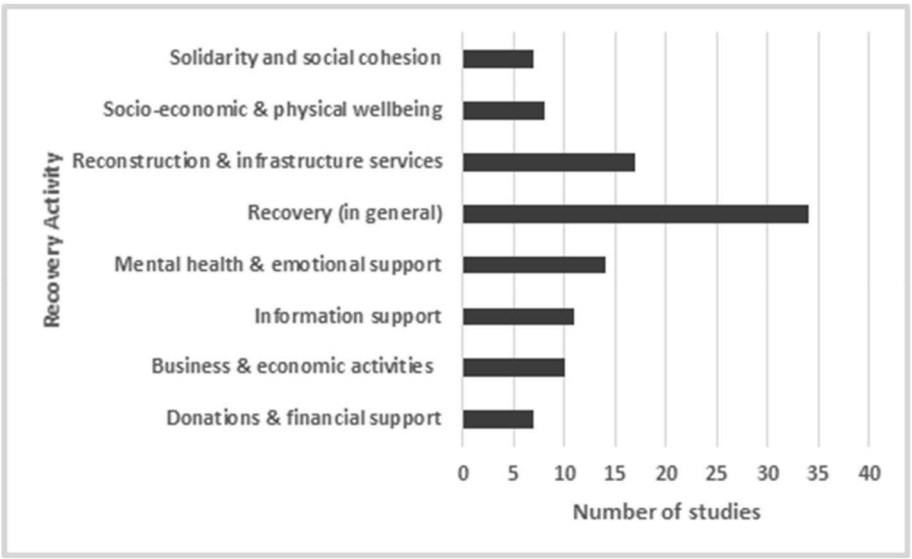

Fig. 7. Different aspects of disaster recovery supported through social media.

3.2. How social media is used to support various types of recovery activities

In this section, we discuss how the articles included in the review have explored social media for disaster recovery. There were seven specific aspects of disaster recovery that were addressed in the literature, namely: donations & financial support; business & economic activities; information support; mental health & emotional support; reconstruction & infrastructure services; socio-economic & physical wellbeing; and solidarity & social cohesion. Articles were assigned to one of the seven categories based on the predominant research aim and/or findings. Where articles discuss disaster recovery in a general sense without focusing on one specific aspect of recovery, we have categorised them as 'recovery (in general)'. Table 1 summarises those studies which relate to disaster recovery in general and have relevance to multiple aspects of recovery. However, we found that while some articles discuss disaster recovery (in general), the reported findings have some particular relevance to a specific aspect of disaster recovery. Where this is the case, these articles have instead been included in the table for the relevant aspect of disaster recovery accessible as part of the supplementary materials associated with this paper.

Table 1
Studies which relate to disaster recovery in general and have relevance to multiple aspects of recovery.

Reference	How the study used social media for disaster recovery	Key findings
Liu et al. (2008)	This research elaborates on the ways in which members of the public participate on social media photo sharing site Flickr, during the response and recovery phases of disasters.	The study found that during disaster recovery, people post photographic social media content on Flickr, including images to inventory their houses for insurance purposes, images of found personal belongings, images of missing persons, images of post-disaster relief activities, and images of disaster tourism where people gather to witness the devastating impacts of disasters.
Taylor et al. [24]	This research investigates the role of social media in supporting recovery and community resilience to disasters.	The study found that social media provides a range of supporting roles in disaster recovery, including empowering individuals and communities to request and provide help, enhancing individuals' sense of connectedness and usefulness, extending the reach of official messages, limiting the psychological damage caused by rumours and troll accounts, acting as psychological first aid to disaster-impacted communities, promoting a collective narrative of the disaster experience, and providing a mechanism to connect with others and receive accurate, timely and relevant information.
Semaan and Mark [25]	This study investigates how social media use supports recovery from crisis.	Social media enables crisis recovery by supporting people to determine the safety of family and friends, seek help and provide assistance, reconstruct their social networks, maintain and develop new social norms, and self-organise to improve the community.
David et al. [26]	This research investigates the role of social media in supporting the response and recovery from disasters.	The results show that social media can provide a range of disaster recovery support, including the expression of emotions (e.g., gratitude), relief coordination, the facilitation of specific calls for help, and the pledging of monetary or nonmonetary assistance by individuals, countries and international aid agencies outside the disaster-impacted area.
Brandt et al. [27]	This study examined the role and use of Twitter as a response and recovery strategy before, during, and after the historic rainfall and flooding in South Carolina.	The most common themes of tweets across all 4 time periods were built environment devastation, weather conditions, natural environment devastation, actions to reduce threats to health, and resource donations. (Focus changed over the time periods analysed).
Fang et al. [28]	This study explored how social media messages from the Weibo platform could inform disaster response and recovery, based on the 2016 Wuhan flood disaster case study.	The study found that messages about disaster impacts focused more on traffic (42.77%), followed by everyday life such as working and studying (34.30%), as well as emotion (13.36%) and disaster loss and damage (9.57%).
Dahal et al. [29]	This study conducted ethnographic fieldwork and 50 in-depth interviews with Nepali youth directly involved in the relief efforts after the Gorkha earthquake of April 2015 in order to understand the role of social media in shaping the relief and recovery process.	The results show that social media such as Facebook was helpful in sharing information, organising volunteers, fundraising, motivating peers, and ensuring accountability. However social media also hindered the relief distribution and coordination process due to fake information and the doubling of aid packages associated with duplication of the same messages.
Willson et al. [4]	This study examined the use of Twitter to support bushfire recovery in Australia	Twitter users from both Australia and overseas supported those impacted with positive messaging mostly in areas of donations, relief support, news updates, and animal welfare. Negative sentiment was mainly focused on concerns over the climate emergency and a perceived lack of political action.

3.2.1. Social media use for donations and financial support

Social media can be advantageous when used to aid donations and financial support for people recovering from disasters. One advantage is the responsiveness and speed with which new forms of citizen aid brokerage (e.g., EcoTrek – a citizen aid initiative in the Philippines) exploit social media to not only solicit donations from local and global donors, but also deliver the aid in a manner that is swift, personalised, and tailored to the immediate recovery needs of disaster victims [30]. This is very promising for disaster relief logistics, as new findings demonstrate that social media data can be analysed to identify the spatial distribution of the demand for relief supplies during the early phase of disaster recovery [31]. An earlier study by Purohit et al. [32] also highlighted the role that social media can potentially play in coordinating donation logistics. The authors analysed Twitter data from Hurricane Sandy and found that social media is not only helpful for identifying requests for items such as shelter, money, volunteer work, clothing, and medical supplies, but also matching the requests with offers made on social media [32]. Analysis of Facebook posts in the aftermath of the 2015 Nepal earthquake, has also shown that social media can be helpful in raising awareness, inspiring people to donate and collecting the donated funds [33]. By using social media to circulate images of beneficiaries, the soliciting organisation can more easily gain the trust of communities and donors [30]. However, a steady flow of donations is more likely when the social media campaign motivates people to donate and is administered in a manner that is transparent, engaging, encouraging, and appreciative of those who donate [33].

Relief donations can be predicted through rigorous statistical analysis of empirical data. One approach, which has been explored with data from Hurricane Sandy, is to examine the relationship between the level of relief-donation chatter on social media and the level of the observed actions related to the chatter (i.e., dollar amount received for recovery) [34]. When compared to traditional methods for predicting donation behaviour (e.g., population, total income of residents, and distance from the disaster area, etc.), this approach was found to be one of the best predictors of donation amounts in the aftermath of disasters because of the superlinearity in

how donations scale with the level of tweeting activities. This is consistent with previous findings drawing on the example of the Haiti earthquake, which revealed that there is a positive correlation between social media coverage of disaster events and the amount of donations received [35]. A key highlight from the study is that social media can sustain disaster stories and help charitable giving to thrive for longer periods of time [35]. Another approach for understanding donation behaviour is to investigate the associations between moral values and charitable donation sentiment [36]. The results from analysing 913,987 tweets posted during Hurricane Sandy showed consistent positive associations between moral care and loyalty framing with donation sentiment and donation motivation [36]. However, in contrast with people's perceptions, moral frames may not actually have reliable effects on charitable donation, as measured by hypothetical indications of donation and real donation behaviour observed in controlled experimentation [36]. These findings are quite striking because they not only bring focus to the psychological processes underpinning donation on social media but also highlight the need to validate the findings from social media analyses with rigorous experimental testing. This should be of concern to the research community considering that more than half of the studies utilising social media data for disaster recovery (refer to Fig. 5) do not validate their findings with additional data sources and research methods.

3.2.2. Social media use for solidarity and social cohesion during disaster recovery

Social solidarity is vital to community recovery from disasters. Social solidarity is the ties that bind people together as one community and help them stay cohesive, despite the increasingly individualistic nature of society [37,38]. The display of solidarity provides emotional support for victims and survivors recovering from disasters [37]. Social solidarity increases the collective response to disasters, allowing community members to stand together, provide mutual aid, and support those in need [38]. In times of crisis, social media can help to build solidarity and maintain a socially cohesive community by providing a space for people to express gratitude, provide help, show sympathy, enhance sense of belonging, build positive social relationships, and stay connected to existing social networks [37,38]. Social media can also serve as a platform to express grievances or concerns, seek support, and drive positive social change in times of crisis [38]. Social media is often used to call out the government's shortcomings in disaster management, including issues of exclusion, marginalisation, and disparities in aid delivery to victims of disaster [37,38]. However, socially divisive communication on social media can potentially undermine the trust, unity, and shared values that bind people together as one community. The communication and sentiments expressed on social media can therefore be mined to uncover any form of social tension or disharmony that could potentially hamper community recovery from disasters.

Social media use has an influence on solidarity and social cohesion during disaster recovery. Social media data can be analysed to uncover changes in community sentiments as well as ways of forming resilience and solidarity over time [37]. A study of the 2014 Sewol ferry disaster has shown that community resilience and solidarity on social media often start in the early phase of the disaster with emotionally charged messages that are full of sympathy and hope for victims [37]. With time, the focus moves to more rational messages calling for the truth, justice, and accountability [37]. At a later stage, social media may be used in the community's reminiscence and commemoration of victims and grieving families [37]. Getchell and Sellnow [39] report on how emergent organisations form online and use social media to contribute to disaster recovery through information sharing and activism opportunity functions within communities. They found that while there is certainly distress among those impacted by a crisis, there is an eagerness by citizens to engage in pro-social behaviours such as care, concern, and support for disaster victims. People who follow social media information about disasters tend to express higher overall levels of care and concern for victims, thereby leading to increased levels of supportive actions such as donations and volunteering [40]. The significant outpouring of support from Canadians and people from other parts of the world during the McMurray wildfire attests to the fact that social media is mostly used in promoting pro-social behaviours, including the provision of support, expression of gratitude, and a show of care and concern for those in need [40].

The level of gratitude expressed on social media in the aftermath of disasters can vary depending on several factors, including the type of support triggering the gratitude. Gratitude is considered as an emotional response to a supportive act, especially when the support provided is deemed to be beneficial and offered consciously, not out of a sense of duty or obligation [41]. Gratitude is linked to physical and mental health, emotional wellbeing, and positive interpersonal relationships [41]. Hence, support and gratitude, expressed through social media, can contribute to a community's ability to cope, heal, and recover from disasters. Six categories of support have been observed through Twitter: emotional or nurturant support, which includes prayers, kind words, and other expressions of sympathy; tangible support, which requires physical acts of kindness such as the donation of food or clothing; informational support, which includes the dissemination of information to keep people informed; symbolic support, which is provided purely to symbolize honour or respect for victims or the impacted community (e.g., moment of silence); role support, which involves support provided by people who hold key roles in the society (e.g., police, first responders, etc.); and circumstance support, which involves the expression of gratitude [41]. Tweets related to the Alabama tornado of May 2011 contained more expressions of gratitude for tangible support such as food and shelter, whereas the tweets related to the 2012 mass shooting at Sandy Hook Elementary School were more likely to concern symbolic or nurturant support. There was a lot more gratitude for those who provided support to victims of a man-made disaster (mass shooting) as compared to a natural disaster (the Tornado), even though the tornado caused more deaths and damage [42]. Overall, the expressions of gratitude for social support could differ from one community to another, depending on the disaster type, access to power supply, average tweeting rate, social capital, amongst other factors [42].

Social capital and social connections are vital to disaster recovery and can be mobilised through social media. Social capital is understood as resources embedded in trust, norms, and networks among people [43]. Using a case study involving Hurricane Harvey and the Chinese-American community in Houston, Texas, Chu and Yang [43] investigated the role of WeChat in facilitating three types of social capital, namely bonding, bridging, and linking social capital. Bonding capital is social capital rooted in close social connections such as kinship and friendship; bridging capital is embedded in less dense relationships such as acquaintances and strangers; while linking capital is accessed through formal relationships between individuals and institutions such as governmental agencies

[43]. The results indicate that the use of WeChat groups is associated with the mobilisation of various types of social capital by the study participants, especially those from sources with which they do not have tight connections (that is, bridging and linking ties). This is an important finding considering that underprivileged communities (e.g., immigrants, minorities, and lower-class workers) tend to rely mostly on bonding capital in times of disaster recovery [43]. Willems et al. [44] also explored social connections and social media use in disasters, but the focus was on young adults. The research, which used the Australian 2019/20 bushfires as case study, investigated the link between the disaster recovery of young adults and social connectedness via social media and virtual communities [44]. The study reported that social media online communities are a preferred source of information and support for young adults recovering from disasters [44]. This is because young adults are always on the move and virtual communities can provide support that people can access from anywhere. With social media communication, young adults, who may otherwise miss out on place-based information, can access information they need to support their recovery [44]. The supplementary material associated with this article contains a summary of other studies that have relevance to social media use for solidarity and social cohesion.

3.2.3. Social media use to support post-disaster reconstruction and infrastructure services

Post-disaster reconstruction is a long-term recovery process to repair the built environment, restore infrastructure and community services, and undertake activities to overcome pre-existing vulnerabilities [22]. This section discusses how social media data can be used to provide insights to support decision-making relating to post-disaster reconstruction and the restoration of infrastructure services. Key issues involve understanding how the government uses social media to support citizens during reconstruction and recovery from disasters. Limited use or poor access to social media can hamper the dissemination of recovery-related information. Social media, as a communication infrastructure, is therefore vital to community recovery. When adequate support, including funding and access to vital information, is not provided to citizens, this can undermine community recovery and cause the affected citizens to relocate. It is equally important to understand how social media data is harnessed to reveal the extent of disruptions and infrastructure damage caused by disasters. The means of exploring social media data to predict such disruptions, including the performance and condition of key infrastructure, are covered in this section. Some of the relevant research projects have adopted case studies involving either flooding or earthquakes, but much of the research around reconstruction and infrastructure services has focused on hurricanes.

The damage and performance issues associated with disaster impacts can be investigated and monitored with social media data. Community recovery from major disasters is often challenging without a clear understanding of the locations and extent of damage caused to key public infrastructure such as power/electricity, roads/transportation, drinking water, wastewater and drainage, buildings, and telecommunication networks [45,46]. In areas where field surveys and satellite imagery may not be readily available or accessible, textual and image data from various social media sources such as Flickr and Twitter have been successfully used to investigate infrastructure failure or performance issues, including the severity and locations of damage caused by hurricanes such as Harvey and Irma [45–49], floods such as the September 2013 floods in Colorado [50,51], and earthquakes such as the August 2014 (Napa) and July 2019 (Ridgecrest) earthquakes in California [52–54]. Such damage information is important in informing recovery activities such as disaster relief, resource allocation, and infrastructure reconstruction.

The approach is typically based on natural language processing of text and machine learning classification of text/images. This is normally achieved by using artificial neural network (ANN) [46,47], logistic regression (LR) models [46,47], multinomial naïve Bayes [46], K-nearest neighborhood (KNN) [46], random forest & decision trees [46,47], and support vector machines (SVM) [46,47,53]. As well as identifying the location and nature of damage, social media data has been used to track the progress of infrastructure recovery following disasters. Chen et al. [48] used social media metrics to identify highways that recovered quickly from Hurricane Harvey as well as those where recovery was slower [48]. Text classification and topic modelling based on Latent Dirichlet Allocation (LDA) and K-Means clustering have also been used successfully to summarise infrastructure-related topics on Twitter, providing a capability to track the performance and conditions of infrastructure across different disaster phases [49]. Local spatial autocorrelation has been demonstrated to be useful in detecting the hot spots and any temporal anomalies [52]. In a recent study, Fan et al. [51] developed an integrated textual–visual–geo framework that relied on an image-ranking algorithm to identify relevant social media images, while the geographical extent of the disruption relied on kernel density estimation. The usefulness of the framework was successfully demonstrated by leveraging social media (Twitter) data to capture both the physical disruptions and the societal impacts of infrastructure failures associated with water release from two flood control reservoirs during the 2017 Hurricane Harvey in Houston, USA [51]. The results of these findings from social media data, including maps showing locations and severity of damage, can be validated through other data sources such as official government reports, news articles, web portals, photos, interviews, and the US Geological Survey (USGS) intensity report [48,54]. Practitioners can use the results of impact assessment to enhance the effectiveness of decision making and the priority allocation of limited resources to restore infrastructure services after disasters occur [45].

Social media is a vital communication infrastructure useful for both supporting disaster recovery and for helping reveal vulnerabilities, recovery progress and challenges. Given the vital role of social media data in recovery from disasters, it is important to identify and address any issues of participation that could potentially undermine the availability of the required citizen-generated social media content. Several studies have revealed how patterns of social media usage may be a useful indicator of community vulnerability and resilience. In a recent study, Wang et al. [55] examined the correlation between social media use patterns and resilience indicators that are vital to disaster recovery, including percentage of households with telephone access, median income, percentage of households with no vehicle, etc. The case study utilised Twitter data related to Hurricane Isaac, USA. The results showed a strong correlation between Twitter use and resilience indicators. Communities with higher Twitter use tend to have better social–environmental conditions and therefore have a better chance of recovering from disasters [55]. There were geographical and social disparities in the use of Twitter, which in turn could have affected the recovery effort of communities [55]. In general, Twitter use was observed to have declined during the recovery phase of the disaster [55]. Page-Tan [56] investigated the relationship between social

media activity and post-disaster recovery from Hurricane Harvey. The study, which focused on the Nextdoor social media platform, reported that the communities which were active on Nextdoor were more likely to recover at a faster rate than communities that were less active on the social media platform [56]. In a study aimed at understanding the extent of infrastructure damage and recovery from Hurricane Michael, the authors, Dhakal and Zhang [57]; found that geographical locations with higher tweeting activities tend to have significantly higher disaster damage and recovery efforts. Socially vulnerable communities with poorer socioeconomic status (e.g., income, housing value, education level) were less active on social media and therefore had a longer recovery time [57]. This is because of poor access to information (internet, cell phones, social media) and resources (aids, disaster relief organisations, volunteer groups) needed to support recovery [57]. It is therefore vital that the government ensures all citizens have adequate access to resources and information required to support their recovery from disasters.

Few studies have focused on how the government uses social media to support citizens during reconstruction and recovery from disasters. Tagliacozzo [21] surveyed and interviewed officials from recovery agencies in order to understand how the government used social media to communicate with citizens during the long-term post-disaster reconstruction that followed the 2010 Canterbury and 2011 Christchurch earthquakes in New Zealand. The results showed that social media was vital in many ways, including the dissemination of information about reconstruction to citizens, responding to citizens' queries and comments, and creating awareness about available grants to support reconstruction [21]. However, the communication was mainly one-directional, from government to citizens. The research participants expressed the need to do more in terms of using social media communication to facilitate stronger community engagement and participation [21]. A similar study by Tagliacozzo and Magni [22] also focused on Government to Citizen (G2C) social media communication to support post-disaster reconstruction activities after the 2012 earthquakes that occurred in Emilia-Romagna, Northern Italy. The findings from field notes and surveys revealed that government agencies mainly utilised social media to disseminate information about housing, infrastructure reconstruction, and funding opportunities [22]. Again, the use of social media for community engagement and G2C bidirectional communication was very limited [22]. Opdyke and Javernick-Will [58] investigated the role of social media platforms as a coordination mechanism for long-term post-disaster reconstruction to improve the recovery process. The study is uniquely interesting because it focused on long-term recovery, with emphasis on the built environment. Results from analysing post-disaster Twitter data from Super Typhoon Haiyan (a.k.a Yolanda) showed that NGOs were very instrumental in establishing connections between government entities and the public at large. Organisational use of Twitter focused on three broad areas, including the needs of communities, particularly from a funding standpoint (30%), response of the organisations in terms of the range of support they provide to disaster-stricken communities (50%), and the impact in terms of how the support provided by organisations is making positive changes to communities (15%) [58].

Any changes within disaster-stricken communities, including information updates and recovery activities, can be monitored by evacuees who often remain connected to the community through social media networks. The sentiments and type of information shared on social media can influence evacuees' decisions to either return to rebuild or relocate elsewhere. Jamali et al. [59] explored social media data (109 million geotagged tweets from the period October 2012–October 2014) to understand residents' decisions as to whether they would rebuild or relocate in the two years following Hurricane Sandy. The study employed a suite of techniques such as machine learning algorithms, Pearson's correlation, and Moran's I statistics to establish linkage between users' discussion topics and their housing recovery decisions [59]. The results revealed that communities with more tweets about social interactions and fewer tweets related to infrastructure and assets were more likely to rebuild rather than relocate. Whereas communities that sent more tweets related to the topic of infrastructure and assets were more likely to relocate rather than rebuild. The findings were validated with real estate information, including the owner's name of each tax lot, as obtained from the Primary Land Use Tax Lot Output (PLUTO). This information helped to determine if there has been a change in ownership within the period investigated. A change in ownership was used to indicate that the original owners had relocated. The results suggest that the immediate restoration of infrastructure following an extreme natural event, especially in communities with a higher concentration of discussion on the topics of infrastructure and assets, can lead to fewer relocations and considerably higher rates of reconstruction within the area [59]. Financial and faith-based discussion topics had insignificant correlation with the decision to relocate [59]. The inclination to rebuild grew stronger as time passed [59].

3.2.4. Social media use for socioeconomic and physical wellbeing during disaster recovery

Socioeconomic and physical wellbeing are vital to the recovery of disaster victims. While physical wellbeing is mostly related to health and wellness of the individual, socioeconomic well-being is more concerned with livelihood opportunities such as income, employment, housing, food, etc. In other words, socioeconomic well-being is linked to quality of life – the extent to which people are comfortable and able to enjoy life. There is not much research looking at the use of social media for monitoring the physical wellbeing (e.g., health recovery) of victims who have suffered bodily harm during disasters. People may not find sufficient motivation to share their personal health recovery journey publicly on social media, however with COVID-19, this is slowly changing. Mackey et al. [60] recently employed the biterm topic modelling technique to analyse COVID-19-related Twitter data in the USA. The results showed that less than 1% of the COVID-19-related tweets contained both first- and second-hand information relating to symptoms, testing, and health recovery. Despite this small percentage of health recovery related tweets, it is hoped that these findings will inspire future infoveillance efforts, exploring social media to monitor health recovery from disasters.

Social media also has the potential to be used in monitoring other socioeconomic necessities that are vital to understanding progress in recovery. Twitter data has proven to be vital in revealing the priorities of victims recovering from disasters, including their socioeconomic necessities such as housing, medical supplies, clothing, and relief packages [61]. The request and access to relief packages such as food items can be harnessed from social media to understand the socioeconomic recovery of disaster victims, both in developed and developing nations [62]. By monitoring the frequency of food-related terms in Twitter data from several disasters in the

USA, Niles et al. [62] established the importance of food in the socioeconomic recovery of disaster victims and the role that social media can play in monitoring food-related aspects of recovery. Social media public sentiment on the housing and used car markets can also be monitored as indicators of socioeconomic recovery from disasters. The underlying notion is that the demand for used cars and housing increases in disaster-impacted communities when the socioeconomic recovery of victims begins to improve [63,64]. Analysis of Facebook and Twitter data from previous disasters in Japan, including earthquakes, hurricanes, and tsunamis has shown excess demand for used cars during the recovery phase of the disasters [65]. Similarly, there was an increase in the leasing price for houses located within 3 km to the building damage zone due to lots of people needing housing [65]. These findings reinforce the notion that the used car market and the housing market can both be used as proxies for socioeconomic recovery. Real time monitoring of social media communication, including the demand for used cars and housing, can therefore provide situational awareness about socioeconomic recovery from disasters.

Housing information and related sentiments expressed on social media can also be useful for monitoring socioeconomic recovery when the focus is geared towards understanding the rate at which evacuees return to their homes. Ideally, we want to see more displaced victims return to resettle in their homes. In this regard, Yabe and Ukkusuri [66] analysed mobility data and Twitter sentiments to understand the factors that influenced the returning behaviour of evacuees after Hurricane Sandy in the USA. The results showed that there is a strong association between returning behaviour and sentiments in social media messages posted near the individual's residential location or those posted by online connected peers. More than 30% of the evacuees were yet to return to their homes even after 10 days from the hurricane. The study concluded that the return rate of displaced victims of disasters decreases exponentially with distance to the evacuation centre or temporary residence. This may be due to the cost associated with travelling back home as this cost is likely to increase with distance displaced. A similar study explored predictive modelling techniques to investigate how the information posted on social media (Twitter) influenced people's relocation decisions in the USA during the recovery phase of Hurricane Sandy [67]. The results showed that information posted by the crowd influenced post-disaster mobility decisions more than information disseminated by official accounts [67]. This result is consistent with a previous study by Niles et al. [62]; who found that it is "everyday" people who are mostly involved in disseminating disaster-related information, not necessarily influential individuals, or organisations with high numbers of Twitter followers. The supplementary material associated with this article contains a summary of other studies that have some relevance to social media use for socioeconomic and physical wellbeing.

3.2.5. Social media use for information support during disaster recovery

Social media can be used to support the information needs of people who are recovering from disasters. It can help to improve situational awareness, enhance communication, and support disaster-impacted communities with the information they need to make informed decisions about their recovery. During the 2014 Hazelwood mine fire in Victoria, Australia, Facebook was used in ways that revealed a lot about the critical role that social media plays in disaster recovery [68]. Social media communication was vital in empowering the community to cope with and recover from the crisis [68]. This happened not just through social connections and timely access to accurate information, but also through the replacement of individual helplessness with a channel to express concerns and enable control and personal/collective responsibility [68]. It has become obvious that social media communication has huge potential to reveal the needs and concerns of the public in the aftermath of disasters.

A growing body of research is concerned with analysing social media crisis communication to gain situational awareness and help authorities stay informed about the recovery needs and concerns of the public. This exploration of social media data is promising because of big data driven methodologies (e.g., lexicon-based approach) that can support real-time categorisation and classification of social media content for disaster response and recovery [69]. The Twitter Situational Awareness (TwiSA) framework, for example, can be used to mine social media data to understand public concerns in the response and recovery phases of natural disasters [70]. A case study involving the 2015 South Carolina flood demonstrated the usefulness of TwiSA to reveal people's concerns during the disaster [70]. The most frequently discussed negative messages were those related to 'victims', 'damages', 'drinking water', 'insurance', 'flood report', 'power loss', 'homelessness' and 'animals', in that order [70]. Similarly, Sovacool et al. [71] analysed Twitter data to categorise the content and examine the themes of each category in order to uncover public opinions and social issues in responding to and recovering from hurricane Irma. The most frequent categories of messages were: (i) reporting own experience (19%) such as power loss and lack of restoration, perception of needs, lack of access to supplies, safety updates; (ii) impact (17.3%) such as magnitude of power loss, fallen trees, flooding, debris, and other damages; (iii) commenting on news coverage (15.9%) such as praise or criticism of coverage, too much coverage of the event, and restriction of non-hurricane content; and (iv) expressing thanks and well wishes (8.8%). Recovery only accounted for 4.7% of the messages, including financial aspects, closure and reopening of schools, businesses, and gas stations.

In mining social media data for situational awareness and areas of recovery needs, it is important to consider both spatial and temporal factors. The hybrid machine learning pipeline proposed by Fan et al. [72] has shown to be useful in understanding the spatial and temporal evolution of Hurricane Harvey in Houston, including situational awareness and a classification of posts into different humanitarian categories (e.g., infrastructure and utility damages, rescue and donation, and injured victims) as needed to support disaster response and recovery. A good understanding of the spatio-temporal evolution of a disaster is vital to identify geographical locations where specific aid is urgently needed. This has motivated a study to explore lexical choice as a measure of urgency in social media crisis communication [73]. The research, which used Hurricane Harvey in Houston as a case study, analysed over 250,000 tweets for relative frequency of antonym pair parts as compared with a reference corpus of general internet English [73]. This was needed to test automatic identification of areas of need during disasters [73]. Lexical choice between antonyms showed that social media capture wide-ranging 'breaches' of normal functioning [73]. The study recommended that antonym selection should be built into screening tools for identifying relevant content [73]. The technique could enable disaster management professionals to identify

relative levels of urgency and deploy recovery aid with more precision regarding the spatial and temporal frames of reference [73]. However high-level precision is only possible when there is a large volume of social media data from which to draw for analysis. The question, however, is whether the high volumes of social media data generation can be sustained as time progresses from disaster response to long-term recovery needs.

Interestingly, few studies have begun investigating crisis communication on social media to ascertain issues relating to the drop-off of messaging volume or social engagement across the disaster management cycle. For example, Yeo et al. [14] investigated Twitter usage during the 2016 Southern Louisiana flood to understand disaster recovery communication behaviours, including the patterns and characteristics of long-term recovery communication. The study found that social media recovery-related messages tend to decline with time, with communication dropping significantly and lacking local voices during the long-term recovery process [14]. Similarly, Yan and Pedraza-Martinez [74] explored social media data to investigate the effect of information exchange on social engagement during disaster preparedness, response, and recovery. The study reported that the effect of information on social engagement increases from preparedness to response and decreases from response to recovery [74]. However, the effect of 'actionable' information reaches its lowest point during disaster response. Organisations can therefore improve the social conversation with users by posting more (official) actionable information for those willing to help disaster victims [74]. But how well do emergency organisations and government agencies engage with citizens on social media platforms?

Some interesting findings have been reported on how government and non-government organisations communicate with citizens during disasters. Analysis of social media use during the response and recovery phases following Hurricane Harvey, revealed communication gaps between government organisations and citizens, which can be improved through regular updates, including information on infrastructure status, availability of shelters for citizens, and volunteering activities [75,76]. Though generally more active than government organisations, users from non-government organisations often participate through retweeting, mentioning, and commenting on disaster-related tweets of other organisations, particularly those of government organisations, instead of posting by themselves [75]. Liu et al. [77] analysed the Twitter networks and communication of 67 government and emergency management organisations to understand how they engaged with the public during and after Hurricane Harvey. The study focused on how these organisations used three strategies in their communication, namely instructing information, adjusting information, and bolstering [77]. Bolstering is a strategy to boost morale, build solidarity, and promote a sense of togetherness amongst community members [77]. Bolstering can be achieved through the expression of sympathy towards disaster victims and the rendering of praise to deserving partners or citizens [77]. Instructing information is the practice of reporting crisis-related information (e.g., warnings) to guard the public against disaster risks [77]. Adjusting information is used to facilitate the coping of psychological stress and threat, including the use of hopeful words, sympathy, and the assurance of the public about any corrective actions [77]. The results of the study revealed that government agencies used the strategy of instructing information predominantly in the preparedness and response phase of disasters, whereas adjusting information and bolstering strategies were utilised more during post-disaster recovery [77].

3.2.6. Social media use for mental health & emotional support during disaster recovery

Studies relating to mental health and emotional support discussed the use of social media for expressions of negative emotional response as well as recovery from disaster. Social media use in these studies was in response to hurricanes, a power outage, massacre, shootings, earthquake, bombing and COVID-19. Negative responses, such as the expression of fear, stress, disgust, the stages of grief, sadness, and confusion were found in some studies [78–82]. However, more concerning symptoms such as trauma, sleep disorders and depression were also reported [78,83,84]. In the study by García-Ramírez et al. [78] following Hurricane Maria, more than half of the tweet sample (55%) focussed on coping with trauma.

The expression of emotions in social media can change or resurface over time [80,81,85]. For example, social media can be used to relive events through "trauma anniversaries". In the study by Song and Xu [85]; several years after the Nanjing massacre, emotions including sadness (73.3%), anger (16.2%) and fear (6.9%) were present. In this study, connecting with those who are like minded in their negative emotional response was important [85], however, other studies also indicated that geographical and social proximity of users played a role in the extent of expression shown in terms of positive and negative responses [82,85,86]. The contemporary and ongoing effects of COVID-19 pandemic will allow for longer term assessment of mental health in social media through tracking the expression of stress, anxiety, depression, and suicidal thoughts on a larger scale [84]. This includes the short- and long-term impacts of isolation and job losses [84].

Examining social media coping behaviours such as actions, seeking information, social support giving and seeking, as well as avoidance, is needed by governments and stakeholders to understand how community resilience can be leveraged [87]. Social media's role in the identification and mobilisation of coping strategies identified in this review ranged from decreasing boredom, confrontation, seeking out the support of others and humour [78,82,87–89]. While social media use can correlate positively with the community's emotional response [90], the broadcasting of activities such as civilians directing traffic or sharing food post-disaster can evoke a sense of community pride, supporting the recovery response [91]. Similarly, the use of social media to express feelings, stories and develop emotional bonds supports personal and community resilience. Humour was also identified as an individual and collective coping strategy [88]. This was seen through memes to mitigate stress during COVID-19 and used to reframe a user's response to a situation or context [88].

3.2.7. Social media use for supporting business & economic activities during disaster recovery

Social media can also be explored to support the economic recovery of disaster-impacted communities. Central to the economy are the businesses operating locally in the disaster-impacted communities. These businesses provide employment. Any large-scale job losses arising from disaster impacts on businesses could potentially undermine consumer spending power, further damaging the

economy. Studies have so far focused on the use of social media for supporting tourism, agriculture, and other business activities that are fundamental to the economy of disaster-affected communities [92–95].

Tourism is by far the most studied business activity in the literature concerning the role of social media for supporting business and economic recovery Yan et al. [92] used geotagged Twitter data to appraise the post-disaster recovery of tourism destinations by examining people's sentiments and perspectives regarding recovery status after a series of earthquakes in Indonesia. The results revealed that social media can uncover the variation in people's sentiments and perspectives around general and specific issues regarding post-disaster tourism recovery over time, including in relation to housing reconstruction progress, tourism recovery status, and living conditions in the affected areas [92]. In another study, Yan et al. [96] proposed a workflow for using geotagged Flickr photos to assess tourism recovery in post disaster areas. The effectiveness of the technique was demonstrated with a case study involving the 2013 Bohol earthquake and the 2013 Haiyan typhoon in the Philippines. The findings indicate that the proposed technique can be useful in extracting information about the post-disaster recovery status of infrastructure and trends in tourist flows [96]. A similar study investigated the role of social media in the tourism recovery of disaster-hit areas [93]. The study was based on using time-series regression models and text-mining techniques to analyse Twitter data relating to a 2011 tsunami and earthquake in Tohoku, Japan [93]. The results showed that the information shared by government authorities on social media has significant, but varied, impacts on the influx of different types of tourists. More specifically, messages with information on cultural and natural heritage had a positive relationship with the number of incoming ordinary tourists, while messages with information on disaster-related words had a negative effect. In contrast, messages with information on tourism resources had a negative effect on the number of volunteer tourists who visited to help rebuild, while messages with information on rehabilitation/reconstruction and on volunteering had a positive effect [93].

To monitor recovery, a couple of studies have focused on exploring social media data to understand the movement of tourists in and out of disaster-impacted tourism destinations. Martín et al. [97] recently analysed geotagged Twitter data to track population movements to and from Puerto Rico after Hurricane Maria. The results showed that 54.6% of those evacuated by the 2017 hurricane had returned to Puerto Rico by May 31, 2018 (nine months after the disaster). However, 3.8% of the Puerto Rico population had migrated without returning. These findings are in line with the United States Census Bureau statistics that reported 3.9% of the population to have been displaced [97]. In terms of tourism activities, the study found that as of August 31, 2018, Puerto Rico had not recovered to pre-disaster levels of non-resident visitors [97]. These findings indicate that social media can potentially complement census and survey techniques in estimating the magnitude, timing, destination, and return of the displaced residents, as well as the number of visiting tourists. Similarly, Ai and Gursoy [98] investigated the effects of social media posts on recovery management for tourism destinations after natural disasters. The study analysed the impacts of Weibo and WeChat posts on potential visitors' perceptions and their willingness to visit tourist destinations in China following a 7.0 magnitude earthquake [98]. The results indicated that individuals who share information from disaster sites tend to focus on the most damaged areas [98]. This messaging can cause secondary damage or slow down the recovery for the destination by decreasing potential tourists' willingness to visit [98]. These findings emphasize the role of social media posts in relation to tourism as a component of economic recovery for many disaster-impacted communities and the importance of actively monitoring social media [98].

Social media activities of small businesses are also of interest to researchers because they can reveal recovery from major disasters. An analysis of Facebook data generated by small businesses, in response to flooding in the Boulder, Colorado area of the USA, reveals that small businesses are engaged in social media activities in the preparedness, response, and recovery phases of disasters [99]. The results of the study showed that small businesses used Facebook to post about road closures, clean up activity, disaster relief, and other information such as mental health impacts [99]. A recent study by Eyre et al. [100] also explored Facebook data to estimate the post-disaster recovery status (i.e., downtime of economic activities) for small businesses in urban areas. This was achieved by comparing the time series of the number of social media posts by small businesses in the period after the disaster with their typical posting activity before the disaster. The framework relies on the assumption that businesses tend to publish more posts when they are open and fewer when they are closed. Hence, by analysing the aggregated posting activity of a group of businesses over time, it is possible to infer when they are open or closed. When there is lower than average posting rate or when posting activity is significantly below the characteristic range of normal activity fluctuations, this is an indication of downtown [100]. A case study involving earthquake and hurricane impacts in Nepal, Puerto Rico, and Mexico showed that the posting activity of small businesses on social media can be used in real time to estimate the recovery status of regions hit by disasters [100].

As well as shaping tourist responses following disasters, social media can also be used to harness the spending power of geographically distant communities to support small businesses and facilitate economic recovery in disaster impacted communities, particularly those heavily reliant on tourist dollars, through supportive purchasing campaigns. Two such examples are the recent Australian "Spend With Them" and "Buy From The Bush" social media campaigns to support businesses in bushfire, flood and drought impacted communities. However, to date there has been little research exploring the role of social media in this type of post-disaster economic recovery activity.

Some other studies have focused on social media usage within specific sectors such as farming, construction, and the hotel industry. For example, Möller et al. [94] explored how social media (Twitter) was used by hotels following Tropical Cyclone Winston in Fiji. The study found that social media was underutilised in preparing and responding to disaster, but it played a crucial role in fundraising and donations during the recovery phase [94]. Similarly, Ahmed et al. [101] investigated social media usage of the construction industry during the response and recovery phases of disasters. The results revealed that the key topics of interest to the construction industry during the recovery phase of Hurricane Michael included construction safety, project closure, and employment opportunities [101]. In another recent study, the authors examined the effects of social media on the livelihood capitals and resilience of farmers to recover from climate change drought disaster [95]. The study found that social media has a direct and indirect positive and significant effect on

the farmers' resilience behaviour through livelihood capitals [95].

4. Research gaps and suggestions for future research

This section highlights some of the key research gaps made evident through the review and identifies some of the emergent possibilities for future research work in this space. While the body of research around social media use for disaster recovery has expanded significantly in recent years, there is a need for further research to explore different geo-cultural, disaster, and digital media contexts, and develop a deeper understanding of the various dimensions and phases of disaster recovery.

There is a clear geographical bias reflected in the current body of literature, with much of the research around social media use for disaster recovery concentrating on the North American context. Further work should examine how social media can support recovery across a wider range of country and cultural contexts, in both the Minority and Majority world. Some countries that are especially prone to natural hazards, such as Bangladesh, are noticeably absent in the studies reviewed. There is also a need to further explore how social media is useful for recovery across the range of different disaster types. Importantly, different kinds of disasters have varied spatio-temporal scales and impacts, with notable implications for how social media can be used to monitor and support recovery. Some disaster types such as droughts and bushfires are significantly under-represented in the existing literature, particularly when considering their potential impacts and likelihood of occurrence.

Alongside the need to better reflect the distribution and diversity of disaster types, future research efforts might seek to better account for differences in social media use among different socio-demographic groups and explore the emergence of new social media platforms. Social media usage, including platform choice varies across age cohorts. There is a particular need for more research focused on social media use for disaster recovery among young people. As the social media landscape evolves very rapidly, new research is needed to examine the role of emergent platforms, such as Tik-Tok, that are growing in popularity (particularly among youth, who are often early adopters).

As noted earlier certain important dimensions of disaster recovery remain under-researched. Much of the research to date has focused on the very early stages of recovery and future research efforts should pay greater attention to longer-term disaster recovery. There also appears to be very little work around the role of social media in supporting ecological recovery from disasters. This is surprising in light of the significance of environmental devastation following many disasters and the role that ecological repair and restoration can play in human recovery. Animal welfare, particularly in relation to pets and wildlife, is currently lacking in social media use for disaster recovery. Future research could look at how to harness social media to better support people with the vital information needed to safely provide first-aid, food, water, and comfort to animals that have been injured or displaced by disasters.

There is also a need for more research on how social media can support real-time monitoring of economic recovery and business activities in disaster-impacted communities. Disasters can often result in the loss of experienced workers, decline in consumer spending power, a depleted customer base, and population shrinkage associated with evacuation or relocation. Future research could investigate how social media data can be used in post-disaster recovery for real-time monitoring of some of these factors, including any loss or gain in business confidence. Importantly, there is a need for future research to explore the use of social media in monitoring the effects of government grants, concessional rate loans to small businesses, and other stimulus packages on the economic recovery of disaster impacted communities.

Particular priority areas for future research regarding certain disaster types, socio-demographic cohorts and social media platforms emerge in relation to different countries and digital media contexts. For example, in the Australian context there is a need for much more work on the particular hazards of bushfire, flood and drought. The devastating 2019/20 Australian bushfires were unprecedented in their magnitude, emerging as a priority area for Australian researchers engaged in this research space. Careful attention should be paid to the politicisation of disasters through social media conversations and how this impacts on community recovery, particularly in relation to climate change attributions and government inaction. These are important issues that affect solidarity and social cohesion during the disaster recovery phase.

Similarly, the scale and scope of the impacts of the ongoing COVID-19 pandemic position this as an important area for future investigation. Social media activity around the global pandemic will be a very rich source of data for future research on recovery and presents intriguing research possibilities. Significantly, this review encourages methodological diversity and interdisciplinary approaches in future research exploring social media use as a source of data for monitoring recovery progress and as a tool to support recovery efforts. Use of diverse methods and research frameworks is useful for validating findings and building convergent evidence and allows for the fact that different social media platforms and aspects of recovery require different types of analysis.

5. Conclusion

This study has reported findings from a systematic literature review that focused on social media use in disaster recovery. A comprehensive picture of the current research landscape has been provided in this review to inform different groups who may want to explore social media for disaster recovery. The review included 108 articles written in English and published online before the cut-off date of July 8, 2021. The findings suggest a growing research interest in social media for disaster recovery, although much of the existing research (55.6%) has focused heavily on the USA. Countries such as Japan, The Philippines, and China also had significant representation in the literature. Overall, Twitter topped the list of platforms used, appearing in 65% of the studies, followed by Facebook at 16%. The situation was different in China, where Weibo and WeChat were the most predominant social media platforms used in research around disaster recovery. Social media was used to support recovery from a wide range of disasters, but the most predominant disasters reported in the literature were hurricanes (33%), earthquakes (20%), floods (12.7%), and typhoons (7.6%). The ways in which social media was used and the associated findings were discussed in relation to various aspects of disaster recovery,

including (1) donations and financial support, (2) solidarity and social cohesion, (3) post-disaster reconstruction and infrastructure services, (4) socioeconomic and physical wellbeing, (5) information support, (6) mental health and emotional support, and (7) business & economic activities. The study culminated in the identification of some key research gaps and suggestions for future research directions, including research opportunities associated with recent large-scale disasters such as the COVID-19 pandemic.

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.

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Appendix A. Supplementary data

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