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Message Strategies of Emergency Management Organizations during Severe Weather Effects

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Abstract. This study examined the strategy and effectiveness of social media warning messages disseminated by three Greek public organizations during severe weather events, 112.gr, the Fire Brigade (FB), and the General Secretariat for Civil Protection (GSCP) regarding severe weather phenomena in a certain timeframe. Utilizing content analysis based on the Warning Response Model (WRM), 156 messages from Twitter were analyzed. We investigated the impact of factors such as threat description, protective action guidance, the inclusion of location and timeframe information, the identification of the message source, and variations in message framing. The research concludes that there are significant variations in framing and effectiveness across the organizations. Results reveal that 112.gr, despite having the smallest follower base, achieved the highest user engagement, attributed to its emphasis on actionable instructions and location-specific information. We found out that these elements significantly enhanced engagement, as measured by favorites and retweets, underscoring the role of content clarity and relevancy in public responsiveness. This research offers critical insights for refining warning message strategies to improve public safety during severe weather, contributing to refining warning message strategies and improving public safety during severe weather events in Greece.

Keywords: Risk communication, warning messages, social media, warning strategies, protective action guidance, message elements, Early Warning Tool, WRM, Message effectiveness, Account engagement.

1. Introduction

Reuter et al. (2016, 2018) and Reuter and Kaufhold (2017) categorize social media usage during disasters into four communication channels: authority-citizen exchange, citizen self-help communities, inter-organizational crisis management, and authority evaluation of citizen-provided information. Social media platforms like Twitter can provide valuable real-time insights into public concerns during natural disasters, enabling disaster management organizations to develop more responsive and effective crisis management plans (Karami et al., 2020). However, the existing

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body of research lacks a comprehensive overview of current social media practices in disasters, limiting the ability of various groups to fully utilize these platforms (Ogie et al., 2022).

Despite these diverse applications, the primary use of social media during crises remains the acquisition and redistribution of information (Reuter et al. 2016). While studies have explored social media's role in crisis communication, very few have focused on message structure and the direct effects on engagement and user responsiveness, (Reuter & Kaufhold, 2017), particularly within the Greek context (Yli-Kauhaluoma et al., 2023).

This study aims to examine warning message elements disseminated by Greek public organizations. We will also investigate the impact of these elements on user engagement and explore variations in message framing across different emergency management organizations.

2. Twitter as an Early Warning Tool

The real-time nature of Twitter and its broad reach make it a valuable tool for sending early warnings in emergency situations. Studies have shown a significant increase in the use of Twitter during natural disasters and emergencies, such as Hurricane Harvey in 2017 (Debnath et al., 2022, Berglez & Al-Saqaf, 2021). Through social networks, citizens can participate in open exchanges of views and information about climate phenomena. Social media has disrupted traditional channels of communication, such as journalists and media editors, political parties and the academic/scientific community, while increasing the ability of individuals to reach large numbers of people. This has allowed citizens to play a much larger role in shaping public discourse on issues such as climate change (Berglez & Al-Saqaf, 2021). In disaster situations, first responders and citizens sought and shared information through this tool (Ford, 2018; Roy et al., 2020).

The ability of this platform to disseminate information in real time has proven invaluable in various crises, including the Great East Japan Earthquake in 2011, where Twitter served as a reliable channel of communication amid overloaded telephone networks (Kenyi, 2022). Other research has shown that National Services use Twitter to communicate severe weather warnings and instructions for taking preventive measures in real time, which can be especially useful during rapidly evolving events such as tornadoes (Liu et al., 2019). Maps, narratives, and multimedia presentations can be powerful tools in enhancing public awareness and fostering accurate perceptions of flood risk (Bodoque, 2019). By engaging public bodies in networks such as Twitter, preparedness awareness efforts can be enhanced, protective action behaviors can be promoted, and dialogue through disaster messaging can be improved (MacIntyre et al., 2019). Furthermore, online platforms allow the public to engage in interactive communication to facilitate a sense of community and seek support during natural disasters (Fraustino et al., 2018). However, without dialogue, social media only functions as a one-way means of communication (Kent & Taylor, 1998).

While research highlights the significance of social media during emergencies, further investigation is needed to understand how these platforms can be most effectively utilized throughout the various phases of a crisis (Panagiotopulos et al., 2016). The added value of this research is that accepting there is no one-size-fits-all approach to communicating uncertain risk information effectively, as Bostrom et al. (2018) noted the best method for quantitatively communicating uncertain risks is multidimensional, with few guidelines that could fit in different cases of disruptive events, we are suggesting a localized and directed review in the Greek context.

Accuracy and reliability of information during disasters is paramount, as poorly written or inaccurate messages can reduce recipients' trust in public organizations and negatively affect preventive measures (Coombs, 2010). The study by Liu et al. (2020) revealed that different types of crisis narratives in social media can shape people's emotional reactions, information-seeking strategies, and willingness to take protective measures during a crisis. Narratives that evoke sadness, such as stories of victims or heroes, may be more effective in prompting information seeking and protective actions than narratives that focus on the specific disaster. It could be argued, that certain messages get more retweets than others. Message content reference to hazard impact and hazard severity, governmental activities, or guidance for protective actions augments the possibility to be retweeted and therefore the warnings to earn the spreading effect of the dissemination of information (Sutton et al. 2015).

Trust and credibility are critical factors in the effectiveness of Twitter warnings. Reuter and Spielhofer (2017) found in a survey conducted in Europe that citizens who use social media during emergencies question the reliability of information and often believe that there is a possibility that it is fake news or exaggerated reactions by public bodies. This result highlights the need to build trust between the public and public organization accounts on Twitter. Verification of information from sources and official bodies is necessary to ensure the accuracy and reliability of warnings in emergencies. The public's perception of the reliability of information shared on social media platforms such as Twitter is also influenced by factors such as prior experience of emergency exposure, source credibility, message consistency, and the presence of supporting evidence (O'Donnell, 2023). Twitter can be leveraged to enhance situational awareness, facilitate emergency response, and strengthen public trust during crises.

Exposure and attention are critical steps of protective action decision making (Eachus& Keim, 2020). A substantial body of research on public warning systems has identified specific characteristics of warning messages that influence public perception and response. These characteristics include message content, style, context, and receiver factors. Effective warning messages that motivate timely and appropriate protective action typically incorporate five key elements: hazard, location, guidance, time, and source (Mileti & Sorensen, 1990). Specifically, an indication of the severity of the risk should always be added, such as the alert level or a description of the expected intensity of the phenomenon. Clear, specific, and practical instructions on what citizens should do to protect themselves should be provided. For example, instead of "limit travel," it could state "avoid travel unless absolutely necessary." Research showed that photographs and

geographically specific messages are popular wherever possible (Eachus & Keim, 2020), visuals such as maps showing affected areas or images depicting the hazard should be used instead of a standardized list of instructions. Effective disaster response relies heavily on precise spatial data to identify the secondary consequences of a disaster and the location of those affected (Shankaret al., 2019). Links to additional information or resources, such as websites or helplines, should be provided.

3. Warning Response Model

The theoretical underpinnings of this research are grounded in the principles of the Warning Response Model (WRM). The WRM emphasizes the inclusion of specific message elements—hazard, location, time, source, and guidance—to enhance the effectiveness of warnings in prompting protective actions (Mileti & Sorensen, 1990). As highlighted in Sutton et al. (2023), WRM serves as a valuable framework for evaluating the completeness and clarity of warning messages and offers a structured approach to crafting messages that are clear, concise, and actionable. The Warning Response Model (WRM), initially proposed by Mileti and Sorensen (1990), has emerged as a cornerstone in the field of risk communication, providing a systematic framework for the design and evaluation of effective warning messages. The WRM's efficacy in guiding the creation of messages that elicit timely and appropriate protective actions has been widely recognized and empirically supported (Olson et al., 2024).

The model's emphasis is on the inclusion of five key content categories such as hazard where the type of imminent threat must be named so the recipients start to assess their actions. Location information where it is specified who is and who is not at risk for experiencing a hazard's consequences, as well as who needs to take protective action (Wood et al., 2018). The way in which a location is described within a threat message, and the level of detail provided, can significantly enhance both the recipient's comprehension of the message and their perception of the threat's personal relevance (Olson et al. 2024). Specifically, precise location information aids individuals in determining their proximity to the hazard, thereby bolstering their confidence in the message's applicability to their situation (Doermann et al., 2021). Timing details in threat messages are vital, conveying when a hazard is expected and its duration (Mileti & Peek, 2000; Sorensen, 2004). They also guide when to take and for how long to maintain protective actions (Mileti & Sorensen, 1990), and indicate when the message itself expires (Mileti, 2018). The source indication remains an important factor that affects the message credibility and increases the chances of being followed (Bean et al., 2016) especially when acronyms and jargon are not included (Sutton & Kuligowski, 2019). Lastly, guidance that helps the public take preventive action measures is often more important than the information of the actual threat (Wood et al., 2012). Furthermore, the WRM underscores the importance of message style, advocating for clarity, specificity, consistency, accuracy, and certainty in the language used (Sutton et al., 2023). The model's comprehensive approach to message design, encompassing both content and style, has proven instrumental in

enhancing the effectiveness of warnings across a diverse range of hazards, contributing to increased public safety and preparedness.

Based on the above, the present study aims at achieving the following objectives:

1. To what extent are the messages sufficient in the presence of all the elements of the WRM?
2. Are there any variations with respect to the presence of WRM elements on posts of different emergency management organizations?
3. Do emergency management organizations differ with respect to their message effectiveness?
4. Which elements of the model are the most effective in triggering user engagement?

4. Methodology

To achieve the goals of this study, we utilized the method of content analysis of early warning messages to draw conclusions. Based on the theoretical foundations of content analysis, as described by Krippendorff (2022), a systematic approach was adopted to quantify and interpret the messages. Given the nature of early warning messages, which often require rapid dissemination and understanding, a quantitative content analysis approach was used, aligned with the framework presented by Riffe et al. (2021). This includes the development of a structured coding scheme for identifying and categorizing key elements of the message.

For the research, posts on twitter were retrieved from three Public Organizations charged with the responsibility of early warning in cases of severe weather events: the General Secretariat for Civil Protection (GSCP), the 112 Emergency number system, and the Fire Brigade (FB). Messages were collected for the period 1/9/2023 to the first semester of 2024. In the case of the FB account, the start time was 19/1/24 to 4/3/2024 as previous messages were not visible. 20 messages were collected from the PS account, 61 from the GSCP account and 75 from the 112 account. A total of 156 messages have been analyzed. It is noted that an attempt was made to collect relevant notifications of extreme weather bulletins from the National Meteorological Service (NMS), however there were no posts during the search period, and links in older posts did not lead to a result. For data collection, reposts of accounts between them and all those not related to severe weather events were excluded.

Messages were analyzed according to date of publication, presence of image or video, hashtag for location tracking, and use of mention. We also collected quantitative data to measure the engagement levels of posts such as the number of favorites, and comments. This was mainly done to evaluate the effectiveness of messages (Sutton et al. 2024; Wood et al. 2017). We also measured the number of retweets of the messages and related the with the impression score of each message. Each message was also analyzed based on Mileti and Sorensen's (1990) six basic types of warning message content that motivate people to take timely and appropriate protective action in response to a warning message, which are referred to as WRM. These types were the following:

1. Description of the threat/event (i.e., the risk) and its consequences (i.e., what is happening and how it will affect people).
2. Guidance for protective action (i.e., what to do).
3. The location and population at risk (i.e., where it is happening).
4. The time the public should start taking protective action,
5. The time protective action should be completed.
6. The sender or source of the message (i.e., who is sending the message).

This methodology allowed for a comprehensive and objective analysis of the content and effectiveness of early warning messages. The research on WRM provides valuable insights into the design of effective warning messages, especially for imminent hazards (Sutton et al. 2020, 2018, 2021).

5. Findings

Of the accounts analyzed, the Fire Brigade account was the most popular based on the number of followers (174.400 followers) followed by the Ministry of Climate Crisis and Civil Protection (99.700 followers) and the 112.gr emergency number (64.700 followers), as Figure 1 shows, during the examined period.

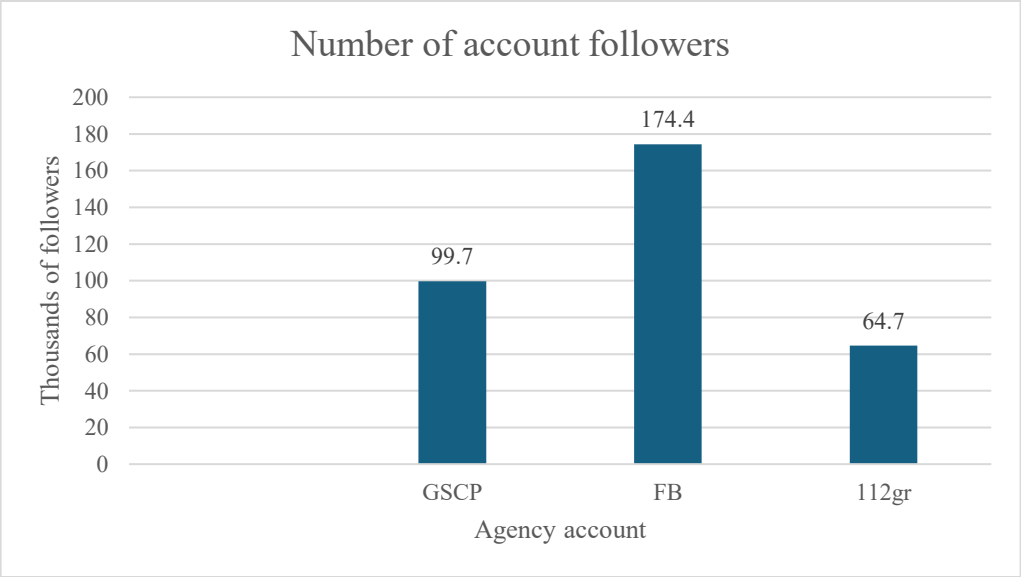

Figure 1 Number of account followers/agency

All three organizations included in most of their message's details about the event and the possible upcoming consequences. Delving into the details of the messages, it can be argued that the 112's account used mainly words that described the severity of the phenomena (e.g., "intense," "severe storms," "dangerous weather phenomena").

Regarding 'Guidance for protective action,' the 112gr account exhibited the highest presence at 98.67%, followed by the FB account at 23.53% and the GSCP account at 18.03%. The contrast in the inclusion of "Guidance for protective action" (FB: 23.53%, GSCP: 18.03%, 112: 98.67%) indicates a clear difference in framing.

Table 1 shows the presence of the six WRM elements across the three emergency management organizations.

	Description and consequences	Protective measures	Location and population at risk	Start time for protective action	End time for protective action	Sender source
FB	100,00%	23,53%	5,88%	35,29%	11,76%	64,71%
GSCP	95,08%	18,03%	19,67%	13,11%	8,20%	83,61%
112	100,00%	98,67%	98,67%	18,67%	16,00%	100,00%

Table 1. Categories of analysis results

112gr heavily emphasizes providing guidance, potentially framing their messages as instructional and action oriented. This pattern is also reinforced by the significantly higher number of posts in a day that is almost three times the maximum posts of the other two accounts as shown in figure 2.

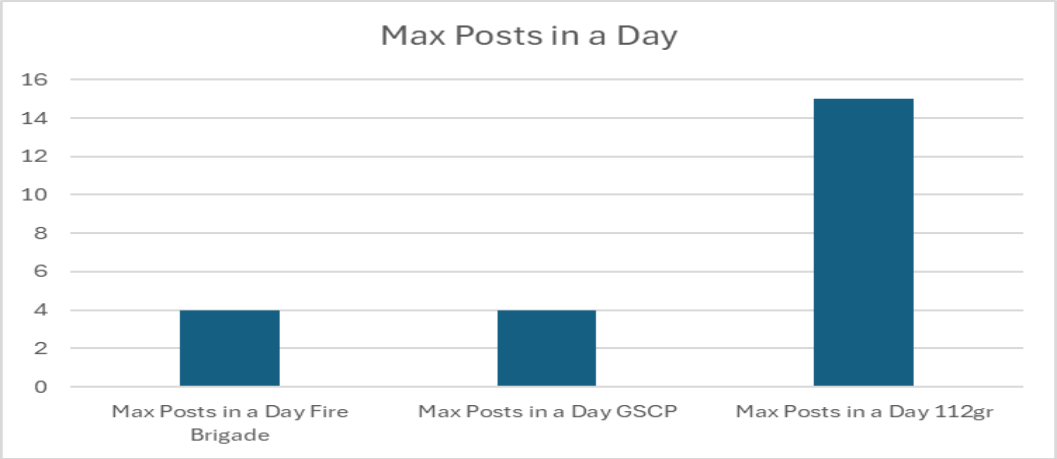

Figure 2. Number of maximum posts in one day/ agency account.

In contrast, FB and GSCP seem to prioritize other elements, focusing more on describing the threat itself or establishing their credibility as the source. Moreover, a repetition of the same instructional phrases and links was observed which suggests that the messages of 112 are largely standardized and not significantly adapted to each specific case. This finding suggests that '112' messages are likely automated or semi-automated, with the aim of quickly and effectively alerting the public in emergencies. This standardization serves the purpose of speed and clarity. Analysis of the 112 tweets revealed that guidance for protective action was consistently present in near all instances.

It was found that the Fire Brigade warning messages mainly focus on imminent or impending severe weather events ("weather deterioration," "heavy rainfall," "storms"). In addition, the words "instructions" and "protection" indicate that these messages include instructions for citizen safety.

For the third variable, 'location and population at risk,' 112gr again led with the highest percentage at 98.67%, with GSCP and FB trailing at 19.67% and 5.88%, each. It can be argued that the warnings of the 112gr specific areas, which aims to personalize the message and increase the sense of risk. At this stage we must point out that we found constant usage of capital letters and jargon in all three accounts.

The fourth element, 'the time the public should start taking protective action,' was explicitly stated in 35.29% of FB messages, 18.67% of 112gr messages, and 13.11% of GSCP messages. This finding leads to the conclusion that there is a lack of tools that could provide the exact point of the upcoming incidents.

The fifth element analyzed, 'the time the protective action should be completed,' had the lowest frequency across all accounts: 16.00% for 112gr, 8.20% for GSCP, and 11.76% for FB. This finding indicates that there the Greek agencies are not prioritizing the guidance of the finalization of the incidents, or they do not have it as a priority of the communication strategy.

Finally, regarding the identification of the message source, 112gr demonstrated 100.00% clear recognition, followed by GSCP at 83.61% and FB at 64.71%.

6. Message Effectiveness/Engagement

Regarding the engagement of the posts, Table 2. presents the mean number of favorites and retweets that posts received across the three organizations.

Agencies	Mean score of Favorites (Standard Deviation)	Mean score of Retweets (Standard Deviation)
FB	36.18 (22.24)	5.58 (4.95)
GSCP	34.01 (33.33)	13.22 (24.48)
112	77.80 (34.07)	62.12 (37.11)
F-value (sig)	33.54 (0.000)	53.42 (0.000)

Table 2. Mean scores of favorites and retweets across agencies

To test whether the three agencies differed with respect to the mean number of favorites and retweets received, two analyses-of-variance were conducted using SPSS 21.0. Results suggest that there was a significant difference at the mean number of favorites ($p<0.05$) across the agencies. Post-hoc tests (Tukey) indicated that the 112.gr received significantly ($p<0.05$) more favorites (M=77.8) than FB (M=36.18) and GSCP (34.01). FB and GSCP did not differ significantly in terms of the mean number of favorites that their posts received. With respect to retweets, significant differences were observed between the agencies (F=53.42, sig=000). Similarly, Tukey's post-hoc tests showed that the 112-account received significantly higher number of post retweets (M=62.12) compared to FB's account (M=5.58) and GSCP (M=13.22). The posts of FB and GSCP did not differ significantly in the mean scores of retweets.

To test the effectiveness of each type of element on the number of favorites and retweet a series of independent samples t-tests. Table 3 shows the results of t-tests for the number of favorites.

	Mean scores of favorites (Standard Deviation)	t-test value	Significance
Description of event			
Yes	56.57 (38.98)	1.929	0.056
No	13.00 (10.58)		
Protective actions			
Yes	74.16 (39.49)	8.270	0.000
No	30.06 (18.94)		
Location			
Yes	74.94 (39.49)	8.446	0.000
No	30.37 (19.06)		
Start date			
Yes	62.92 (41.29)	1.080	0.282

No	54.10 (38.57		
End date			
Yes	71.52 (43.52)	1.869	0.064
No	53.75 (38.07)		
Sender			
Yes	57.32 (39.75)	1.496	0.137
No	41.93 (30.53)		

Table3. Results of t-test for number of favorites

Based on the findings, no significant differences were observed ($p>0.05$) in the mean scores of favorites for messages that contained a description of the event ($t=1.929$, $sig=0.056$), the start ($t=1.080$, $sig=0.282$) and end date ($t=1.869$, $sig=0.064$) of the actions required as well as the source of the message ($t=1.496$, $sig=0.137$) compared to messages that did not contain these elements. On the contrary, significant differences were observed in the mean scores of favorites with regard to the use of protective actions ($t=8.270$, $sig=0.000$) and location ($t=8.446$, $sig=0.000$) in the warning messages. Specifically, messages that contained calls to protective measures and included the location of the incident received more favorites compared to posts that did not contain these elements.

Table 4 shows the results of t-tests for the number of retweets.

	Mean scores of retweets (Standard Deviation)	t-test value	Significance
Description of event			
Yes	36.97 (39.61)	1.394	0.166
No	5.0 (1.0)		
Protective actions			
Yes	56.19 (40.67)	9.093	0.000
No	8.75 (10.84)		
Location			
Yes	57.77 (40.39)	9.844	0.000
No	8.11 (7.75)		
Start date			
Yes	32.67	-0.543	0.588
No	37.16		
End date			
Yes	38.26 (28.37)	0.198	0.137
No	36.33 (40.91)		

Sender			
Yes	39.22 (40.15)	2.695	0.008
No	11.68 (20.49)		

Table3 Results of t-test for number of retweets

In a similar vein with favorites, no significant differences were observed ($p>0.05$) in the mean scores of retweets for messages that contained a description of the event ($t=1.394$, $sig=0.166$), the start ($t=-0.543$, $sig=0.588$) and end date ($t=0.198$, $sig=0.137$) of the actions required compared to messages that did not contain these elements. On the contrary, significant differences were observed in the mean scores of retweets with regard to the use of protective actions ($t=9.093$, $sig=0.000$), location ($t=9.844$, $sig=0.000$) and sender identity ($t=2.695$, $sig=0.008$) in the warning messages. Specifically, messages that contained calls to protective measures and included the location of the incident and the sender identity received more retweets compared to posts that did not contain these elements.

7. Conclusions and Discussion

This study investigated the impact of warning message elements on social media engagement during severe weather events in Greece. We analyzed the presence and clarity of threat descriptions, and protective action guidance, as well as the inclusion of location at risk and timeframes for action. We also examined the impact of message source identification and variations in message framing across emergency management organizations. By evaluating these factors and the relationship between message characteristics and public engagement.

In conclusion, Twitter's real-time nature and broad reach make it a valuable tool for early warnings, capable of influencing preventive actions and activities. By analyzing messages from Greek organizations, our study contributes in the area by enriching the research. Our findings offer valuable insights into how these factors may influence public response in the Greek context.

Based on the findings almost all organizations described the event and included the sender of the message. In general, we also found that organizations do not include the end-date of the protective measures. The content analysis of the messages from the three sources (112, Fire Service, General Secretariat for Civil Protection) reveals that all agencies use clear language, even though there is a certain amount of technical jargon. This is consistent with the best practices described in the reference article, which emphasizes the importance of using common words that do not require interpretation. The messages provide basic information about the type of hazard (e.g., storms, snowfalls), which aligns with the Warning Response Model (WRM) that requires a description of the threat/event. The warnings appear to be issued in a timely manner, allowing citizens to prepare.

However, we observed several variations between the organizations. For example, the 112.gr messages included more protective measures and location as well as the population at risk. On the other hand, the account of the Fire Brigade promoted messages that included the starting time of the events. Overall, the analysis shows that '112' messages are designed to quickly alert citizens to an emergency and urge them to take immediate action, while 'Fire Brigade's' messages aim to provide more comprehensive information and guidance to help citizens prepare for and respond to the emergency. In relation to GSCP messages, we find that they focus mainly on informing about the activation of crisis units to deal with extreme weather events. In addition, the reference to "civil protection" and "climate crisis" suggests that these messages are part of a broader framework of crisis management and civil protection.

We also sought decode differences between the organizations with respect to the users' engagement that they trigger. Results showed that 112.gr received higher levels of user engagement in terms of favorites and retweets compared to the other two organizations even though the account had the lowest number of followers than the other accounts. This could be attributed to the fact that 112.gr messages were more instructive in nature and contained the location of the event. This finding is aligned with Sutton et all., (2015) finding that messages with practical directives and localized information foster a heightened sense of personal relevance, increasing the likelihood of public engagement. For instance, messages incorporating protective actions and location details significantly outperformed others in attracting favorites ($t=8.270$, $p=0.000$ for protective actions; $t=8.446$, $p=0.000$ for location) and retweets ($t=9.093$, $p=0.000$ for protective actions; $t=9.844$, $p=0.000$ for location).It is made clear that actionable response, guidance and concrete information enhance the public's engagement irrespectively of the followers account. These elements were found to influence users' engagement (favorites and retweets). Moreover, we also found that messages that included the sender's identity triggered more virality compared to messages that did not include the source of the post. The presence of the sender's identity likely instills greater confidence in the information, driving users to share it more widely, thus amplifying message reach and impact.

In contrast, elements such as the start and end date of action did not significantly influence favorites or retweets, suggesting that temporal specifics may be less immediately engaging than protective guidance and locational cues. This may be due to users' preference for practical and location-relevant information over specific timelines in rapid-response scenarios.

Overall, our research contributes to the knowledge on effective risk communication via social media. The results of this study could be utilized to refine warning message strategies, ultimately improving public safety during severe weather events.

While this study contributes into the effectiveness of social media warning messages in Greece area, it also highlights several areas for future research. Further investigation could explore the impact of incorporating specific instructions and visual aids on protective actions within the Greek context. Examining optimal message framing strategies for severe weather events in Greece, considering risk perceptions, would also be beneficial. While this study provides valuable insights

into current practices and areas for improvement, Additionally, a bigger time frame of research into tailoring messages and understanding the effects of repeated exposure to warning messages on public trust and preparedness in Greece could further enhance our understanding of effective communication trends customized for certain public audience.

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