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Disaster warning messages in Rio Grande do Sul: challenges and opportunities in risk communication

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Abstract
This research analyzes the effectiveness of warning messages issued by authorities in Rio Grande do Sul during a climate disaster that occurred between April 26 and May 7, 2024. This extreme event resulted in over 700 mm of rainfall, affecting 96% of the municipalities and causing 182 deaths, with more than 2.39 million people affected. Using an analytical framework, 88 warning messages were examined for the presence of essential elements: source, hazard, location, protective actions, and period. The results reveal that 62.5% referred to river floods. The analysis showed high consistency in naming the source and hazard (100%), but a low presence of details about impacts (22.7%). The specification of the affected area was addressed in 80.7% of the messages, but only 39.7% mentioned specific municipalities. All messages included protective actions, but the specificity varied, with 10.2% recommending evacuation. Temporal accuracy was consistent in 80.7% of the cases. The research concludes that although the messages were clear and organized, they lacked details about impacts and specific areas, reducing the effectiveness of preventive communication and population preparedness.

Keywords: Risk management. Communication. Environmental emergency. Response.

Mensagens de alerta de desastres no Rio Grande do Sul: desafios e oportunidades na comunicação de risco

Resumo
Esta pesquisa analisa a eficácia das mensagens de alerta emitidas pelas autoridades do Rio Grande do Sul durante um desastre climático ocorrido entre 26 de abril e 07 de maio de 2024. Este evento extremo resultou em precipitações superiores a 700 mm, afetando 96% dos municípios e causando 182 mortes, com mais de 2,39 milhões de pessoas impactadas. Utilizando um quadro analítico, 88 mensagens de alerta foram examinadas quanto à presença de elementos essenciais: fonte, perigo, localização, ações de proteção e período. Os resultados revelam que 62,5% referiam-se a inundações. A análise mostrou uma alta consistência na identificação da fonte e do perigo (100%), mas uma baixa presença de detalhes sobre impactos (22,7%). A especificação da área afetada foi abordada em 80,7% das mensagens, mas apenas 39,7% mencionaram municípios específicos. Todas as mensagens incluíram ações de proteção, mas a especificidade variou, com 10,2% recomendando evacuação. A precisão temporal foi consistente em 80,7% dos casos. A pesquisa conclui que, embora as mensagens fossem claras e organizadas, faltaram detalhes sobre impactos e áreas específicas, reduzindo a eficácia da comunicação preventiva e a preparação da população.

Palavras–chave: Gestão de risco. Comunicação. Emergência Ambiental. Resposta.

Mensajes de alerta de desastres en rio grande do sul: desafíos y oportunidades en la comunicación de riesgos

Resumen
Esta investigación analiza la eficacia de los mensajes de alerta emitidos por las autoridades en Rio Grande do Sul durante un desastre climático ocurrido entre el 26 de abril y el 7 de mayo de 2024. Este evento extremo resultó en precipitaciones superiores a 700 mm, afectando al 96% de los municipios y causando 182 muertes, con más de 2,39 millones de personas afectadas. Utilizando un marco analítico, se examinaron 88 mensajes de alerta en cuanto a la presencia de elementos esenciales: fuente, peligro, ubicación, acciones de protección y período. Los resultados revelan que el 62,5% se referían a inundaciones. El análisis mostró una alta consistencia en la identificación de la fuente y el peligro (100%), pero una baja presencia de detalles sobre impactos (22,7%). La especificación del área afectada se abordó en el 80,7% de los mensajes, pero solo el 39,7% mencionó municipios específicos. Todos los mensajes incluyeron acciones de protección, pero la especificidad varió, con un 10,2% recomendando evacuación. La precisión temporal fue consistente en el 80,7% de los casos. La investigación concluye que, aunque los mensajes eran claros y organizados, faltaban detalles sobre impactos y áreas específicas, reduciendo la eficacia de la comunicación preventiva y la preparación de la población.

Palabras clave: Gestión de riesgos. Comunicación. Emergencia ambiental. Respuesta.

1 Introdução

The state of Rio Grande do Sul is located in the southern region of Brazil, one of the most vulnerable regions to extreme weather events in the country. Between April 26 and May 7, 2024, the State experienced the worst disaster in its history, because of a complex interaction of meteorological systems acting on different scales (INPE, 2024). The torrential rains, which reached more than 700 mm in some municipalities during the period mentioned above (CEMADEN, 2024), caused floods and landslides that affected 96% of the state's municipalities - 476 (DEFESA CIVIL RS, 2024). Furthermore, over 2.4 million people were affected, of which more than

75.000 were left homeless, 806 were injured, 182 died and 29 disappeared amid the recorded waters and landslides.

Reducing the impacts of disasters is also possible with the adoption of risk communication strategies (FONSECA; GARCIAS, 2021). When an adverse event is imminent, for example, authorities must issue warnings to people, especially those at risk, to motivate protective actions (BEAN, 2019). After that, the person must understand the message and attribute meaning to the information presented. If the person does not believe that they are the target of the message, they are unlikely to pay attention or act according to the recommended action (SUTTON et al., 2018). This can cause people to ignore future messages (KIM et al., 2019b). Therefore, the person needs to understand, for example, what the threat is, what the potential impacts are, who is at risk, who is the source of the message, and the timing and duration of the protective actions that should be taken (WOOD; MILLER, 2021).

Therefore, warning messages that include the right and effective content are necessary. Messages that include source, hazard, location, time, and protective action (MILETI; SORENSEN, 1990) increase the likelihood that people will protect themselves quickly (DOERMANN; KULIGOWSKI; MILKE, 2021). Research shows that warning messages issued by authorities do not have all the elements necessary for an effective warning (KULIGOWSKI et al., 2023; SUTTON; OLSON; WAUGH, 2024). The lack of protective guidance on how to reduce the effects of tornadoes prevented respondents from taking protective actions (SUTTON; FISCHER, 2021). In addition, some people take time to authenticate information, listen to the media or consult their social network, which reduces the time to take protective actions (BUYLOVA et al., 2020; PROVITOLO et al., 2022). In Rio Grande do Sul, risk communication was considered one of the failures in the disaster response (A PUBLICA, 2024). Therefore, improving the content of alerts is a step towards response (NEUSSNER, 2021).

Therefore, this research aims to evaluate the content of disaster warning messages issued by authorities before and during the disaster that occurred in Rio Grande do Sul between the end of April and the beginning of May 2024. The research is based on the warning message model (KULIGOWSKI et al., 2023; MILETI; SORENSEN, 1990), to show the content necessary for a warning to be considered effective. The model is used to evaluate messages for natural (SUTTON; FISCHER; WOOD, 2021a; SUTTON; OLSON; WAUGH, 2024b) and technological hazards (KIM et al., 2019a; WOOD et al., 2018). The research focuses on the application of a matrix for analyzing the content of warnings from the national civil defense and protection system. The results are presented on a scale of subcomponents and the temporal evolution of the messages. A discussion concludes this research, both on methodological aspects and on the benefits, it may present in the short term.

2 Conceptual Frameworks

2.1. Message content

The content of a message is defined as "what is said" or represented in a message. It was in the 1990s that the first framework of clear, precise, and effective warning messages appeared (MILETI; SORENSEN, 1990). Defined as the Warning Response Model (WRM), the model emphasizes the presence of five variables in a

warning message. The first variable is a recognizable source. Warnings that do not include a source or one that is recognized due to lack of knowledge and/or the use of an acronym can lead to a decrease in the credibility of the message (BEAN et al., 2015). The type of hazard is another variable that must be present in a warning message. In addition to naming the hazard, a warning must provide details so that people understand the characteristics of the hazard agent from which they must protect themselves (MILETI; PEEK, 2000). Another approach is to describe the expected impacts on the population or an area (POTTER et al., 2018). Describing potential impacts can be crucial during infrequent events (MORSS et al., 2018).

Protective action emphasizes what actions people should take to stay safe in case of a hazard (MILETI; PEEK, 2000; BANDURA, 2010). In fact, providing guidance information is often more critical than communicating risk (SUTTON; FISCHER; WOOD, 2021). Location information specifies who is and who is not at risk of suffering the consequences of a hazard (WOOD; MILLER, 2021). This means including a description of an area that may be affected (SUTTON; OLSON; WAUGH, 2024). The way a location is described can increase confidence that the threat is relevant and help people know whether they are close to the risk. Generic locations ("In your area", for example) can lead people to feel that they are not at risk (SUTTON; FISCHER; WOOD, 2021). Messages also need to be coded so that everyone understands the location. There are places that are known by popular names other than the official ones, as "Rua do Posto de Saúde" (Health Post Street).

Messages also need to include time-related information. Temporal information can show the start and end times of the occurrence of the hazard and its potential impacts (SUTTON; OLSON; WAUGH, 2024), which provides an estimate of how long protective actions should take place (MILETI; SORENSEN, 1990). The model emphasizes the style of the message - the way the content is communicated. The challenge is to use words that have meaning for people (WOOD; MILLER, 2021). Messages should be complete and clear, with simple vocabulary, without conflicting information (WILLIAMS; EOSCO, 2021) and ambiguous or unknown terms (SUTTON; OLSON; WAUGH, 2024a). Abbreviations of words, the use of acronyms and operational or scientific language should also be avoided (SIVLE; AAMODT, 2019). For communication to be accessible to the public, it should be written at a fifth or sixth grade reading level (MANI et al., 2021).

The style can increase the sense of urgency by using an imperative voice, an exclamation mark and capital letters (SUTTON; FISCHER; WOOD, 2021b). The use of capital letters is a practice that should be adopted with caution, as messages can be difficult to read (SUTTON et al., 2018), while capturing the reader's attention. Alerts that have a mixed-case format (upper and lower case) are easier to read and understand than those written only in upper case letters (WHITMER; SIMS, 2023). The structure of the message refers to the way the content is presented (DILLARD; SHEN, 2012); this includes the order of the content and the format (FISCHER et al., 2023).

2.2. Disaster Monitoring and Warning Systems

A disaster monitoring and warning system consists of a set of capabilities needed to generate and disseminate prompt and meaningful information to prepare people threatened by a hazard to act appropriately and in a timely manner to reduce

damage and losses (UNDRR, 2022). To ensure that this information reaches the population, authorities have increasingly used Short Message Service - SMS (LUHT-KALLAS et al., 2023). However, character limitations pose a challenge for local managers to construct a concise message under stressful conditions (BEAN, 2019). Short messages (limited to 90 characters, for example) tend to be incomplete and lack specificity (WOOD; MILLER, 2021). There is a set of protective actions that can be reduced to phrases for short messages (BEAN et al., 2014).

3 Materials and Methods

3.1. Characterization of the sample

The analysis was based on the content of the warning messages sent by local managers to the mobile devices of people who registered in the civil defense and protection system by sending the postal code of their interest (ANATEL, 2024). Between April 25 and May 10, 2024, warnings were issued for various events on different scales in Rio Grande do Sul. The messages of adverse events sent between April 25 (four days before the disaster) and May 10, 2024 (three days after the rain stopped and one day before the arrival of a cold front) by local managers to the population were analyzed. Thus, the sample consisted of 88 messages.

3.2. Method

The analysis was developed from an analysis matrix to decide the presence of (1) source, (2) hazard, (3) location, (4) protective action and (5) time (Table 1). The variables were divided into subcomponents in an Excel spreadsheet, based on the coding structure developed by several researchers (DOERMANN; KULIGOWSKI; MILKE, 2021; MILETI; PEEK, 2000; MILETI; SORENSEN, 1990; SUTTON; OLSON; WAUGH, 2024). Each part has the same weight; if an element is present, it is assigned the value 1 (one), but 0 (zero) if it is absent.

Table 1 – Categories and definition of the components of the message analysis matrix

Category	Subcategory	Definition
Source	Organization	Name of the organization issuing the message
Hazard	Hazard name	Name of the hazard, threat, or imminent event
	Potential impacts	Potential consequences for the population and area
Location	Geographic area	Spatial reference (region, city, locality)
Protective action	Suggested action	Actions people should take to protect themselves
Time	Period	The time when impacts will begin and end

Source: the authors (2024)

In addition to the variables above, four others were considered optional: detailing the hazard (rain intensity in millimeters, wind speed, for example), detailing the protective actions (name of the shelter, evacuation route, for example), syntax

(grammatical and spelling correction, no use of acronyms, abbreviations and capital letters throughout the sentence) and order of items (logical sequence of information). In this case, partially elaborated variables are likely to receive a value of 0.5. In the case of syntax, the following stands out: 1) use of capital letters throughout the sentence – the value of 1 is applied when only one or two subcategories are written in capital letters to highlight them. For example: "ALERT", "PROTECT YOURSELF"; 2) message written with abbreviations, acronyms and words written incorrectly. The same situation applies to "Order". If it partially follows the sequence of the subcategories described above, it receives a value of 0.5. Optional variables were not considered in the overall score.

Standardization was developed within the scope of categories and evaluation by summing the points. This method allows assigning a score to each variable, then calculating a total score and a ratio, given by the number of points obtained divided by the maximum number of points expected - 6 points. The analysis is followed by detailing the temporal evolution of the warning and disaster messages and the respective presence of the categories in Table 1. The messages presented as examples in this research were transcribed as they are available on the platform (ANATEL, 2024). Any error in the messages is not the result of a typing error or alteration by the authors, but rather a reproduction of the original content.

4. Results

The results show that only 12.85% (11) of the alert messages sent by civil defense and protection agencies via SMS can be considered complete, that is, they have the source, name of the hazard, location, protection action and time.

4.1 Message content analysis

The analysis of the 88 messages sent by the civil defense and protection agency to the population of Rio Grande do Sul between April 25 and May 10 revealed that approximately 63.6% of the messages had the word "Alert". The remaining messages did not have any category – alert, warning or bulletin (32). From a temporal point of view, the week of April 29 to May 6 accounted for the largest number of messages (62), especially between the 2 e 3 day. Most of the messages were related to "river floods" (62.5%). In this typology, "alerts" were the most frequent (89%). The second typology with the most messages was "Heavy Rains" (22). It is followed by "flash flood" (4), river flood (1), landslide (1) and dam rupture/collapse (1) (Table 1).

Table 2 – Analysis of message content. Percentage value (%)

Category	Urban Flood	Heavy Rain	Landslide	Flash Flood	Riverine flood	Dam Collapse	*Score*
Source	100	100	100	100	100	100	100
Name	100	100	100	100	100	100	100
Impacts	0	46,15	0	0	5,45	0	8,6
Area	100	46,15	100	100	96,36	100	90,4
Guidance	100	100	100	100	100	100	100
Period	100	96,15	100	50	76,36	0	70,4

Syntax	100	100	100	100	100	100	100
Order	50	50	50	50	50	50	50,0
Hazard Detail	100	7,69	0	50,91	0	0	26,4
Guidance Detail	0	0	0	0,00	0	0	0
Score	81,3	79,8	81,3	75,0	78,5	68,8	77,4

Source: the authors (2024)

The results show high consistency in the presence of the source and name of the hazard in all messages. The description of the impacts was limited, present in only 5.45% of the messages about river floods and 46.15% about heavy rains. The geographic reference was present in all typologies, except for heavy rains (46.15%). The recommended protective actions are present in all messages of all typologies. The inclusion of the time (beginning and end of the alert) varied in the messages. The syntax was correct in all messages of all typologies, with the logical order of the information being supported in 50% of the cases in all typologies.

4.1.1. Source

Naming the source is essential for the population to recognize and trust the responsible authorities, ensuring that the recommended actions are followed appropriately. During the disaster, all warning messages (100%) included the identification of the source, such as Civil Defense.

4.1.2. Name

Including specific hazard names is essential for the public to understand the nature and severity of the hazard. During the disaster, 100% of warning messages included a clear identifier, making it easier to quickly understand the type of event that was occurring. Additionally, 77% of messages provided added details about the hazard, increasing the accuracy and usefulness of the information. This detail is vital to providing a deeper understanding of the event, allowing the public to prepare and take the necessary precautions to protect themselves more effectively.

4.1.3. Impacts

Describing potential impacts is an essential part of effective warning messages. During the disaster in Rio Grande do Sul, only 22.7% of messages highlighted the potential impacts of a hazard occurring, particularly the possibility of flooding and impacts on the state's coastal areas. Only one message highlighted direct impacts on the population, such as material damage, interruptions to essential services, and risks to life. Including these details is crucial for the population to understand the severity of the situation and prepare adequately, avoiding underestimating the risk and taking inappropriate measures.

4.1.4. Area

The specification of the affected area in the alert messages was named in 80.7% of the messages. Clearly delimiting the affected areas is crucial for the population to name whether they are directly at risk and to be able to take the necessary precautions. Accurate identification of the region, municipality and location affected is vital to ensure an effective and coordinated response to the disaster. Accuracy in the location was varied. Approximately 76.1% of the messages specified the areas likely to be affected on a macroscale (e.g., "in Rio Grande do Sul"), 39.7% mentioned the municipalities, and 27.3% detailed the specific locations. This lack of precision can lead to a less coordinated response and inadequate preparation in areas that were not clearly identified as affected.

4.1.5. Protective actions guidance

Protective actions in warning messages are essential to guide the population on how to respond appropriately to adverse events. During the disaster in Rio Grande do Sul, all messages included some type of guidance, but the specificity varied. Only 10.2% of the messages mentioned the need to evacuate. Other actions were detailed in the messages: 95.5% encouraged contact with authorities, 29.5% recommended seeking a safe place and 19.3% recommended avoiding risky situations. Other actions such as protecting household appliances, furniture, and important documents, following more news or detailed information in another medium such as social networks, monitoring the evolution of the occurrence of the hazard and forms of self-protection were not named, suggesting a gap in communication. Including more actions could improve preparedness and the effectiveness of the response.

Detailed guidance is essential to ensure that the population knows exactly what to do. However, a lack of clear recommendations for further information or more actions can limit the effectiveness of messages. Improving the specificity of suggested actions is essential to ensure a proper response to the disaster. In addition to providing guidance on how the population should react to the disaster, it is important that warning messages include detailed recommendations to ensure concrete actions and efficiency in the response. During the disaster in Rio Grande do Sul, none of the messages had detailed guidance. The recommendations provided were general, such as "Evacuate the risk area", "Find a safe place" and "In an emergency, call 199". General guidance, while useful, may not be enough to ensure that people know exactly what to do in specific situations. Including more detailed actions, such as "Check for available evacuation routes," "Stay informed through official channels," and "Prepare an emergency kit with essential supplies," can improve the effectiveness of warning messages. Detailed guidance helps ensure that people know exactly what to do at each stage of the disaster, increasing the effectiveness of the response and minimizing the risks associated with the event.

4.1.6. Dates and Times

Accurately naming the start and end times of alert messages is crucial to ensuring that people know how long to still be vigilant and when it is safe to resume normal activities. For example, a message with clear information such as "Alert valid

from 20/07, 12:00 to 21/07, 18:00" provides a specific period, allowing people to plan their actions and stay informed during the risk period. Consistency in these details is crucial to avoid confusion and ensure that everyone knows when the alert is in effect and when measures can be adjusted as the situation evolves. Approximately 80.7% of the messages were consistent about these details, of which 64.7% corresponded to the duration of the alert in terms of 24 hours (for example: "Civil Defense: Flood alert. Gravataí River with rising levels. Valid for 24 hours. In case of emergency, call 190/193") and 35.3% to a specific time of day (for example: "Civil Defense: Heavy rain with risk of flooding, intense winds and electrical discharges. Lasts until 10 am on Saturday. Emergency Call 190/193.").

4.1.7. Syntax and Order

Maintaining clear syntax and a logical order in warning messages is essential to ensure that information is effectively understood. During the disaster in Rio Grande do Sul, the syntax and order of messages were supported in 100% of cases, ensuring clarity and comprehension. A well-organized structure in warning messages helps the population to quickly assimilate crucial information and act according to the authorities' recommendations. Only 50% of the messages had the full expected impact, which may have limited the population's complete understanding of the situation. Well-structured messages, such as "The Rio dos Sinos has risen 3 meters, with a forecast of continuing to rise, affecting low-risk areas", offer a clear view of the expected impact and help the population make informed decisions. A lack of complete information can lead to a partial understanding of the severity of the event, making it difficult to respond and adopt necessary protective measures.

4.2. Temporal evolution of messages and the disaster

A significant variation in the number of messages was named by disaster type: urban flood (1); heavy rain (26); landslides (1); flash floods (4); river flood (55); dam collapse (1). Most of the messages warned about heavy rain and river floods (81 or 92.05%). This analysis allows us to understand not only the communication of the responsible authorities, but also to evaluate the population's preparedness and response to the occurrence of the adverse events that devastated Rio Grande do Sul during the period. On April 25, the alert message mentioned "rain and wind, occasionally heavy, with electrical discharges and occasional hail", reaching a presence rate of 68.75%. The structure of the alert, which detailed the situation and included recommendations for calling emergency services, proved a format that would be repeated in the following days.

On April 26, two alerts of heavy rain reached 75% presence in the categories. They highlighted the possibility of adverse events, which proved to be critical in the following days, but without specifying the possible impacts, and recommended that people contact the numbers 190 and 193 in case of emergency. On April 27, even before the disaster, two alerts highlighted (1) the possibility of adverse events and (2) the river flood risk in the municipality of Quaraí. On the same day, municipalities in the Vale do Rio Pardo registered impacts due to rain and hail. Between April 28 and 29, seven alerts for heavy rain, urban flood and river flood were issued (average of

81.25% of categories). Four messages related to the possibility of adverse events, without specifying affected areas (for example: "Civil Defense: Heavy rain, strong winds, electrical discharges, risk of hail and flooding. Valid until 4 pm this Saturday. Emergency Call 190/193."). The others are related to the river flood (for example: "Civil Defense: Warning of risk of flooding. Santa Maria River slowly rising in Rosário do Sul. Valid for 24 hours. Emergency call 190/193.").

On Sunday, April 28, the Civil Defense named damage in 15 municipalities after the storm the previous day. The National Institute of Meteorology (INMET) issued an orange warning with a risk of storms for the entire southern half of the state. On the same day, two warnings were issued by the Civil Defense about the possibility of adverse events, but without specifying the potential impacts or the areas likely to be affected. On April 29, the forecast intensified, and at the end of the day, INMET issued a forecast of high rainfall for half of the state, marking the beginning of the disaster. This increase in the severity of the forecasts coincided with the alerts issued by the protection and civil defense agencies, which increased in number and kept a high percentage of presence of the categories necessary to characterize an effective alert. On that day (April 29), three warnings messages highlighted the river flood risk, the river and the municipality likely to be affected (for example: "Civil Defense: Alert for high levels and flood risk. Ibirapuita River rising rapidly in Alegrete. Valid for 24 hours. In case of emergency, call 190/1").

On April 30, Rio Grande do Sul named its first deaths due to storms, with two deaths in the municipality of Paverama after a car was swept away by the water in the municipalities of Pântano Grande, Encantado and Santa Maria. The Civil Defense warning messages on that day (six) continued to emphasize the river flood risk with specific messages for different rivers, such as the Sinos river and the Jacuí river. Three messages specify the municipality that could be affected (for example: "Civil Defense: RS: Flood warning. Jacuí River rising from Cachoeira do Sul. Valid for 24 hours. In case of emergency, call 190/193."). Two warning messages only mention the river's elevation (for example: "Civil Defense: RS: Flood warning. Gravataí River rising. Valid for 24 hours. In case of emergency, call 190/193."). The percentage of categories remained high, around 81.25%, reflecting the ongoing dangers.

The highest number of warning messages issued by authorities occurred between May 1 and 3: 31, for river floods and heavy rains, with percentages ranging from 68.75% to 93.75%. On May 1, when the State of Public Calamity was declared by the State government (114 municipalities and 19 thousand people affected to this day), seven alerts were sent to the population. The first two (9:49 am and 4:53 pm) highlighted the occurrence of adverse events, without specifying the impacts and areas likely to be affected and recommended contacting the emergency services in case of an emergency. During the night, five flood alerts were sent to the population, two of which emphasized an "extreme" risk.

On May 2 and 3, when 265 municipalities were affected, the Taquari River reached its highest level, and 19 new deaths were identified in 24 hours. In addition, 24 warning messages were issued, emphasizing the river flood risk, flash floods and landslides in municipalities and the partial rupture of a dam. Despite the situation, only half of the messages recommended that people evacuate and seek a safe place (for example: "Civil Defense: RS: Alert for partial rupture of the 14 de Julho HPP in Cotipora: Evacuate risk areas, seek safe places. Valid for 24 hours. Emergency

190/193"). The others referred to contact in case of an emergency. On May 3, the effects of the disaster reached the city of Porto Alegre and the level of the Guaíba River reached 4.77 meters, surpassing the 1941 record.

From May 4 onwards, the frequency of messages continues high, but with a slight decrease in the percentage of presence of necessary categories (68.75% to 81.25%). On that day, seven warning messages were issued, of which three correspond to the possibility of adverse events occurring in the state, with the time and day of validity of the alert and a recommendation to contact 190 and 193. The other four refer to the occurrence of river flood risk (three mention areas likely to be affected – cities or regions). In addition to the recommendations in the earlier messages, the authorities recommended that people evacuate/seek a safe place in just two messages (for example: "Civil Defense: RS: Alert for a large rise in the levels of the Laguna dos Patos, reaching coastal areas, evacuate areas at risk. Valid for 24 hours. Emergency call 190/193"). With the number of confirmed deaths at 55, the tragedy surpassed the one that occurred in the Taquari Valley in 2023, which left 54 victims, becoming the largest disaster in the state.

On May 5, when 78 deaths were recorded and 840 thousand people affected, the lowest number of alerts was issued during the current disaster period: five, for flooding in coastal areas and along the Uruguai and Sinos rivers. However, only two highlighted the need to evacuate or seek a safe place (for example: "Civil Defense: RS: Flood alert on the Sinos River, levels stay high from Campo Bom to Canoas, seek safe places. Valid for 24 hours. Emergency call 190/193"). On May 6, eight alerts were sent to the population, about the risk of flooding along the Jacui, Uruguai, Laguna dos Patos and Guaíba rivers (three highlighted the need to seek a safe place). On the same day, the mayor of Porto Alegre recommended that residents of the Cidade Baixa and Menino Deus neighborhoods leave the region after the water began to rise in the area. The news took residents by surprise, as their properties were affected.

Starting on May 7, when the intensity of the rain decreased but the river levels remained high, the messages emphasized the possibility of adverse events, flood risk along the Uruguai, Jaguari, Cai, Taquari rivers and Laguna dos Patos and the monitoring of the rivers and recommended that people avoid being in risk areas and seek safe places. On May 8, the floods reached the south of the state, affecting cities such as São José do Norte, São Lourenço do Sul, Pelotas and Rio Grande, putting thousands of people on high alert and forcing many to leave their homes. Warning messages continued to be issued, keeping the population informed about the risk of flooding, possible areas that could be affected, recommendations to avoid risk areas, seek a safe place and contact the emergency services in case of emergency (for example: "Civil Defense: RS ALERT: Gradual flooding of the Uruguai River, rising levels from Sao Borja to Barra do Quaraí, avoid risk areas. Emergency call 190/193").

The relation between the warning messages and the events that occurred in Rio Grande do Sul during this period shows the role played by Civil Defense and Protection agencies in keeping the population informed about meteorological risks. However, the analysis reveals that, despite the alerts presenting a high number of elements necessary for an alert to be effective, the intensity and scale of the climate events exceeded the response capabilities of the civil defense and protection agencies and the population, resulting in a tragedy of great proportions.

5. Discussion

5.1 Warning messages about the Rio Grande do Sul disaster

The analysis of the messages sent by civil defense and protection agencies in Rio Grande do Sul during the disaster that occurred between April 25 and May 10, 2024, in the state reveals lessons that transcend local and temporal circumstances. The results show that 1.83% of the alert messages can be considered complete, that is, they present the source, name of the hazard, location, protective action, and the time of the alert. This result corroborates recent research, which shows that incomplete warning messages issued by public authorities are common (KULIGOWSKI et al., 2023). In the United States, for example, only 8.5% of the warning messages sent between 2012 and 2022 are complete (OLSON et al., 2024) and, in the case of Covid-19, less than 3% of the messages held the suggested elements (BEAN et al., 2022). By providing the types of information needed to act, alerts can reduce information seeking, information insufficiency (GUTTELING; TERPSTRA; KERSTHOLT, 2018) and delay in protective actions (SEEGER et al., 2018).

Communication before and during a crisis is a crucial element that can save lives and minimize damage. In the case of Rio Grande do Sul, 63.6% of the messages held the word "Alert". This strategy, although necessary, did not provide information before critical days. Combining warnings with preventive information is vital to increase the population's resilience in the face of disasters (KROCAK et al., 2023; ZABINI et al., 2021). The challenges seen in Rio Grande do Sul also reflect issues that are relevant in any scenario. For example, the disaster that occurred on the northern coast of São Paulo in 2022 proved how inadequate communication can lead to disastrous consequences. The warning messages sent by local authorities, which did not emphasize the extent of the rains (G1, 2022), illustrate a universal problem: the underestimation of risks. This same pattern was seen in Rio Grande do Sul, where only 17% of the messages detailed the potential impacts. The inclusion of these details is crucial for the population to understand the gravity of the situation, not underestimate the risk (POTTER et al., 2018) and adopt measures to protect themselves (WOOD et al., 2018).

This problem is not exclusive to the events mentioned above. In other places in the world, failures in disaster communication can be attributed to a lack of systemic vision that integrates all dimensions of risk. For example, in Brazil, events such as the heavy rains in Pernambuco in 2022, which resulted in dozens of deaths, show that communication often focuses on one aspect of the disaster, such as floods, but neglects others, such as landslides, which can be equally devastating. Messages that emphasize only the immediate aspect without providing detailed information about potential impacts, such as interruptions to essential services, do not adequately prepare the population. In Rio Grande do Sul, the focus on warning without including detailed instructions on how to act, such as evacuation routes or measures to protect critical infrastructure, highlighted this gap in communication.

Inclusive communication, which considers the needs of vulnerable groups such as the elderly, children, and people with disabilities, is another aspect that should be incorporated into any risk communication strategy. Including specific guidance for these groups is a common challenge worldwide (LINDELL et al., 2016).

In Rio Grande do Sul, the analysis revealed that warnings did not adequately address the needs of these groups, with few messages offering guidance on how to help these populations protect themselves adequately. Another protective action that could be included is the recommendation to create emergency kits. Detailed guidance on the essential items that should be included in these kits, such as water, non-perishable food, medicines, and important documents, can increase the population's resilience during disasters. Research shows that creating emergency kits can significantly reduce the impacts of disasters (REYNOLDS-TYLUS; MARTINEZ GONZALEZ, 2021). In addition, the preparation of evacuation routes should be addressed in warning messages. Guidance on which routes to avoid, road conditions, and the location of support points along routes can make a significant difference to public safety (LIU; CHEN; CHEN, 2021).

Geographic accuracy also emerges as a critical element for the effectiveness of risk communication, as evidenced in evacuation situations during hurricanes or tsunamis. In Rio Grande do Sul, the lack of geographic accuracy in messages (only 27.3% detailed specific locations) may have led to inadequate preparation and insufficient response in severely affected areas. When location information is generalized, unspecific, or absent, people may feel anxious and seek more information to reduce their anxiety, resulting in a delay in protective action (OLSON et al., 2024). This inaccuracy can also cause people to underestimate the threat or mistakenly assume that they are safe, resulting in disorderly evacuations and increased risks to public safety (SUTTON et al., 2023). However, geographical, and temporal inaccuracy can be explained by the uncertainties inherent in the hazards - gap between prediction and occurrence (FAKHRUDDIN et al., 2020; LUO et a., 2024).

Another aspect is the importance of source credibility in communication. Regardless of the context, public trust in the information provided is essential to ensure an effective response. In Rio Grande do Sul, all messages included clear identification of the source, namely the Civil Defense, which is crucial to ensure public trust. Clear identification of the source helps coordination between different entities involved in the disaster response and ensures that the recommended actions are adequately followed by the population (SUTTON; OLSON; WAUGH, 2024).

Therefore, the analysis of messages during the disaster in Rio Grande do Sul offers valuable insights that are applicable globally. Disaster risk communication is an essential tool for building resilience, and the principles named – such as the need for comprehensive, adaptive, accurate and inclusive communication – are timeless and relevant in any context. By discussing these topics from a broader perspective, it is possible to contribute significantly to the advancement of disaster risk communication at a global level, helping to better prepare populations for the challenges that are intensifying in the face of climate change and increasingly frequent and intense natural events.

5.2 Challenges and opportunities

The analysis of the warning messages issued during the disaster in Rio Grande do Sul reveals significant opportunities and challenges for improving risk communication and response to adverse events. One of the main challenges is the limited space in warning messages, often restricted to 160 characters. This limitation

imposes considerable difficulty in transmitting detailed and complete information, which can result in messages that do not convey all the information necessary for an effective response (WOOD; MILLER, 2021). Research shows that effective communication requires sufficient detail to allow the population to understand the severity of the situation and the actions to be taken (SUTTON; OLSON; WAUGH, 2024). To mitigate this limitation, it is crucial to implement a multichannel communication system (FONSECA; GARCIAS; SILVA, 2023), using digital platforms and social networks. The integration of these tools with traditional warning systems can provide more effective communication, allowing for a wider dissemination of information (BOPP; DOUVINET, 2022).

The training of civil defense and protection agents is also essential to prepare them to act in a coordinated and efficient manner during a disaster (RIGHI et al., 2021; FONSECA; FERENTZ; PINHEIRO, 2022), especially in a scenario of structural and operational limitations faced by local agencies (PINHEIRO et al., 2021; MARCHEZINI et al., 2022; LOOSE; LONDE; MARCHEZINI, 2023). The effectiveness of messages is linked to the ability of the professionals involved in their preparation and dissemination. Furthermore, in the disaster risk management process, improving warning messages should be an ongoing priority. Regular reviews of communication protocols are necessary to ensure that they include all essential information in a clear and concise manner. Another point is the continuous evaluation and feedback on the effectiveness of warning messages. Collecting feedback and detailed analysis of responses and impacts after an event are essential to find areas for improvement and adjust future communication protocols (FISCHER et al., 2023). This approach allows for the incorporation of lessons learned and the improvement of warning and response practices.

Therefore, collaboration between distinct levels of government, educational institutions, non-governmental organizations and the private sector can help translate technical information into clear, complete, useful and understandable messages for the public, increasing the preparedness and effectiveness of risk communication (JEANNETTE, 2019). Integrating the community in this process is another significant challenge. Warning messages must be accompanied by community engagement efforts that empower citizens to interpret and react appropriately to the information received. Active community participation and education about disasters can improve the effectiveness of the response and reduce impacts (SUFRI et al., 2020). Educational campaigns and community meetings are effective tools for building a prepared community network (HUDSON; HAGEDOORN; BUBECK, 2020). Simulations, training exercises and evacuation are essential to evaluate and adjust communication and response procedures, increasing preparedness and coordination during a real event (PINHEIRO et al., 2021).

Therefore, the analysis of warning messages during the disaster in Rio Grande do Sul highlights the importance of a multifaceted approach to improving communication and response to adverse weather events. Overcoming structural limitations, improving communication practices, continuous training of professionals and community engagement are essential to ensure a more effective and coordinated response. The experience of this disaster in Rio Grande do Sul underscores the need for a continuous and collaborative effort to better protect the population and minimize the impacts of adverse events.

6 Conclusion

This research aimed to evaluate the content of the adverse event warning messages issued by civil protection and defense agencies before and during the disaster that occurred in Rio Grande do Sul in late April and early May 2024 through the application of a quality control indicator. The results revealed that the analyzed messages presented highly effective aspects, such as the clear identification of the source and the name of the event, both with a score of 100%, which reinforces the credibility and trust in the information transmitted. In addition, the messages were consistent in including recommended protective actions, showing a commitment to safety. However, the analysis also pointed out significant deficiencies, such as the insufficient description of potential impacts, which obtained an average score of only 8.6%, and the geographic and temporal accuracy of the information, which varied, compromising the effectiveness of the population's responses. These gaps show the need to improve the detailing of the impacts and the accuracy of the affected areas and periods in the warning messages, aspects that are crucial to increasing the population's preparedness.

The contributions of this study are both theoretical and practical. Theoretically, the development and application of the quality indicator have proven to be effective tools for evaluating warning messages, contributing to the field of risk communication and disaster management. This study offers a model that can be adapted and applied in other regions and contexts, helping to standardize and continuously improve risk communication practices. Practically, the results offer clear guidance for public authorities, emphasizing the importance of including specific details about potential impacts and the need for geographic and temporal precision in messages. To address the identified deficiencies, it is recommended to implement continuous training for professionals involved in preparing messages, as well as the adoption of multichannel systems that allow for more detailed and segmented dissemination of information, addressing different audiences and specific needs.

However, it is important to highlight that the main limitation of this study lies in its case study nature, focusing exclusively on the disaster that occurred in Rio Grande do Sul between April and May 2024. Therefore, the results and conclusions presented here cannot be automatically generalized to other contexts or types of disasters without conducting added studies that consider different scenarios. The specificity of the event analyzed implies that the recommendations obtained should be applied with caution in other contexts.

In conclusion, the analysis of the warning messages during the disaster in Rio Grande do Sul highlighted both the effectiveness and the limitations of the communication strategies used. The clarity and consistency of the messages were strengths, while the lack of detail on potential impacts and geographic precision appeared as areas that require improvement. To mitigate these deficiencies, it is essential that authorities invest in continuous training and in technologies that allow for more detailed and adaptive communication, ensuring that the population is properly informed and prepared to face future disasters. This study reinforces the importance of well-structured risk communication, capable of evolving and adapting to emerging needs, as a fundamental part in effective disaster management.

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