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multi-Risk sciEnce for resilienT commUnities undeR a changiNg climate

Spoke TS3 *– Communities' resilience to risks: social, economic, legal and cultural dimension*

WP 6 *– New models of education and communication for resilience to risk*

TK 6.1 *– International benchmarking*

Deliverable 6.1.1

Identifying Best Practices in Risk Communication: A State-of-the-Art-Review of International Literature

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Executive Summary

This deliverable aims to illustrate the main results of the literature review conducted within Task 6.1. The literature review aims to identify the characteristic factors based on previous risk communication experiences. Specifically, particular attention will be given to identifying best practices, elements contributing to risk communication success, and inhibiting factors. These operations serve various objectives, including:

(a) A panoramic reconstruction of research on concrete examples of risk communication, with the aim of mapping areas for further investigation and highlighting areas that require more in-depth study.
(b) Identifying a toolkit containing the most suitable tools for communicating risks in different stages and across multiple media environments.
(c) Gathering a database of practices and analytical considerations to consult in various project steps.
(d) Listing a repertoire of practical actions and strategies to use as a foundation in formulating the communication campaign.

The project "Return" aims to enhance basic knowledge about risks and strengthen Italian risk and disaster management governance. In the contemporary era, designing practical communication tools is increasingly relevant for mitigating complex and often hard-to-predict risks. Linear and one-way communication approaches must now contend with communication environments that are increasingly intricate and multifaceted. Moreover, the unique nature of risks leaves room for uncertainty, further complicating communication scenarios.

The literature review presented in this deliverable collects the main trends in communicating natural risks. The search string on risk communication gathered 1387 articles from five databases (Scopus, Web of Science, IEEE Xplore, ACM, EBSCO). After screening the abstracts and reading the articles in depth, this literature review consists of 125 papers.

The literature review aims to answer three research questions: (1) What are the main characteristics of the literature focused on risk communication? (2) What are the critical success factors in risk communication? (3) What are the inhibiting factors for effective risk communication?

The selection of articles was based on the concept of the *intentionality* behind the production and dissemination of a message, as embedded in academic definitions of communication campaigns. This led to excluding articles solely focused on user perceptions, information usage and consumption, and journalistic representations. While these themes are essential for risk communication, they are not entirely central to addressing our research questions.

The article selection process resulted in the identification of papers that address three main themes: (1) communication campaigns, understood as intentional messages disseminated through mass media to achieve specific objectives; (2) tools for risk communication, understood as valuable instruments for transferring information or initiating processes of information and knowledge sharing; (3) case studies, understood as accounts of specific experiences that occur in a particular geographical context, within a delimited time, and that document one or more risk communication actions undertaken by a defined actor.

The 125 papers identified after the abstract screening and in-depth reading are divided as follows: 7 papers delve into risk communication campaigns; 45 articles describe significant case studies for risk communication; and 73 papers analyze prominent tools for risk communication.

The papers included in the literature review have been published between 2006 and 2023, mainly in journals specialized in natural risks and environments. No significant generalist communication journals have been intercepted.

Papers are mainly based on a single-risk approach. Flooding and hydrogeological risk are among the most discussed topics (N=28), followed by storms, typhoons, hurricanes, and tornadoes (N=26). Most papers (N=69)

return experiences of national extension, while few experiences resume international collaboration. Most of the experiences are settled in America, and only one paper summarizes African experiences. About half of the risk communication actions address pre-risk phases.

The campaigns are analyzed from a comparative perspective. For each campaign, it was chosen to isolate the constituent elements to benchmark the practices and processes of conducting the campaigns. These campaigns feature experiences from various countries and aim to inform about a wide range of risks, including earthquakes and climate change. They are mainly led by institutions and governmental agencies based on a tailored media mix. The target audience for these campaigns is the general public.

Case studies encompass risk communication initiatives aimed at sharing information about risks. National risk management agencies, governmental departments, and civil protection institutions are among the main actors involved in case studies. The main findings underscore the crucial role of effective risk communication by national agencies and emergency departments during risk events and in the post-event or recovery phase.

Tools differ from case studies in that they place greater emphasis on describing the object itself rather than contextual dimensions. Most of these tools are geared towards either disseminating information effectively or improving the sharing of critical information. Due to the different tools' applications and characteristics, they can be adapted to different contexts. Indeed, the literature underscores that general results leading to a 'one-size-fits-all' approach to risk communication cannot be identified.

The main results underline that organizational resources, audiences' characteristics, media environment, formal and narrative organization, as well as citizen engagement and participation in risk communication initiatives, are among the factors affecting both the success and failures of risk communication initiatives and strategies.

The Project

Return (Multi-risk science for resilient communities under a changing climate) is an extended partnership to strengthen research on environmental, natural, and anthropogenic risks at the national level and promote participation in strategic European and global value chains. The project aims to enhance fundamental knowledge about risks by contributing to the application of technologies specifically designed to facilitate knowledge transfer. The project will improve the governance of Italian risk and disaster management by engaging public administrations, private actors, and stakeholders.

Research and design of communication actions are focused on risk mitigation within the operational framework of the project. As part of the planned activities, citizens will be encouraged to adopt best practices before, during, and after a catastrophic event.

Risk communication is based on conveying to citizens expert quantitative assessments of the impact and scope of risks (Sturloni, 2018). Communication in risk management has become increasingly important as we live in a society that is becoming progressively complex. In 1986, German sociologist Ulrich Beck published the essay "Risk Society." In this now-classic text in the sociological discipline, he asserts that contemporary societies must confront ever more ineffable and constantly changing risks—many of which lack precedents. This intensification of risks would be a significant consequence of industrialization processes. These new, globally-reaching risks are often hard to predict and quantify. At times, these risks may seem distant from individuals' direct experiences and lifestyles, yet they could impact their daily lives. As a result, contemporary risks require experts' technical and scientific mediation to be understood and addressed. The extension of modern risks ultimately amplifies the dimension of *uncertainty*. Every human decision brings forth new risks: think about the consequences of urbanization on natural ecosystems. Due to this *human factor*, risks and their management give rise to controversies and conflicts. On one hand, risks are not always equally distributed. On the other hand, contemporary risks also fit into narrative and argumentative frameworks that transform them into subjects of discussion, partly due to the complex formulation of the probabilistic language that characterizes them, which leaves room for uncertainty.

The *sociocultural theory of risk* (Douglas & Wildavsky, 1982) suggests that attitudes towards risk are shaped by the culture in which individuals reside. Culture refers to the complex set of norms, values, symbols, belief systems, and behaviors employed to decode and attribute shared meanings to cultural objects (Griswold, 2012). Hence, it is possible to explain the difference in interpretations with which different social groups perceive risks and their associated controversies. As a result of this interpretation, it may be concluded that factors other than technical analyses also contribute to evaluating or accepting risk. As a result, it is essential to consider social and cultural factors and how individual perceptions affect and guide risk conceptions. This complexity is also linked to a progressive stratification and multiplication of communication environments (Cottle, 1998). If culture, understood as a complex web within which individuals weave shared meanings (Geertz, 1973), is an essential factor in the contemporary understanding and definition of risks, mass media are environments in which issues distant from or impending upon experience become part of individuals' knowledge (Silverstone, 1999).

Thus, the literature on risk communication points out how risk communication has progressively moved away from *deficit* or unilinear models (Douglas, 1991) in favor of participatory and collective approaches, intending to reduce uncertainty challenges.

Today, (mediated) risk communication faces numerous challenges. Part of this difficulty arises from multiple and still emerging risks, such as those induced by *climate chaos*. Other critical issues stem from a generalized distrust of institutional or scientific authorities (Nichols, 2017). Additionally, the polyphonic nature of contemporary media contributes to multiplying access points to risk information and sources of information and dissemination. On one hand, the persistence of processes underlying ordinary newsmaking (gatekeeping, news values, framing) (McQuail, 2005; Shoemaker & Reese, 1991; Tuchman, 1978) that turn risks into news is observed. On the other

hand, online platforms, their mechanisms (van Dijck et al., 2018), and access logic (Gillespie, 2018) offer incredible opportunities for sharing relevant information and best practices while still being vulnerable to contestation and misinformation.

In these multifaceted arenas, public discussion on risks and attempts at literacy and socialization toward best practices and risk mitigation efforts occur. Therefore, the design of effective communication actions must consider these complexities. For this reason, the research action described in the rest of the report will be directed toward identifying best practices and proactive risk communication strategies.

What to take home

- ⇒ Risk communication is based on conveying to citizens expert quantitative assessments of the impact and scope of risks (Sturloni, 2018)
- ⇒ The extension of modern risks amplifies the dimension of *uncertainty*
- ⇒ The *sociocultural theory of risk* (Douglas & Wildavsky, 1982) suggests that attitudes towards risk are shaped by the culture in which individuals reside
- ⇒ The design of effective communication action and tools should embrace complexity

Definition of Research Strategy

Logic and Identification of Research Questions

This literature review examines articles related to the communication of natural hazards and those related to climate change. Particular attention will be paid to papers that address *communication campaigns* conducted between 1984 and the present. This date was chosen in accordance with the first literature reference to risk communication[1]. Additionally, articles describing specific risk communication actions will be reviewed, such as ad hoc *tools* or the empirical analysis of *case studies*. In light of the exploratory nature of our research, we have chosen not to restrict the nature of the tools or campaigns (e.g., whether they are face-to-face or mediated) or the geographic areas of interest that we will examine.

This literature review examines articles related to the communication of natural and environmental hazards and those related to climate change. Particular attention will be paid to papers that address communication campaigns conducted between 1984 and the present. This date was chosen in accordance with the first literature reference to risk communication. Additionally, articles describing specific risk communication actions will be reviewed, such as ad hoc tools or the empirical analysis of case studies. In light of the exploratory nature of our research, we have chosen not to restrict the nature of the tools or campaigns (e.g., whether they are face-to-face or mediated) or the geographic areas of interest that we will examine.

We have decided to conduct a state-of-the-art review based on scoping review principles to assess the extent of the existing literature and the points of interest addressed in the literature concerning our research topic (communication campaigns and actions for environmental risk management or climate change-related risks). Despite its many definitions, a scoping review can be distinguished from systematic literature reviews by lacking a quality assessment of the studies. Considering the need to include articles characterized by diverse methodological applications (content analysis, case studies, etc.) and also based on qualitative approaches (such as in-depth interviews or focus groups), such a step would have narrowed the field of eligible materials. Using techniques specific to scoping reviews provides greater systematicity than traditional literature reviews, such as narrative reviews, typically used in communication studies. Indeed, this scoping review aims to synthesize significant trends in the literature and systematically summarize the primary research outcomes.

According to Anderson et al. (2008), a scoping review has several objectives: (1) mapping of relevant literature, (2) conceptual mapping, (3) policy mapping, (4) stakeholder consultation. In our case, these objectives are defined as follows: (1) identification of relevant papers and state-of-the-art in the literature regarding communication of environmental/natural risks or climate change-related risks; (2) mapping of definitions and constituent elements of communication campaigns; (3) mapping the main actions carried out by independent actors, institutional actors, civil protection bodies, and other bodies engaged in risk communication, to deduce recurring policies or functional elements (used in identifying the guidelines that will be analyzed as a background for task 6.2); (4) using the results of the scoping review for subsequent research actions, including stakeholder consultation.

This literature review contributes to the subsequent research actions planned for the project Return to be performed by the research team of the Department of Communication and Social Research (Sapienza University of Rome). Therefore, the research questions that have guided our work aim to identify the relevant elements for

[1] Leiss (1996) reports that the first article published in an academic journal containing the expression “risk communication” dates back to 1984.

the design of campaigns, as well as their evolution. The research questions that the literature review will address are as follows:

> ***RQ1**: What are the characteristics of the literature that have addressed communication campaigns and/or actions related to the communication of environmental/natural risks and/or climate change-related risks?*
>
> ***RQ2:** What are the success factors in designing and implementing communication campaigns and/or actions related to the communication of environmental/natural risks and/or climate change-related risks?*
>
> ***RQ3**: What are the inhibiting factors regarding the success of communication campaigns and/or actions related to the communication of environmental/natural risks and/or climate change-related risks?*

Identification of Keywords and Search Strings

To address the RQs, which are functional to achieving the research objectives, keywords were identified to gather articles focused on risk communication campaigns and their constituent elements. The keywords were compiled through a brainstorming process in which research team members discussed the need to combine recurring aspects from theory and empirical indicators. Therefore, generating keywords involved comparing elements of an inductive nature and those of deductive origin.

The selected keywords were subsequently grouped into four areas characterized by maximum internal homogeneity regarding thematic coherence and differentiation from elements placed in other groupings. The identified sets are as follows: a) natural hazards and climate change; b) communication; c) best practices and case studies; d) trust and information quality; e) campaign outcomes.

In total, 187 keywords were tested in at least one search string. The tested keywords and their groupings are listed in Table 1.

TABLE 1 – TESTED KEYWORDS

Risk	natural risk; natural disaster; climate change; earthquake; flood; fire; tsunami; extreme weather events; landslide; rockslide; extreme events; natural hazard; environmental hazard
Communication	communication campaign; campaign co-design; channels; strateg*; information sources; top-down campaigns; bottom-up campaigns; visual communication, infographics, meme*; communication sources; broadcast media; television; radio; press; newspaper; personal communication; newsmedia; digital media; online platforms; social media; social network sites; SNS; entertainment; journalism; public sector communication; institutional communication; fiction; science fiction; documentary; reality television; governmental communication; science communication; visual campaigns; communication; information campaign; face to face; personal interaction; interpersonal communication; film; short film; picture; video; participation; unidirectional; co-design; multistakeholder; source, flow, channel, media, medium, audience reception; social marketing, advertising, commercial media, artificial intelligence; smartphone application; app; metaverse; augmented reality; mobile communication; immersive reality; Facebook; Twitter; Instagram; TikTok; Weibo; Whatsapp; Telegram; communication strategy
Best practices	best practices; guidelines; lesson learned; protocols; case study

Trust/information quality	trust; mistrust; uncertainty; nudge; nudging, framing; disinformation; misinformation; malinformation; fake news; hesitancy; confidence; credibility; frame; skepticism; gender-sensitive communication, intercultural communication, diversity, minority
Campaigns results	Risk mitigation; risk adaptation; risk preparedness; climate change adaptation; risk knowledge; risk awareness; resilience to risk; climate change awareness; climate resilient development; climate change policies

The keywords were combined into search strings characterized by different purposes and breadth of knowledge objectives. The choice was made to use the English language both to maintain consistency with the disciplinary field of risk communication, which sees many of its contributions stemming from the work of American or Anglo-Saxon academics and practitioners and because English, as the *lingua franca* of the scientific community, allows for the collection of more material related to assorted national contexts.

Technically, the strings were formulated to be used in major databases without changes (or minimal syntax adjustments) and guided by identifying an internal coherence logic. The strings, therefore, balanced various keywords to probe aspects suitable for addressing the research questions. A total of 55 strings were tested, hypothesizing from the centrality of specific knowledge aspects. In particular, each tested string aimed to gather papers on specific thematic cores. The formulated strings can be grouped according to the relevance of the knowledge objective, determined by the concentration of keywords related to a given topic. The resulting strings can be grouped based on their central topic:

a) generic (exploration of themes);
b) focused on the nature of risks;
c) centered on communication;
d) collection of case studies and best practices;
e) interest in campaign outputs;
f) relevance of themes related to information quality, trust, and understanding of risk communication.

All the strings were tested on two databases (Scopus and Web of Science) to explore the quantitative and qualitative dimensions of the results. These preliminary operations served the purpose of formulating the final string. This string was collectively refined through multiple discussions with other members of WP6 (particularly the team from the University of Florence). It involved using keywords consistent with the choices made by researchers from WP5. The detailed dimension of natural and environmental hazards is thus aligned with the decisions of other working groups. This dimension was reconstructed from the literature, providing a comprehensive overview of the natural risks that have affected or could affect the Italian territory. The second area targeted is that of risk communication. The intent of the three keywords contained in this area ("risk communication" OR "communication campaign" OR "communication strategy") is to isolate papers relevant to the communicative field. Finally, the last area comprising the string aims to detail the elements specific to communication campaigns and actions, partly deriving from McGuire's classic input-output framework for constructing persuasive messages (2013). The identified string is as follows:

> *("climate change" OR "natural disaster" OR "natural hazard" OR "natural threat" OR "disaster risk" OR "environmental risk" OR "extreme event" OR "natural risk" OR earthquake OR hydrogeological OR flood OR drought OR fire OR volcan* OR landslide OR tsunami OR rockslide OR hurricane OR avalanche OR "precipitation extreme" OR seismic OR storm OR multislide OR tornado OR typhoon OR "cold wave" OR "heat wave" OR "sea level rise" OR thunder OR lightning) AND ("risk communication" OR "communication campaign" OR "communication strategy") AND (source OR flow OR "top-down" or "bottom-up" OR channel OR medium OR media OR digital OR "social network site" OR "audience reception")*

Databases and Results

The search string was run across the primary databases. The selected databases include Scopus, Web of Science, EBSCO, ACM, and IEEE Xplore. By choosing these databases, we sought to blend a generalist approach with a specific focus on technology and digital environments, employing a multidisciplinary approach. No filters were applied to selecting articles, except for the language (English) and publication format. Research was restricted to papers published in scientific journals, excluding monographs, book chapters, and proceedings.

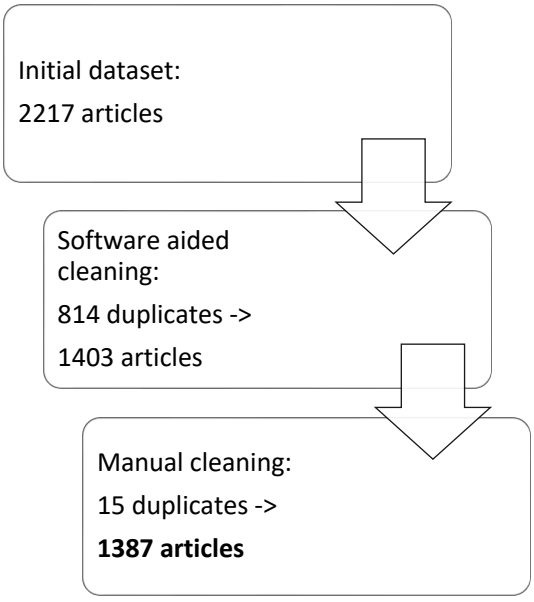
Whenever possible, particularly in extensive databases like Scopus, the database was queried to isolate keywords if they appeared in the title, abstract, or author-indicated keywords. Table 2 summarizes the results of this search.

TABLE 2 - DATABASES AND RESULTS

Databases	Results
Scopus	511
Web of Science	484
EBSCO	670
IEEE Xplore	356
ACM	196
Total	2217

The results have been imported into Zotero. A total of 1403 papers have been included in the corpus after duplicate articles have been removed (N=814) by the software. As part of the cleaning phase of the database, additional duplicates were identified and removed manually (N=15). In total, 1387 papers are included in the final dataset. Articles have been retrieved in June 2023.

FIGURE 1 - DATASET



Inclusion and Exclusion Criteria

As the database was being organized, specific inclusion and exclusion criteria were defined to guide the screening of abstracts and the subsequent selection of articles for in-depth analysis. The researchers involved in the project collaboratively deliberated on the fundamental attributes for identifying suitable papers. Primarily, the main focus area was determined. Consequently, the chosen articles for analysis needed to comprehensively delve into communication campaigns, risk communication tools, or case studies centered around specific instances of risk communication. The query has been run without any restrictions about the geographical context. Due to the substantial volume of articles, the researchers focused on the concept of *intentionality*, considering the academic definition of a "communication campaign" as theoretical insight. This definition will be elaborated further in the following paragraph. This led to the exclusion of papers addressing the subsequent topics, although pertinent to effective risk communication:

- Media coverage, representations, and framing effects;
- Real-time data sourced from social media and social networking sites (e.g., hashtag studies, real-time disaster communication, etc.);
- Perception and reception when detached from specific communication actions;
- General articles on risks and risk management (such as policy discussions, deliberations, and civic assessments) lacking communicative implications;
- Software models and engineering applications;
- Health risks tied to environmental concerns but not caused directly by natural risks or disasters (e.g., cancer risk following exposure to hazardous fumes from factory fires; food contamination);
- Media usage, information sources, and usage contexts when not tied to specific initiatives.

Hence, the selected elements conformed to the abovementioned criteria, implying a certain degree of intent in production and/or direction. The following were encompassed: a) communication campaigns with clearly identifiable promoters and goals; b) case studies detailing strategies, actions, and approaches of specific institutions; c) tools employed in communication and risk awareness (e.g., visual graphics, specific formats, using of social networking sites for information dissemination, communication tools involving participatory projects, etc.). The specific inclusion criteria are outlined in Table 3, while exclusion criteria are detailed in Table 4.

TABLE 3 - INCLUSION CRITERIA

Inclusion criteria
Topic:
a) Communication campaigns related to natural and environmental risks or connected to climate change (for the concept of campaigns, refer to the definitions provided in the literature);
b) Specific tools (e.g., brochures, artificial intelligence, visual data) for risk communication and prevention;
c) Case studies on specific risk communication activities.
Additional Inclusion Criteria:
a) Papers may refer to any geographical context;
b) Campaigns, actions, or case studies employing any form of media dissemination and usage (face-to-face, media broadcast, digital media, etc.);

c) Specific communication actions (e.g., dissemination, issuing alarms and alerts, promoting guidelines) conducted at any time (before the presence of the risk, during the occurrence of the risk, in emergencies, after the occurrence of the risk);
d) Intentional dissemination of actions concerning environmental risks or climate change;
e) Presence of a case study and/or empirical analysis;
f) Inclusion of prototypes or hypotheses of campaigns, including tests and surveys on specific communication actions when addressed as "risk communication" in the paper (e.g., data visualization, the value of co-participation, mobile communication, etc.)

TABLE 4 - EXCLUSION CRITERIA

Exclusion criteria
a) Off-topic (e.g., cybersecurity risks);
b) Exclusive focus on risks other than environmental ones (e.g., Covid-19: exclusion, but inclusion in cases where multi-risk scenarios are present; e.g., Covid-19 prevention in tornado shelters) – potential exclusion after reviewing the article if it is biased toward risks other than natural ones;
c) Lack of case studies or empirical analysis;
d) Reviews or contributions other than articles;
e) Themes related to environmental issues and risks (e.g., land exploitation, gas, and oil extraction) that do not explicitly address risk issues (e.g., land exploitation and sustainability; the presence of polluting industries and civic engagement) or are solely attributed to anthropogenic action;
g) Full text not available

The initial dataset was analyzed in light of the said criteria. A researcher from the team read the abstracts of all collected articles (N=1387), evaluating whether they could be suitable for the subsequent phase, which involved reading the full text. The guiding principle was the identification of specific campaigns, tools, and case studies. The definitions will be discussed in the paragraph titled: "Focus: Identifying campaigns, tools, and case studies."

The identification of relevant articles was preceded by extensive discussions with the research team to reach a consensus definition of the corpus. Doubts regarding inclusion were primarily resolved by considering abstracts and keywords (explicit references to risk communication were considered decisive) and discussing the possible inclusion with other team members.

Following this review, 200 articles were identified for full-text reading. The reading of the full text was guided by an analysis grid, the design and application of which will be illustrated in the paragraph titled: "Data Collection." The articles were eliminated for the following reasons, derived from the exclusion criteria already applied for abstract reading:

- Off-topic (for example, exclusively addressing health-related risks),
- Insufficiently described tools or actions,
- Exclusive focus on perceptions or media usage, without specifying the nature of actions or content,
- In a language other than English,

- Full text not available. Articles were primarily retrieved from electronic resources available at Sapienza University of Rome[2]. When unavailable, Google or Google Scholar were consulted. When not found in search engines, authors were contacted via email if available, or social network sites like Academia.Edu or ResearchGate were utilized.

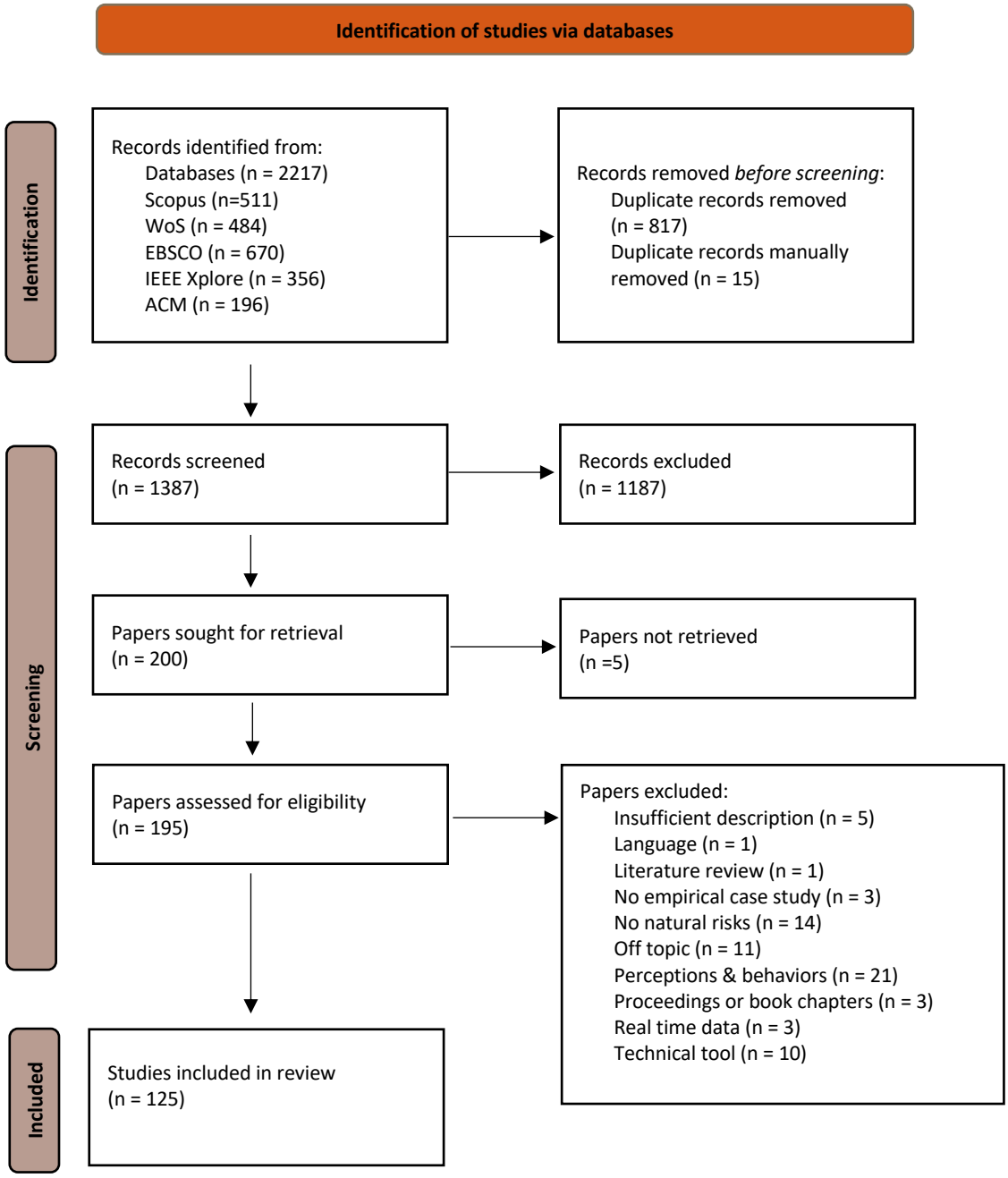
After retrieving the papers and reading the full text, 75 articles were eliminated. The factors that led to the exclusion of the papers are listed in the Table 5. Figure 2 summarizes the steps leading to the final dataset, using the PRISMA flowchart.

TABLE 5 - EXCLUSION MOTIVATIONS

Motivations for exclusion	**Number of papers**
Full text missing	5
Insufficient description	3
Language	1
Literature review	1
Empirical case study missing	3
Risks other than natural ones	14
Off-topic	11
Perceptions & behaviour	21
Proceedings or book chapter	3
Real-time data	3
Technical tool	10
TOTAL	**75**

[2] Sapienza Libraries subscribes to thousands of subscriptions to electronic periodicals from Italian and foreign publishers in all subject areas. A list of the publishing platforms to which Sapienza subscribes can be found at the following link: https://web.uniroma1.it/sbs/en/ejournals/ejournals.

FIGURE 2 - PRISMA FLOWCHART



Focus: Identifying Campaigns, Tools, and Case Studies

This paragraph explores the definitions of campaigns, tools, and case studies that led to abstracts' selection and papers' reading.

Communication campaigns. Central to risk communication and communication studies, campaigns are described by multiple definitions that identify their constituent elements and objectives. Characterized by the *intentionality* of the broadcaster to distribute a message and consequently by the intentionality of the promoters to pursue a goal, campaigns have been the privileged object of *mass communication research* (Katz & Lazarsfeld, 1955). According to Paisley (1989), communication campaigns are defined in relation to their goals and methods, which primarily aim to influence the beliefs or behaviors of a group of people using communication. Atkin (1981) describes communication campaigns as promotional messages of public interest disseminated through the mass media to reach the desired audience.

Papers selection and analysis were based on the definitions of campaigns provided by Rice and Atkin (2009). This description, not specifically related to risk communication, was chosen because of the adaptability and generalizability provided. This definition can, by extension, intercept any form of public communication about risk and guide the analysis of the communication environments and production processes that comprise it:

> Public communication campaigns can be broadly defined as (1) purposive attempts (2) to inform, persuade, or motivate behavior changes (3) in a relatively well-defined and large audience, (4) generally for noncommercial benefits to the individuals and/or society at large, (5) typically within a given time period, (6) by means of organized communication activities involving mass media, and (7) often complemented by interpersonal support (adapted and expanded from Rogers & Storey, 1987). The use of digital media in campaigns extends the traditional definition a bit. The International Society for Research on Internet Interventions (www.isrii.org) defined "Internet interventions [as] treatments, typically behaviorally based, that are operationalized and transformed for delivery via the Internet. Usually, they are highly structured; self-guided or partly self-guided; based on effective face-to-face interventions; personalized to the user; interactive; enhanced by graphics, animations, audio, and video; and tailored to provide follow-up and feedback," but do not include sites that just provide information (Ritterband et al., 2006). (Rice & Atkin, 2009: 436)

Rice and Atkin (2013) describe dimensions that characterize the design and implementation of communication campaigns to achieve changes in perceptions or behaviors. According to the authors, qualitative or quantitative specifications can be identified. Regarding the *qualitative* nature, messages must be (1) *credible*, considering both the content and the sources promoting it. In addition, the proposed content must be (2) *engaging*, providing essential information "packaged" with stylistic execution that is entertaining and appealing to audiences. Content must be conveyed through (3) *material and stylistic devices* that are appealing and relevant to the habits of the subjects. A central dimension concerns the (4) *understandability* of promoted messages, which must have detailed but straightforward content that is extensive but understandable to the subjects. Finally, persuasive campaigns must intercept (5) *motivational incentives.* Other elements to be considered in message dissemination are inherent in the *quantitative* dimension. These criteria must be established at the design and implementation stage of campaigns as they relate to their reach and visibility. Thus, (1) the *volume of stimuli* must be defined, not only in terms of campaign reach and frequency of exposure but also in terms of understanding and recognizability of the stimuli proposed to audiences. Campaigns must then have some degree of (2) *repetition of specific executions* to make audiences learn relevant notions or behaviors. However, these repetitions must avoid boring the audience. Also appropriate is (3) *prominence* of messages in media (e.g., whether these appear on the home page of websites or the front page of newspapers) for various issues, ranging from recognizability to hierarchy and attribution of salience. Campaign planners must then consider the (4) message presence *scheduling,* considering the need for distribution over time or concentration in specific periods. Finally, the (5) overall campaign *length* is

related to the nature of the problem being addressed. Sometimes, these problems are complex and need perpetual and constant awareness. In other cases, however, there is a need to concentrate information in specific or limited periods.

Tools for risk communication. The term "risk communication" first appeared in the literature in 1984. Since then, scholars and experts have formulated their definitions of risk communication, considering the increasing complexity and pervasiveness of risks in everyday life and the tools for risk communication. Risk communication is the "process of exchanging information among interested parties about the nature, magnitude, significance, or control of a risk" (Covello, 1992: 359–373). Risk communication draws from several disciplines in the natural and social sciences. Kamrin (2014: 174-176) stated: "Research in this field includes studies of human perception and decision-making as well as investigations of a socioeconomic nature. Risk communication practitioners include government officials, business and industry representatives, public interest group members, academics, media professionals, and the general public. Because of its short history, the concept of risk communication is still evolving."

Over the years, different models have been promoted, and various tools have been tested. It should be noted that models are influenced by the increasingly crowded media landscape and the diverse nature of the media channels in use. In other words, this transition has affected the risk communication models, shifting from linear transmission to the expectation of feedback or greater interactivity. Thus, alongside modes of risk communication of a broadcast nature, some tools involve citizen participation or are based on the ability to select information. In simpler risk communication models, experts address the mass media and convey risks to the public through them. This standard model emphasizes the "myth of mediated centrality" identified by Couldry (2012), in which it is believed that all information relevant to society must necessarily pass through the central and centralized mediation of the media. These transmission models are often characterized by a top-down logic, in which citizens are the end-users of communication processes initiated by experts and conveyed by mass media. These models often assume the existence of knowledge deficits that need to be filled. Such models are not without problems, as previously stated; trust in the source is necessary for communication to be effective.

Moreover, mass media and their logic can misrepresent risks, even referring to technical assessments, thus distorting risk perceptions. Therefore, these models have gradually been supplemented with various tools to increase participation or target messaging. The shift to bi-directional models includes, among other things, considering the public as partners in message production or for disseminating accurate information. Not all risks can be managed through straightforward solutions. This complexity and uncertainty have led to guidelines and recommendations for risk communication to promote societal engagement.

In light of the above, in this deliverable and the literature analysis, we will consider tools for risk communication as all devices suitable for transmitting information or initiating participatory processes of information consumption or distribution. These can be specific models or graphic, visual, or content formats. They may also include actions explicitly intended for communication or information dissemination. These tools can follow broadcast logic (e.g., weather forecast maps) or narrowcasting logic (e.g., real-time risk information-sharing platforms). To facilitate the reading of the literature review, it should be noted that tools specifically intended for risk communication, with purposes different from communication, such as "serious games" mainly designed for pedagogical purposes, have not been considered. We have used the paper's objectives and theoretical frameworks, as indicated by the authors, as decisive elements for the possible exclusion of papers.

Case study. A case study can be understood as a functional unit that can be analyzed through various methods within the context in which it occurs. Case studies typically have some connection to contemporaneity. The scientific debate regarding case studies has shown a tension between definitions that emphasize the case's dimension and those that view the case study as a research methodology. In Yin's description (2013), case studies are empirical investigations intended to analyze contemporary phenomena within real-world contexts, especially

when the boundaries between phenomena and contexts are unclear. Case studies, therefore, allow the analysis of phenomena or events within the context in which they occur.

Usually, case studies involve methodological triangulation and the combination of theories, techniques, research methods, and strategies. According to Stake (1995: XI), "Case study is the study of the particularity and complexity of a single case, coming to understand its activity within important circumstances." Research based on case studies does not involve sampling; often, the choice of the case study is dictated by the object or objectives of the investigation. Sometimes, "atypical" cases are more functional in explaining specific situations, while in other instances, the case study selection is due to the "typical" traits it exhibits. In Stake's description (1995), the primary goal of case studies is not generalization but rather particularization. Specifically, the aim is to consider a single case study and understand how it functions or what its characteristics are. Following this argument, the goal of using case studies is not to assess how a case differs from others but to understand how it is composed and what it does. The emphasis is on uniqueness rather than differences.

In this deliverable, we will consider a case study as an organized account of a specific experience characterized by a temporal and geographical range and one or more recognizable communication actions undertaken by a defined actor.

What to take home

- ⇒ Communication campaigns are promotional messages of public interest disseminated through the mass media to reach the desired audience
- ⇒ Effective tools for risk communication are devices suitable for transmitting information or enhancing participatory processes of information consumption or distribution
- ⇒ Case studies encompass specific experiences characterized by a temporal and geographical range and recognizable communication actions undertaken by a defined actor

Data Collection

The data collection form was based on the theoretical insights presented in the previous paragraph. The guideline was designed to gather as much information as possible to address the research questions. The design phase, therefore, included the possibility of isolating the necessary information to understand the nature of campaigns, tools, and case studies, identifying success and inhibiting factors. The data collection guideline consists of the following sections: (1) general information; (2) objectives and theoretical framework; (3) details about campaigns, tools, or case studies; (4) methods and population; (5) key results. The outline of data collection guidelines is detailed in Table 6.

TABLE 6 - DATA COLLECTION

General information	
Authors	Authors' names
Title	Paper's title
Journal	Journal's name
Year	Year of publication
Keywords	Copy keywords as listed by authors
Abstract	Copy abstract as proposed by authors
Main topic	Specify if the paper describes a tool, a campaign, or a case study
Risk	Specify the risk(s) addressed
Stage	Specify the stage of the risk (pre-, during, or post-risk) that the action is intended to address
Name	Specify the name of the campaign, case study, or tool as reported by the authors.
Existing or prototype	Specify if the campaign, case study, or tool is a running one (existing) or a test (prototype)
Geographical context	Specify the geographical context in which the campaign, tool, or case study takes place
Period	Specify the timespan in which the campaign, tool, or case study takes place
Description	Insert a short description of the campaign, tool, or case study
Main goals and theoretical framework	
Aims and scopes of the paper	Specify the purposes and scopes of the paper as listed by the authors
Aims and scopes of the campaign, tool, or case study	Specify the aims and scopes of the campaign, tool, or case study. They can be inserted as listed by authors or retrieved by reading the full text
Definition of risk communication	Specify the definition of risk communication used, if present, as described by the authors. Authors' intention to provide a definition should be considered (e.g., list only those definitions as the ones starting as such: "Risk communication is…").

Theoretical (communicative) framework	Specify the theoretical framework presented in the paper to clarify the approach leading to the campaign, tool, or case study. The theoretical framework should present communicative or sociological theories and should be listed by the authors as relevant to the object investigated in the paper to avoid misinterpretation
Details about campaigns, tools, or case studies	
Promoted change	Specify the change promoted (e.g., information, awareness, community resilience…)
Promoters or main stakeholders	Specify the leading promoters of the campaign, tool, or case study or the stakeholders involved in the campaign, tool, or case study design or implementation
Agenda	Specify if the campaign, tool, or case study derives from public discussions about issues or problems concerning risk communication failures
Financing	Specify the source and/or the amount of money invested in the campaign or tool
Campaign design	For campaigns only. Describe the campaign's main characteristics
Tool design	For tools only. Describe the tool's main characteristics
Design and past experiences	Specify what are the main steps in the design of the campaign, tool, or case study. Alternatively, specify what are the previous experiences leading to the actual campaign, tool, or case study
Case study characteristics	For case studies only. Describe the campaign's main characteristics
Case study selection	For case studies only. Provide the motivations leading to the case study selection, as presented by the authors
Co-participation	List co-participation initiatives recorded in the campaign, tool, or case study
Media	List media used in spreading the campaign, tool, or case study
Target audiences	Specify the target audiences of the campaign, tool, or case study
Preliminary research	Specify if preliminary research has been conducted
Guidelines	Specify if third-party guidelines inspire the campaign, tool, or case study
Methods	
Methods	Specify if the paper relies mainly on quantitative, qualitative, or mixed methods
Strategy of inquire	List the main methods or techniques used in the empirical research
Population	Specify the population. For non-human participants, list the number of elements (post, content, etc…) studied. Indications of population selection are admitted
Experiment details	Resume the main research activities
Data analysis techniques and strategies	List the methods and techniques used to analyze data (e.g., statistical methods, qualitative enquires, etc.)
Main results	

Main results	List the main results as identified by the authors
Efficacy factors	List the efficacy factors as determined by the authors
Inhibiting factors	List the inhibiting factors as specified by the authors
Best practices and lessons learned	Resume best practices and lessons learned
Limitations	List limitations of the study as identified by the authors

Main Results

Characteristic and Main Themes

In this section, the main descriptive results will be summarized. These results are aimed at answering the first research question:

> ***RQ1**: What are the characteristics of the literature that have addressed the theme of communication campaigns and/or actions related to the communication of environmental risks and/or climate change-related risks?*

In general terms, the summary given here is intended to illustrate the state of the art of the literature, especially concerning general aspects, such as the time distribution and nature of the risks examined. Please note that the results refer only to the 125 eligible articles following full-text retrieval and in-depth reading.

Journals and Time Frame of Publications

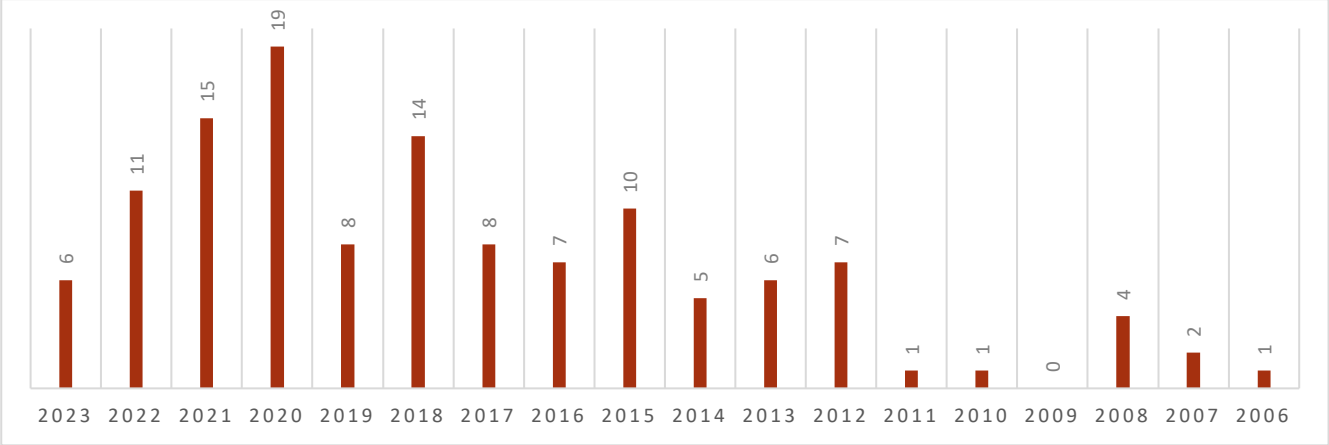
The 125 selected articles are distributed in *66 peer-reviewed journals*. The journal with the most occurrences is the *International Journal of Disaster Risk Reduction* (n=15), followed by *Communication Design Quarterly Review* (n=7). Thus, it can be seen that risk communication fits into frameworks relevant to risk reduction, mitigation, and tool design. The presence of journals specifically focused on studying and understanding natural phenomena is significant. These aspects suggest a "technicality" concerning tools, which precedes broader social or communication processes. Not surprisingly, the presence of journals dealing exclusively with communication is sparse. Table 7 resumes the list of the journals where more than one paper selected in the literature review has been published.

TABLE 7 – JOURNALS

Journals	N. Paper
International Journal of Disaster Risk Reduction	15
Communication Design Quarterly Review	7
Sustainability	6
Weather, Climate, and Society	6
Environmental Communication	5
Natural Hazards	5
Bulletin of the American Meteorological Society	4
Environmental Hazards	4
Disaster Medicine & Public Health Preparedness	3
Frontiers in Communication	3
Frontiers in Earth Science	3
Natural Hazards and Earth System Sciences	3
Annals of Geophysics	2
Disaster Prevention & Management	2
International Journal of Environmental Research and Public Health	2
Journal of International Crisis and Risk Communication Research	2
Journal of Risk Research	2
Public Relations Review	2
Risk Analysis: An International Journal	2

The results of the *time distribution* data are not generalizable. It should be remembered that no time limits were set when collecting the papers in the databases. Thus, the first paper collected was from 1989 but excluded at the abstract selection stage. The first paper considered eligible for reading was from 2005, which was then excluded at the full paper reading stage. From 2006 through 2023, all years record the publication of at least one paper considered eligible, except for 2009, in which we find no article. The year with the highest number of papers is 2020 (n=19). However, the results obtained do not reflect the actual production and publication of articles over the years as much as the distribution of papers meeting the inclusion criteria formulated for this literature review. The distribution of papers over the years is shown in Figure 3.

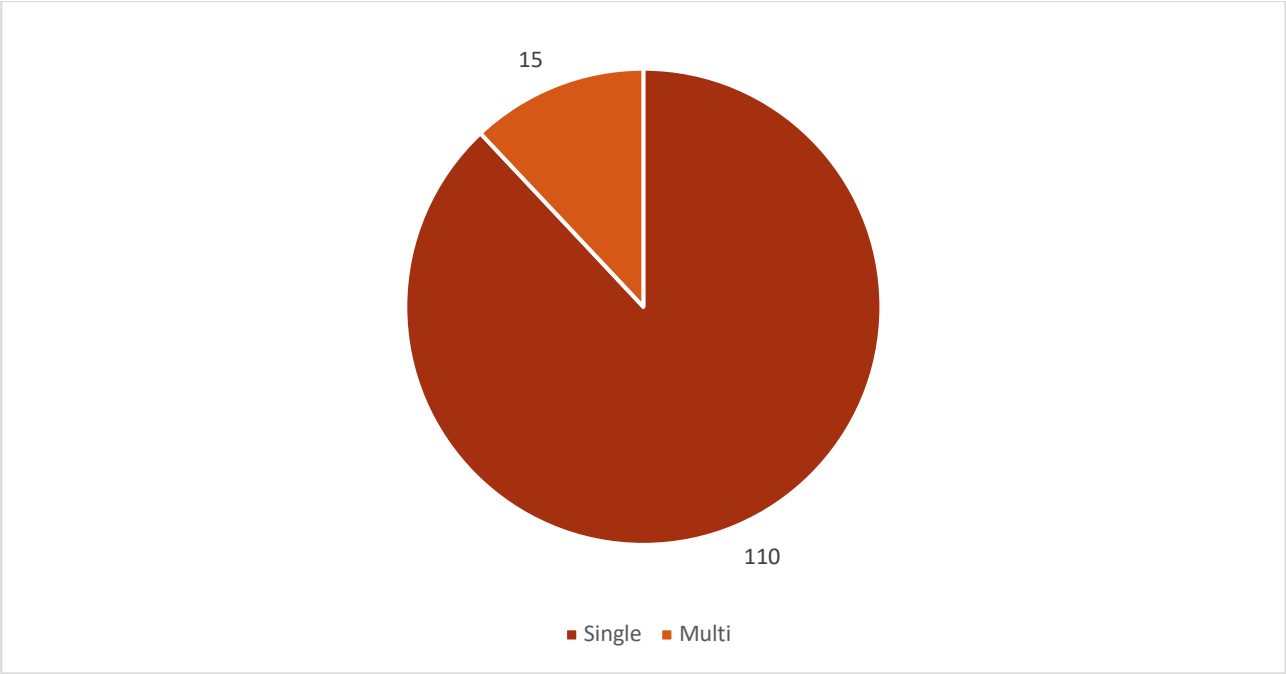
FIGURE 3 - TIME SPAN



What Kind of Risk?

Of the 125 articles analyzed, 110 take a single-risk approach (thus dealing with a single, specific risk), while 15 describe a multi-risk situation.

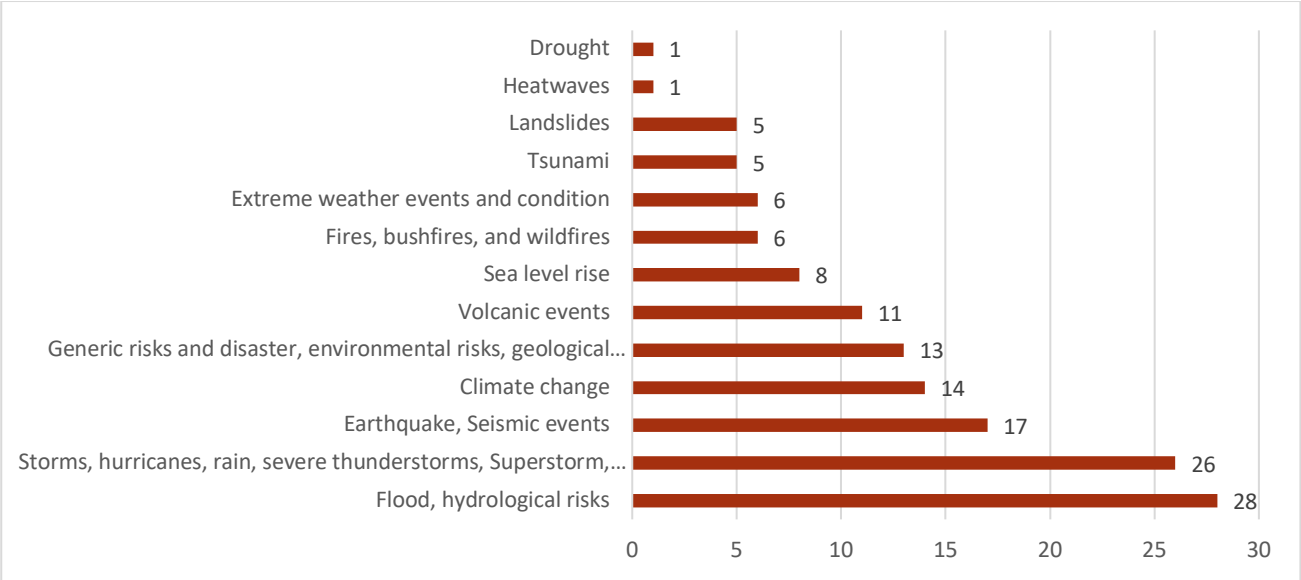
FIGURE 4 - SINGLE OR MULTI RISK



Flooding and hydrogeological risk are among the most discussed topics (N=28). This is followed by storms, typhoons, hurricanes, and tornadoes (N=26). We assume that these occurrences are due to the geographic contexts of production of the tools and to the fact that they are predictable and, therefore, communicable hazards

(not surprisingly, part of the tools on the subject involve forecasting and representation models of storms in the affected areas). Earthquakes and seismic risk are addressed in 17 occurrences, while climate change is the subject of 14 papers. 13 papers address hazards from a generalist perspective, while volcanic hazards are addressed in 11 instances. Drought and heat waves are among the least represented hazards (N=1 article each). Figure 5 summarizes the main results. Please note that more risks were found per paper.

FIGURE 5 - NATURAL RISKS



Most communication activities addressed in the papers can be placed in a *pre-risk* stage. This is about half of the risk communication actions addressed (N=54). These initiatives include activities related to alerting, thus anticipating the actual occurrence of the risk. Also included in this phase are tools or activities dedicated to preparing the population for the possible occurrence of risks or the dissemination of protective elements.

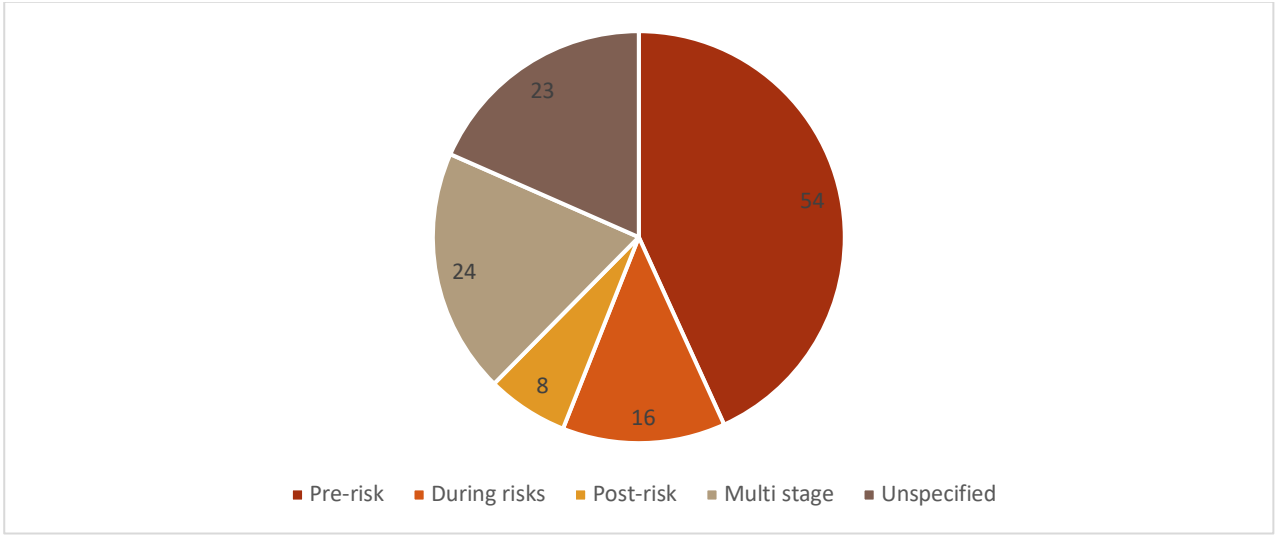
Sixteen papers describe activities undertaken *during* the occurrence of hazards. These papers address crisis and emergency communication topics, illustrating tools and applications.

The *post-risk* stage is featured in 8 articles. These are primarily tools or initiatives aimed at organizing recovery or response operations.

Some more versatile tools pertain to multiple stages of risks (N=24). We have termed these *multi-stage* tools because they can be applied in different situations. These tools can, for example, disseminate information widely or help show behaviors to be adopted.

Finally, some articles *do not specify* the stage of risk to which the illustrated elements refer (N=23). Especially those tools or initiatives dedicated to communicating ongoing risks or those with a progressive nature, such as climate change or rising sea levels, fall into this category. These risks do not have identifiable phases; therefore, the tools dedicated to them are primarily about awareness or prevention. In addition, in some papers, the authors do not specify what degree of risk they refer because the tools and activities described are so generalizable that they can be applied to any circumstances, as in the case of visuals and graphics presented in weather forecasts. Figure 6 illustrates risk stages.

FIGURE 6 – RISK STAGES



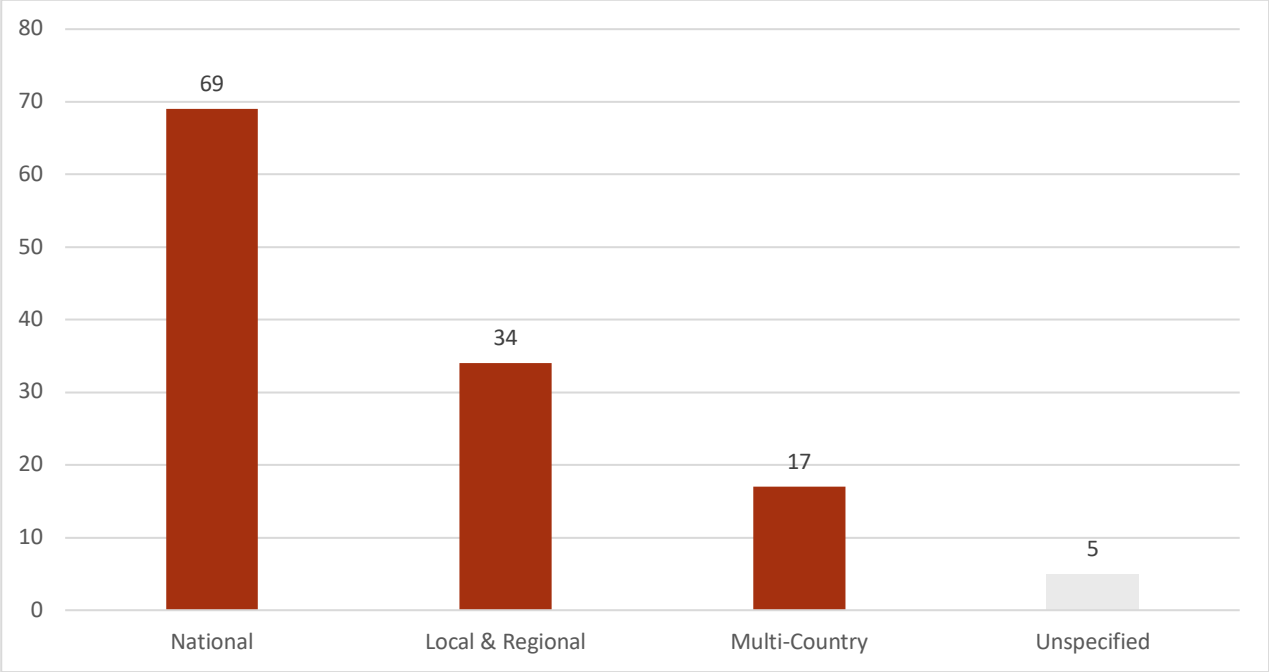
Geographic Distribution and Extension

Of the 125 papers reviewed, 120 indicate the geographic context where the presented risk communication tool or action take place.

Of the papers indicating geographic location, 17 present experiences in multiple country contexts. We have termed these operations "multi-country." These experiences are primarily collaborative risk communication operations regarding the proposition of the same tools or communicative practices in multiple country contexts. For clarity of exposition, we specify that papers set in the U.S. were considered a single-country context, especially when the references were to communication actions undertaken by federal agencies or broadcasting operators throughout the territory. Likewise, operations about individual U.S. states were also considered national in scope, given the extent of the territories and the centrality of the initiatives. In contrast, papers recounting joint experiences between multiple EU countries were considered "multi-country" operations, given the timid European action on joint or shared risk communication operations.

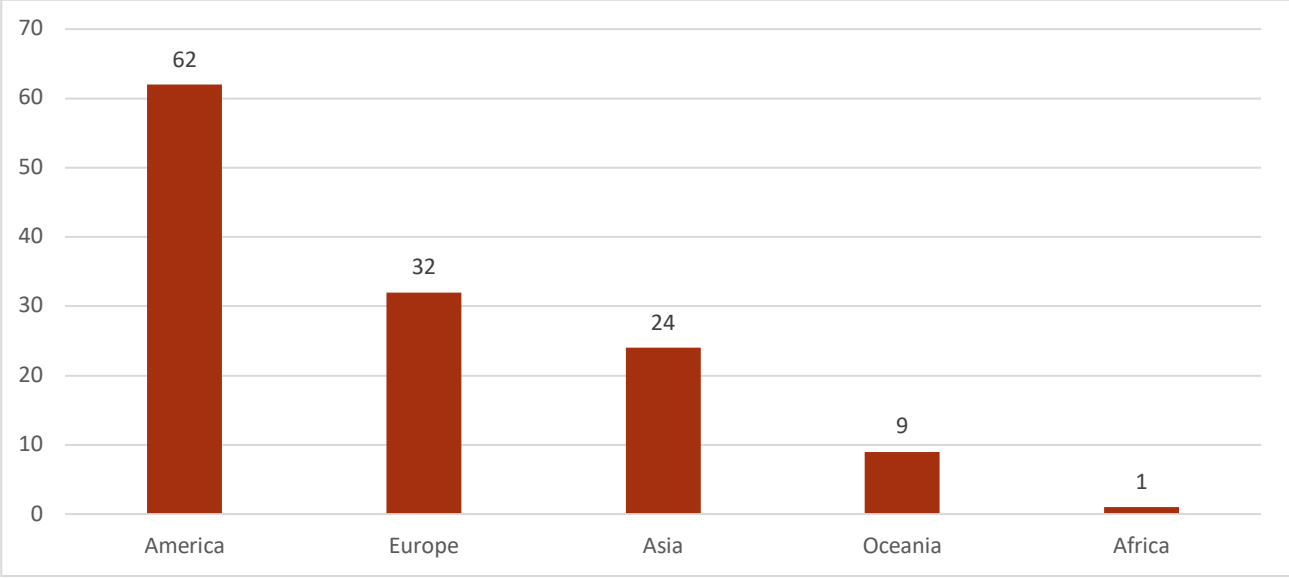
However, most of the papers (N=69) return experiences of national extension. This concerns campaigns, case studies, or initiatives aimed at extensive risk communication, not necessarily site-specific. On the other hand, 34 papers address the local and regional dimensions. Here, experiences become more focused, and the solutions presented are often tailored to address specific issues or respond to particular events. Highly targeted risks or disasters that have affected a specific area are often the subject of these "customized" solutions. The geographic extension will be presented in Figure 7.

FIGURE 7 - GEOGRAPHIC EXTENSION



Expanding the view to consider the geographical distribution of papers, it can be observed that the results confirm a tendency toward an American focus on risk communication. Sixty-two papers report on American experiences. Most of these focus on United States experiences, while some mention Canadian cases. Only three papers recount experiences in Central America, and an equal number in South America. European affairs follow, with 32 papers dedicated to them. Asian context is represented in 24 articles. Nine articles focus on Oceanic countries. Only one paper presents the African experience. This distribution demonstrates that, even though current risks may have global implications, each geographical context may face specific and unique risks compared to the region in which they are situated, and attention to risk communication remains uneven.

FIGURE 8 - GEOGRAPHIC DISTRIBUTION

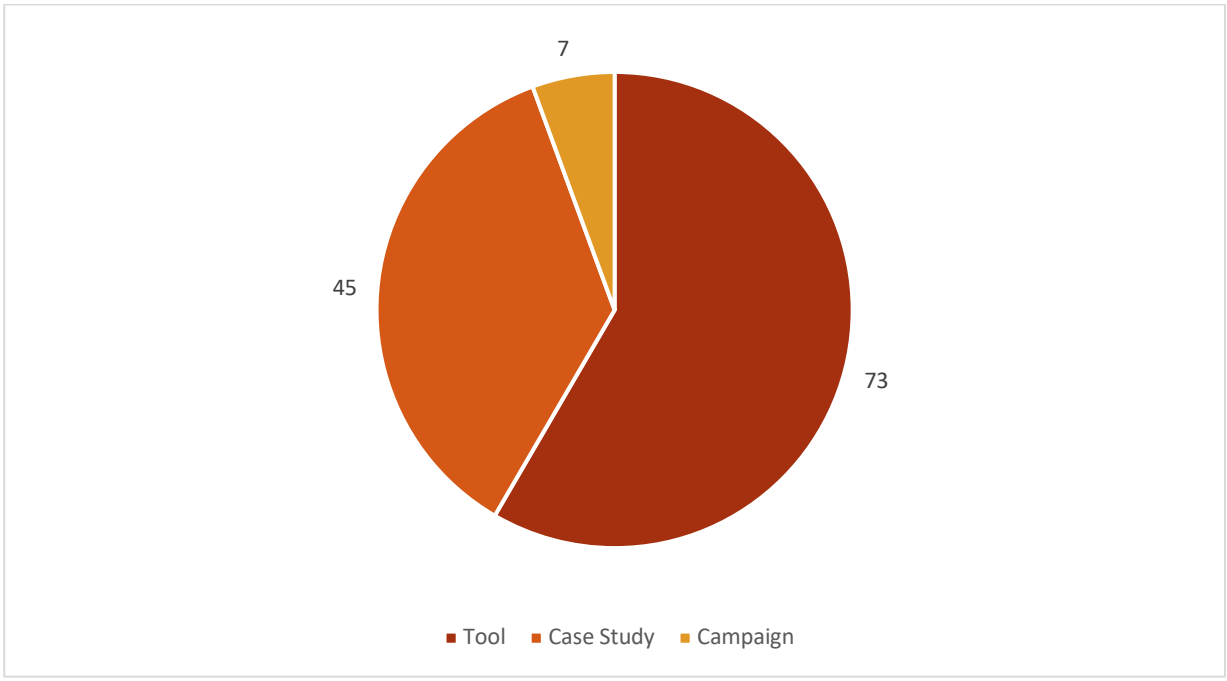


Main Topics & Theoretical Framework

Main Topics

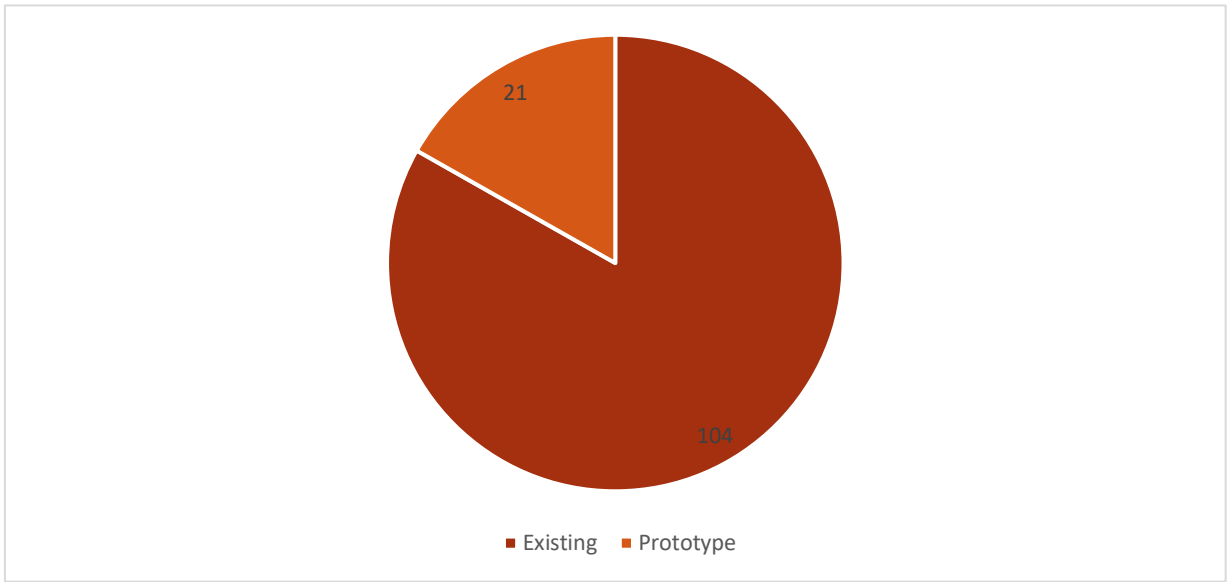
Concerning the three macro thematic areas identified in the literature, the final body of papers reviewed consists of (1) 73 papers dealing with risk communication *tools*, (2) 45 papers addressing *case studies*, and (3) 7 papers summarizing risk *communication campaigns*. Thus, it can be inferred that the research mainly focused on micro aspects, as individual tools can be, or broader dimensions, as demonstrated by the frequency of case studies. Indeed, the case studies return the link between ongoing communication actions and a specific social or applied context.

FIGURE 9 - MAIN TOPICS



Of the 125 papers examined, 104 account for existing risk communication experiences, while 21 articles are based on prototypes or tests of specific risk communication tools or communicative methods.

FIGURE 10 - EXISTING OR PROTOTYPE?



What is Risk Communication?

Only 18 papers clearly state what risk communication is. We decided to include only the definitions of risk communication explicitly expressed by the authors in our analysis. We may suppose that such underrepresentation of basic definitions of risk communication is because most of the papers in our study are published in highly-specialistic journals, with natural and environmental risks as the main topic. Therefore, a scholarly definition of risk communication would probably be deemed unnecessary, as it may be intended as common knowledge for the reading communities. The definitions retrieved from the literature are listed in Table 8.

Summarizing all the definitions, we may state that:

> Risk communication is an interactive and dialogical process expected to involve general audiences. Experts, practitioners, and significant stakeholders are the primary sources of risk communication. Risk communication must be informative, meaningful, systematic, and based on a scientific method and a parsimony principle. It may include significant information about probabilities and potential outcomes of an event that may or may not take place. To be effective, it may use graphical and visual tools. Risk communication aims to exchange information in a high-concern environment. It may explain potential threats, share warning messages, and post-events recommendations. Risk communication relies on the audiences' feedback because it may build repertoires of experiences, interpretations, and concerns about risks.

TABLE 8 - WHAT IS RISK COMMUNICATION?

Authors	*Definition*	*Source*	*Characteristics*	*Aims*	*Flow*	*Audience*
Agrawal; Hana; Debadutta; Neelakshi (2022)	Risk communication as any meaningful exchange between stakeholders regarding environmental risks, which include natural or human-made hazards such as flooding, wildfires, heatwaves, and droughts	Stakeholder	Meaningful	Exchange of information regarding environmental risks	Exchange	Unspecified
Badri; Lubis; Susanto; Suharjito (2018)	Risk communication promotes the exchange of assessments, forecasts, and opinions on hazards and risks among the various stakeholders involved	Stakeholders	Unspecified	Exchange of assessments, forecasts, and opinions on hazards and risks	Exchange	Unspecified
Bica; Weinber; Palen (2020)	Risk communication is an interaction between readers, mediators, and messages which often contain graphics that are intended to parsimoniously describe risk	Unspecified	Parsimony; graphical communication	Describe risks	Interaction	Unspecified
Bird; Gísladóttir (2020)	In a broad context, risk communication aims to prompt people to redefine the environment they are in, from one that is safe to one that contains an imminent (disaster warning) or possible threat (hazard education)	Unspecified	Unspecified	Disaster warning and hazard education	Unspecified	General audience
Charrière.; Junier; Bogaard; Mostert; Malet; van de Giesen (2017)	The definition of risk communication itself has changed from a process of informing individuals about risks to actions based on dialogue. Risk communication favors the expansion of social capacities, such as the knowledge, skills and networks that are needed to successfully manage hazard occurrences	Unspecified	Actions based on dialogue	Favors the expansion of social capacities, such as the knowledge, skills, and networks needed to successfully manage hazard occurrences	Dialogical	Unspecified
Cool; Claravall; Hall; Taketani; Zepeda; Gehner; Lawe-Davies (2015)	Risk communication is an essential component of crisis or emergency management and is one of the core capacities required under the International Health Regulations	Unspecified	Core capacity	To cope with crisis or emergency management	Unspecified	Unspecified

Heidenreich; Masson; Bamberg (2020)	Covello defines risk communication as a two-way exchange of information, which highlights the importance of a feedback loop between all actors of the risk communication process	Unspecified	Bi-directional	Exchange of information	Feedback loop	Unspecified
Herovic; Sellnow; Sellnow (2020)	Risk communication may be characterized as a dialogue about probabilities and potential outcomes of an event that may or may not take place, which people use to make decisions (Reynolds and Seeger 2012). More specifically, risk communication involves scanning the environment for potential threats, discussing such risks among experts, persuading various publics to make healthy decisions, producing warning messages, and providing post-event recommendations (Reynolds and Seeger). Mitroff (2004) describes risk communication succinctly as preparing for potential crises by improving 'our abilities to think about the unthinkable' (p. 11)	Experts	Include probabilities and potential outcomes of an event that may or may not take place	Searching for potential threats, preparing the audiences via warning messages and post-event recommendations	Dialogical	Various Publics
Hicks; Armijos; Barclay; Stone; Robertson; Cortés (2017)	Risk communication should seek to prevent and mitigate harm from hazards by informing people about potential threats, and empowering them to adopt protective measures. Specific initiatives of risk communication will adopt more narrowly defined goals, dependent on the purpose of the communication and the characteristics of the audience	Unspecified	Adopt narrow goals dependent on the purpose of the communication and the characteristics of the audience	Prevent and mitigate harm from hazards by informing and empowering people	Unspecified	Unspecified
Jiang; Zhang; Guo; Cheng; Peng (2022)	Risk communication is defined by the U.S. National Academy of Sciences as a systematic, structured, scientifically based method for communicating effectively in high-concern, high-stress environments	Unspecified	A systematic, structured, scientifically based method	Communicate effectively in a high-concern, high-stress environment	Unspecified	Unspecified
Kinsky; Chen; Drumheller (2021)	Risk communication, which is a future-oriented process of identifying the potential for crisis and attempting to prevent or minimize the effects of	Unspecified	Future-oriented process	Identify the potential for crisis	Unspecified	Unspecified

	the crisis (Ulmer et al., 2019). Crisis and risk communication are interrelated as messages developed in preparation for a crisis can influence the responses, which then influence future risk communication preparations (Lachlan et al., 2016)					
Link; Stötter (2015)	This contribution refers to risk communication as a meaningful interaction and a flow of information in which knowledge, experiences, interpretations concern and perspectives on risks are exchanged back and forth between academic experts, regulatory practitioners, interest groups and the general public, cf. Leiss (1996), Löfstedt (2003) or van Asselt and Renn (2011)	Academic experts, regulatory practitioners, interest groups	Meaningful	Exchange knowledge, experiences, interpretations, concerns, and perspectives	Interaction; feedback	General audience
Matti; Ögmundardóttir; Aðalgeirsdóttir; Reichardt (2022)	The term "risk communication" refers to interactive flows of information to notify people of the probability of a hazard occurring, likely consequences, and mitigation actions (Plough and Krimsky 1987: 6). […] Participatory risk communication involves community members engaging in two-way dialogue with risk managers; it also provides an opportunity for both groups to raise and understand concerns	Risk managers	Unspecified	Notify people of the probability of a hazard and its consequences, mitigation actions, raise and understand concerns	Interactive flows; two-way dialogue	Unspecified
Rowel; Sheikhattari; Barber; Evans-Holland (2012)	Crisis and emergency risk communication is the capability to provide accurate, credible, actionable, and timely information to the public in culturally and linguistically appropriate ways to inform decision-making and reduce uncertainty before, during, and after a public health emergency. It involves an iterative process of developing, coordinating, and disseminating information to the public, responding to inquiries and reactions from the public, and evaluating the effectiveness of the	Unspecified	Accurate, credible, actionable, and timely information to the public in culturally and linguistically appropriate ways	Inform decision-making and reduce uncertainty	Iterative process, feedback	Unspecified

	information provided and the delivery channels utilized. (CDC, 2009, p. 43)					
Salvati; Pernice; Bianchi; Marchesini; Fiorucci; Guzzetti (2016)	Risk communication is a complex activity moving from the one-way distribution of information towards a two-way exchange of knowledge and more participatory approach (Höppner et al., 2010) […]. In POLARIS we define risk communication as a two-way exchange of related information and knowledge on natural hazards and associated risk for the population	Unspecified	Complex activity	Exchange of information	Two-way exchange	Unspecified
Shepherd; van Vuuren (2014)	Emergency risk communication is "information that allows individuals, stakeholders, or an entire community to make the best possible decisions about their well-being."	Unspecified	Unspecified	Allow people to make better decisions about their well-being	Unspecified	Individuals, stakeholders, or an entire community
Shrestha; Gurung; Khadgi; Wagle; Banarjee; Sherchan; Parajuli; Mishra (2021)	Risk communication is defined as two-way communication between stakeholders about the existence, nature, form, severity or acceptability of risks. Risk communication is an interactive process of exchange of information and opinion among not only individuals but also groups and institutions	Stakeholders	Unspecified	Communication and exchange of information and opinion about risks	Two-way communication, interactive process	Individuals, groups, and institutions
Yudarwati.; Putranto; Delmo (2022)	Disaster risk communication is that part of disaster management that aims to reduce or even prevent potential damage from disasters that have already occurred, ensure immediate and appropriate assistance is given to victims, as well as rebuild infrastructure efficiently and effectively (Khan, Vasilescu, & Khan, 2008)	Unspecified	Part of disaster management	Reduce or prevent damages, ensure assistance, rebuild infrastructures	Unspecified	Victims

Theoretical Frameworks

To gain a better understanding of the distinct approaches to risk communication, we examined the theoretical frameworks used in the papers. This analysis aims to facilitate the connection between theory (and, in some cases, the "abstract" knowledge of macro phenomena) and practical tools for risk communication. Indeed, the link between insights from theory and the tools or actions outlined in the papers was the guiding principle behind the identification and synthesis of theoretical frameworks. As a precaution against overinterpreting the theoretical frameworks and the risk of arbitrarily ascribing meanings to one or more frameworks that are not explicitly related to the practical aspects of the paper, we decided to isolate only frameworks that are explicitly related to the empirical case described in the paper. In other words, we did not consider in the literature review relevant frameworks the theoretical references when (a) they were not explicitly relevant for understanding actions or research; (b) they consisted of a list of (even divergent) summarizations of risk communication attitudes; (c) they don't pertain to the sociological or communicative domain. In this way, 52 papers containing at least one explicit theoretical framework were identified. Below, the main approaches identified will be recapitulated.

The risk society perspective (*N=3*). Beck asserts that modern risks are reflexive as they are self-induced. In high modernity, risks are mainly the consequences of human activities (Beck 1986). Modern risks are typically the result of technological advancements (e.g., nuclear power, pollution, land-grabbing activities). Science and technology have an essential role in modern risks. Science and technology are involved in causing risks and are asked to formulate the diagnosis and the eventual solutions to contemporary problems.

Risk knowledge and information presentation. This approach encompasses cognitive heuristics, mental models (*N*=6), and framing (*N*=5). *Heuristics* summarize all those theoretical references for which cognitive and decision-making processes impact how risks are experienced and information about risks is understood, processed, and applied. They may affect *mental models*. A heuristic is a general rule or strategy for solving problems that help people make decisions more quickly and efficiently. As a result, they may affect how we perceive and evaluate risks and risk-related information. In decision-making and cognitive functions, mental models play a critical role. Mental representations are used by people to understand the world and to make decisions in it. Mental models can be derived from personal experience, knowledge from other sources, or readily available information. They can influence their perception of risks since they determine how a person interprets and evaluates situations. Indeed, a mental model is a representation of a problem that supports understanding, reasoning, and prediction. Reasoning about situations that have not been directly experienced can be accomplished using mental models. Generalizations and analogies derived from experience are the basis for many mental models.

Framing is a complex process. It involves sociological, psychological, organizational, and cultural dimensions. One of the most effective definitions of framing is the one provided by Entman (1993). According to Entman: "To frame is to select some aspects of a perceived reality and make them more salient in a communicating text, in such a way as to promote a particular problem definition, causal interpretation, moral evaluation and/or treatment recommendation for the item described". Framing plays an essential role in how people perceive and interpret risks. Indeed, framing contributes defining a situation as "problematic." Moreover, framing solutions may affect people's reactions, proactive behaviors, trust, and institutional credibility.

The media and communication perspective. This ensemble of theoretical frameworks encompasses communication theories (*N*=5), communication models (*N*=8), and digital media theories (*N*=2).

Communication theories focus on analyzing the complex media system through which information, including risk-related information, is disseminated and perceived by society. The main perspectives and theories that address this issue are the following: (1) *Mediatization* (Couldry & Hepp, 2013) perspective suggests that the media have taken on a central role in our daily lives. Our social interactions and perceptions of the world are mediated. Information regarding risks, for instance, is often communicated to the public by the media, which shape and transmit it according to their logic and interests. In this sense, media are considered a robust infrastructure. (2)

Media Ecology (Broad et al., 2013) theory considers the whole media environment in which we live and interact. Consequently, risk information is influenced by the media ecosystem in which it is communicated. (3) *The Design of Everyday Things* (Norman, 2013) perspective focuses on the design of objects around us, including media. Design affects the usability and accessibility of information. In the context of risk information, the design of messages and media tools can influence the understanding and perception of the audience. (4) The *Actor-Network Theory* (Latour, 2007) examines how actors (both human and non-human) interact and influence communication processes. It examines how relationships between individuals, technologies, and media influence risk information dissemination and understanding.

Communication models explain information diffusion and audiences' involvement. Then, few studies rely on the "one-way model" of communication, which is considered valid for sharing official information (what people should know during emergencies). Most papers adopt an approach based on "two-way models" of communication. These models consider feedback as an integrative part of communication and information transfers. An article (de Leon, 2021) indicates Stuart Hall's encoding-decoding model (1980) in its theoretical framework. This model suggests that there may exist a gap between how institutions and official actors code messages and how people read and decode messages. Power and cultural imbalances are relevant in this process. Finally, a paper (VanDyke et al., 2021) refers to the two-step flow of communication by Katz and Lazarsfeld (1954) to explain the relevance of personal mediation in information sharing.

Digital media theories-inspired papers adopt critical perspectives, such as the one of digital positivism by Fuchs and Mosco (2016), or combine the complexity of social media affordances to the display of networked relations, as in the networked publics approach (boyd, 2010).

Social amplification of risks (SAR) and social constructivism. Eight papers consider the SAR approach or analyze risks from a constructivist perspective. SAR framework suggests that risks derive from actual hazards and dangers and culture and social experiences. According to Kasperson and colleagues (1988: 181), "information processes, institutional structures, social-group behavior, and individual responses shape the social experience of risk, thereby contributing to risk consequences". Information contributes to the amplification of risks. Then, risks are not given but partially depend on how they are socially processed and transmitted. Risk is a social construction defined starting from the "real" definition given by experts and influenced by perceptions and social definitions.

Model and perspectives for understanding risk and risk communication. Several papers (*N*=5) are based on well-known risk communication and understanding models. These papers cite models such as the Protective Action Decision Model (PADM). It is a model aimed at integrating information from the social and environmental context with information transmitted via communication channels. Reception, attention, comprehension of warnings, exposure, attention, and interpretation of environmental and social cues are significant in processing risk-related information. A paper applies the information-deficit model (Stephens & Richards, 2020). This model suggests that citizens are not fully aware of risks and lack fundamental information and scientific culture. Therefore, experts must transmit, in a linear process, relevant information using mass media.

Public relations and organizational theories. Several approaches are founded on the comprehension of dynamics internal to organizations and on how organizations should engage with the public during risks and crises (*N*=6). Organizational communication encompasses the various channels and modes through which organizations (including corporations, NGOs, public sector, and government organizations) interact. Organizational communication includes internal communication processes and outward-facing communication between the organization and its relevant stakeholders. Organizational communication principles can be used to analyze effective risk communication, especially when describing organizations' reactions to risks and crises. Public relations techniques contribute to strategic communication processes to create a significant relationship between an organization and its public. PRs usually employ media strategically to enhance trust. Coombs's (2007) Situational Crisis Communication Theory tests an organization's communication ability during crises.

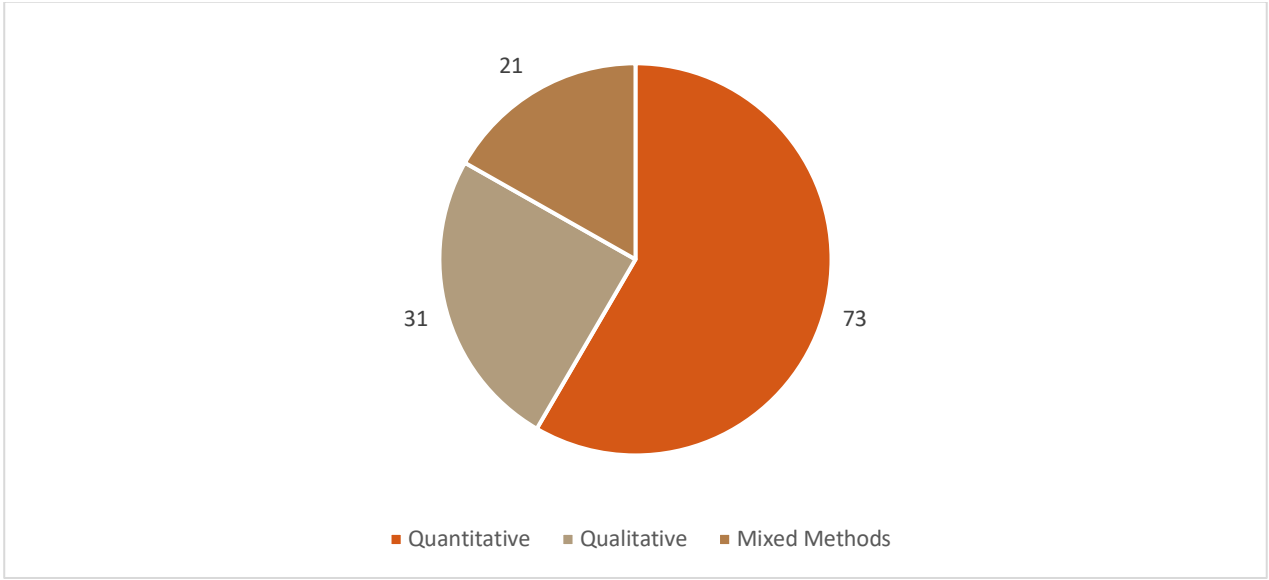
Social movements and collective action theories (*N*=5). Collective action refers to a diverse range of activities that rely on the coordination and collaboration of individuals. They are fundamental in risk communication, aiming to attain a shared goal, including maintaining public goods that benefit society. Social movements and collective action theories may partially explain how people engage and interact by adopting prosocial behavior. Relevant contributions cited in the literature review are the ones from Benford and Snow (2000). They claim that the framing concept may be applied to social movements and collective action. Indeed, framing may intervene in resource mobilization. Sense-giving processes contribute to (a) defining a specific situation as needing public attention – the problem identification phase in the *framing* process; (b) persuading people to actively participate in solving the problem.

Finally, five papers present **specific or ad hoc theories** to understand risk communication and its applications. For instance, Holmes and McEwen (2020) rely on Sustainable Flood Memory (SFM) to explain how memorization may affect citizens' reactions and preparedness in risky situations, while Rainear and colleagues (2018) discuss the role of the uncertainty reduction theory to improve risk communication.

Methods

The results of this literature review indicate that research in the field under consideration is based on various research methodologies. Anyway, it should be noted that the inclusion criteria induced an imbalance towards qualitative methods, as case studies or tools and campaign descriptions have been privileged. In particular, out of a total of 125 articles examined, it was found that the majority, accounting for 58% (N=73), employed a qualitative approach in conducting their research. The authors of these articles favored in-depth exploration through the detailed analysis of qualitative data, such as interviews, focus groups, or document analysis. Meanwhile, 25% of the papers used a mixed approach (N=31), combining qualitative and quantitative methods to understand the research problem comprehensively. Lastly, 17% of the articles relied on the quantitative research method (N=21), emphasizing statistical data and analysis.

FIGURE 11 – METHODS



Techniques for Research and Data Collection

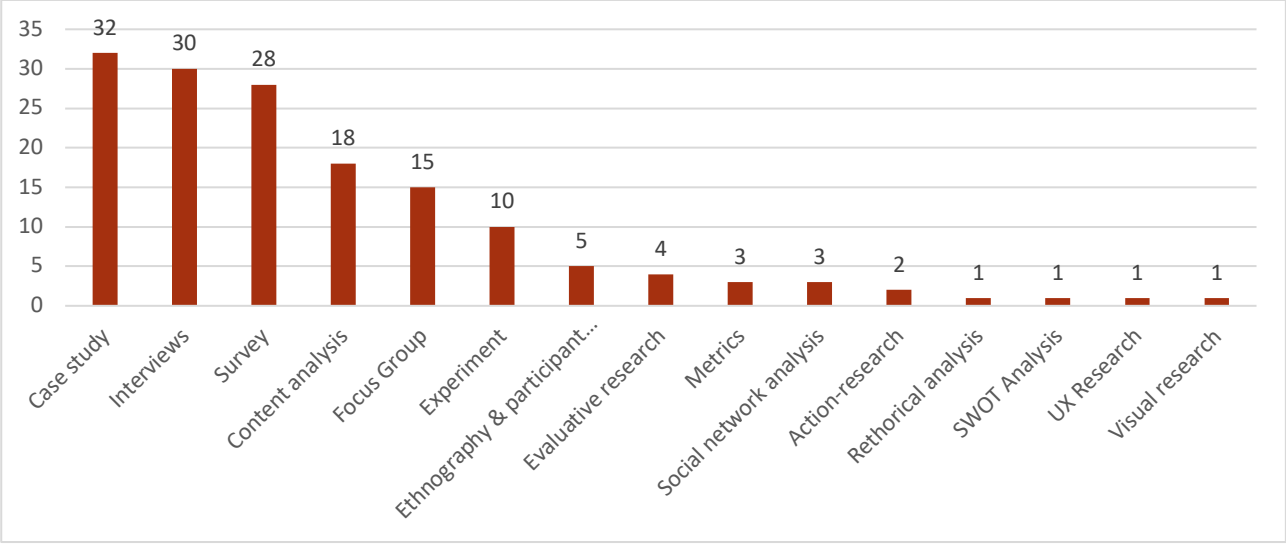
All papers present at least an indication of the techniques and strategies used to collect data. Some articles adopt a multi-technique approach. Consequently, data analysis is affected by the research design and the nature of the data.

The *case study* has emerged as a standard research approach in the literature, mentioned in 32 instances. Of course, the inclusion criteria affected this result. When stated by the authors, we considered case study as a method, and when it was clear reading the text that data collection and presentation was led by presenting an in-depth analysis of a single case or a small number of cases to gain a thorough understanding of risk communication. *Interviews* were extensively used in 30 articles. This technique involves structured or semi-structured conversations with key experts, practitioners, or general audiences to collect qualitative data. Thematic analysis is one of the most frequent techniques to analyze interview transcripts. *Surveys* were widely used in 28 articles. Collecting quantitative data through standardized questionnaires is common in risk communication research, especially regarding the audience's perceptions or evaluation of tools.

Content analysis was mentioned in 17 cases. This method implicates systematic analysis of the content of risk campaigns or informative content, as well as official documents and strategic guidelines to extract meanings, patterns, or trends. *Focus groups* were mentioned in 15 cases. This technique has been mainly used to record structured group discussions to explore participants' opinions and perceptions of risk communication tools. *Experiments*, including eye tracking and the Q-method, were used in 10 instances. These methods comprise rigorous control of variables to test tools and different content presentation strategies in risk communication. *Ethnography and participant observation* were used in 5 cases. These techniques include researchers' immersion in social contexts to understand cultural and behavioral dynamics. Long-durée observations are used to explore specific risk communication initiatives, such as risk communication in multicultural environments or aimed at transient communities.

Evaluative research was mentioned in 4 articles. This approach focuses on the evaluation of programs and policies for risk communication. *Metrics* were mentioned in only three pieces, focused on investigating the role of specific accounts on social network sites in spreading information during crises or post-disasters. *Social network analysis* emerged in 3 instances, although personal and social networks are relevant in understanding information diffusion and risk socialization. *Action-Research* was mentioned in only two articles. This approach combines research and action to offer practical examples of risk communication in specific situations. *Rhetorical analysis* and marketing techniques, such as the *SWOT analysis*, were mentioned in only one article, indicating a marginal presence in the analyzed literature. Despite the relevance of user experience and the attention to the graphic and visual aspects of risk communication, *User Experience* (UX) research was mentioned in only one case, and *visual methods* were used in only one article.

FIGURE 12 - TECHNIQUES FOR RESEARCH AND DATA COLLECTION



What to take home

- ⇒ Selected papers have been published between 2006 and 2023 in 66 different journals
- ⇒ Flooding and hydrogeological risk are among the most discussed topics followed by storms, typhoons, hurricanes, and tornadoes
- ⇒ Most of the communication activities addressed in the papers happens in a *pre-risk* stage
- ⇒ Most of the papers return national experiences; America is the most represented continent in analyzing risk communication
- ⇒ 73 papers deal with risk communication *tools*, 45 papers address *case studies*, and 7 papers summarize risk *communication campaigns*
- ⇒ Only a few papers clearly state what risk communication is
- ⇒ Theoretical frameworks range from classical approaches pertaining to risk society to social movements theories
- ⇒ Most of the papers present qualitative inquiries

Campaigns

This section summarizes the campaigns' main characteristics and achievements. Seven papers of 125 outline campaigns overview. These experiences are from different countries and aim to inform about several risks, from earthquakes to climate change. They are mainly led by institutions and governmental agencies based on a tailored media mix. Those campaigns are directed to general audiences.

Campaigns are mainly directed at leveraging information effectively to foster meaningful conversations and enhance public awareness about risks and climate change. This involves creating awareness and actively working to change risk perception among individuals. Sometimes, campaigns are designed to engage citizens in prevention activities and exercises, such as drills or workshops. This active involvement may promote a cultural shift towards preparedness and loss reduction. This shift supports public awareness and equips people with the necessary risk knowledge to better understand mitigation and preparedness strategies. Moreover, campaigns such as the one sponsored by the Swedish government to foster the reduction of gas emissions are intended to make citizens more prone to accept governmental policies to mitigate climate-related risks. By involving people at all levels, from grassroots initiatives to policy advocacy, campaigns address the challenges posed by climate change and natural risks, building a more resilient society.

The campaigns' main results highlight the importance of participation, trust, and risk narratives. Pflugfelder (2019) claims that the success of the #14gallons campaign (focused on water storage) was evident through extensive media coverage and active public engagement. Moreover, combining crucial topics is a powerful way to organize risk-related information, as proven by the campaign that leveraged health-related information to raise awareness about climate change (Sanderson et al., 2020). Over time, the cumulative effect of various campaigns significantly enhanced risk awareness among the public. Exposure to distant imagery about risks and local events contributed to a deeper understanding of the potential consequences (Shenar et al. 2015, 2016). Risk communication campaigns underscored the importance of considering the normative context and the public's desire to actively reduce risks in local and national communities (Fontana et al., 2012). Indeed, trust in scientific communities, agency reputations, and consensus played pivotal roles in effective risk communication (Jones & Benthien, 2011). A multifaceted issue, such as climate change and related policies, should be reported with nuanced framing, as oversimplification hinders informed decision-making (Ulla, 2008).

The campaigns are analyzed from a comparative perspective. For each campaign, we isolated the constituent elements, derived from the definitions identified in the literature, to benchmark against the practices and processes of conducting the campaigns. This benchmarking operation was performed only on the campaigns and not also on the tools or case studies, since the campaigns were more homogeneous than the tools and case studies recounted in the papers.

Benchmarking was therefore directed toward identifying the constituent elements to isolate the significant campaign achievements and best practices.

The elements considered aimed to assess the quality of the tools used in relation to possible contextual pressures (the public agenda), material constraints (the allocated budget), and the nature of the stakeholders involved.

This activity has made it possible to identify some significant elements in the design of campaigns: on the one hand, they must be declined in multiple media channels, including offline interaction contexts or contextualization in everyday interaction environments. The reiteration of messages in different forms or channels can be functional for memorizing campaign content. The context in which these occur is relevant, as is the timing. Proposing campaigns related to major natural disasters that did not directly affect the target populations, or following minor phenomena, can promote memorization. Finally, target audience involvement, including through forms of co-production, can contribute to affective participation in risk communication.

Table 9 summarizes the main characteristics of risk communication campaigns retrieved in the literature review, as performed in the benchmark activity. Indeed, as the small number of cases does not allow for systematic generalizations, we decided to focus on each campaign describing its main features.

TABLE 9 - COMMUNICATION CAMPAIGNS

Make it better campaign (Canada)	
Authors	Sanderson, Doyle, Walsh (2020)
Stage	Pre-risk
Geographical context	Canada
Period	August 2019
Aims	To leverage information to engage in climate conversations
Promoters	Governmental agencies
Agenda	Unspecified
Financing & budget	Bringing together partners from the health and environmental sectors, the project was funded by The Atmospheric Fund.
Campaign description	The #MakeItBetter campaign was designed to educate people about the health impacts of climate change and encourage them to take climate-friendly actions. Through a health-focused messaging campaign, the campaign sought to mobilize action on climate change.
Co-participation	The campaign promoted community-building resources and encouraged individual activism through messages such as "Engage in climate conversations in your community", "Start your own neighborhood climate action group" and "Become a change-maker in your community!"
Media mix	Multi-media mix: broadcast, print media, social media
Target audience	Generic/Unspecified
Preliminary research	Yes
Main results	Media coverage and public engagement demonstrate the campaign's success by using health-related information to raise awareness about climate change.
#14gallons campaign (Oregon)	
Authors	Pflugfelder (2019)
Stage	Pre-risk
Geographical context	Oregon
Period	October 2015
Aims	Increasing public awareness and preparedness
Promoters	Public Broadcasting Network
Agenda	Unspecified

Financing & budget	Unspecified
Campaign description	In the event of a cataclysmic earthquake, #14gallons served as an educational campaign that encouraged individuals to collect and store 14 gallons of fresh water per person. After collecting it, people were encouraged to take a selfie with their water and tag others to do the same. This campaign illustrates the potential for nonrational environmental risk communication strategies that encourage participants to bring the affective forces of their collectives into a more extensive presentation of risk.
Co-participation	Participants were asked to take "risk selfies."
Media mix	Social network sites (Twitter)
Target audience	Generic/unspecified
Preliminary research	No/unspecified
Main results	The campaign, intended to communicate risk through social media, has become a crowd-sourced expression of non-rational risk.
Earthquake Awareness Campaigns (Israel) #1	
Authors	Shenhar, Rozenfeld, Radomislensky, Peleg (2016)
Stage	Pre-risk
Geographical context	Israel
Period	From 2011 to 2013
Aims	Creating awareness
Promoters	Government
Agenda	Unspecified
Financing & budget	Each of the three campaigns described in the paper had a cost of more than 1 million dollars
Campaign description	Leading Israeli advertising agencies prepared the campaigns. Campaigns were conducted over two weeks via television, radio, and the Internet. Video clips aired on the three main national television channels during most campaigns. The first campaign in 2011 comprised two video clips, each about 30 seconds long, which focused on the intimidating aspect of the threat. The first video showed a room with a baby sleeping in a cradle that suddenly began to shake violently, followed by the voiceover message: "A strong earthquake in Israel is only a matter of time; don't let it catch you unprepared!". The second video clip showed a mother taking her baby out of his bed, hugging him, and leaving the room safely. In 2012, a second campaign was conducted just before the massive week-long earthquake drill "Turning Point 6," which also received extensive media attention. The campaign included one video clip, 47 seconds long, presenting two well-known characters: a famous comedian and a doll from the "Puppets" show. The third campaign in 2013 was launched immediately after several small-scale earthquakes shook the soil of Israel, with mass media covering the issue for several days. The message was, "This sequence of earthquakes might forebode a coming of a really strong earthquake!". The campaign included a 28-second video clip. In the video, a scrabble board filled with preparedness-related

	words violently shakes, and the announcer verbally describes what needs to be done during an earthquake and provides information on the subject.
Co-participation	Not present
Media mix	Broadcast media
Target audience	Generic/unspecified
Preliminary research	No/unspecified
Main results	Over time, the cumulative effect of campaigns tends to impact raising risk awareness substantially. The public may benefit from images of earthquakes that have occurred elsewhere to understand their consequences better. Additionally, exposure to minor earthquakes in the country may have helped raise public awareness about possible earthquakes.
Earthquake Awareness Campaigns (Israel) #2	
Authors	Shenhar, Radomislensky, Rozenfeld, Peleg (2015)
Stage	Pre-risk
Geographical context	Israel
Period	2011
Aims	Change risk perception and prepare people to face risks
Promoters	Government
Agenda	Unspecified
Financing & budget	The total cost of the campaign was about 1 million US dollars
Campaign description	The 2011 campaign took place during two weeks through television, radio, and Internet broadcasts. The more significant part of the campaign included video clips in Hebrew on the three major national TV channels. To motivate behavioral change, the campaign aimed to frighten the audience. The 2011 campaign included two different videos, each approximately 30 seconds long. The first showed a room beginning to shake while a baby was sleeping in a bed, after which the alarm clock fell and started ringing. The voiceover states, “A strong earthquake in Israel is only a matter of time, don’t let it catch you unprepared”. The second video shows a mother grabbing her baby from his bed, hugging him, and leaving the room. Suddenly, the room shakes, and parts of the ceiling fall onto the baby’s bed, destroying it. The voiceover says, “A strong earthquake in Israel is only a matter of time, strengthening infrastructure and learning how to act during an earthquake can save lives. Don’t let it catch you unprepared.”
Co-participation	Not present
Media mix	Broadcast media
Target audience	Generic/unspecified
Preliminary research	No/unspecified

Main results	Surveys show that campaign affected risk knowledge and preparedness
Hydro-geological risk hypothetical campaign (Italy)	
Authors	Fontana, De Amicis, Rossetti, Garcia (2012)
Stage	Pre-risk
Geographical context	Mountain Consortium of Municipalities Valtellina di Tirano
Period	Unspecified
Aims	Involve citizens in prevention activities
Promoters	Unspecified
Agenda	Unspecified
Financing & budget	The total cost of this campaign is about 70,000 euros.
Campaign description	As the campaign's goal is to get close to the objective of a commercial campaign, the operation procedure is modeled after advertising strategies. The action promoted in the campaign can be summarized by its four symbols: "Know the territory", "Inform yourself", "Listen," and "Protect yourself". The symbols consist of text and images joined together as a single unit. Consequently, the symbols are more understandable since the text and the image are complementary. The four symbols are grouped in a single image representing the campaign's logo.
Co-participation	Risk prevention meetings have been scheduled with students, teachers, and local authorities.
Media mix	Multi-media mix: flyer, gadget (an umbrella with the logo of the campaign), billboards, and a website
Target audience	Families
Preliminary research	Yes
Main results	Risk preparedness campaigns must take into account the normative context and the people's desire to know how to reduce the risk in their territory directly
Shakeout Earthquake Drill (California)	
Authors	Jones & Benthien (2011)
Stage	Pre-risk
Geographical context	California
Period	2008
Aims	Involve people in drills; change culture of preparedness; loss reduction
Promoters	Several scientific societies, utility lifeline operators, emergency services, public health, local governments
Agenda	Previous disasters

Financing & budget	The overall effort was created without dedicated government funding. FEMA, the USGS, the National Science Foundation, the California Emergency Management Agency, the California Seismic Safety Commission, and other agencies supported individual components.
Campaign description	The campaign was aimed at making people participate in a drill. It was a one-day event serving as a deadline for people to participate and get prepared. The training followed many months of broad outreach to involve as many people as possible.
Co-participation	People are asked to participate in a drill
Media mix	Multi-media mix: Web site, billboards, and a gadget (T-shirts)
Target audience	Generic/unspecified
Preliminary research	Yes
Main results	Trust in scientific communities, agencies' reputation, and consensus are fundamental in risk communication campaigns
The Swedish climate campaign (Sweden)	
Authors	Uggla (2008)
Stage	Unspecified
Geographical context	Sweden
Period	2002
Aims	Promote public awareness and risk knowledge to accept governmental policies
Promoters	Governmental agency
Agenda	Public and political discussions about governmental policies to contrast climate change
Financing	Unspecified
Campaign description	The campaign combined central and local activities to maximize effectiveness and used available networks. The main objective of the central and national activities was to make climate change a public issue, establishing it on the media agenda and in the public discourse. The strategic concept of the campaign was summarized in the following phrase: "The greenhouse effect – a big problem with many simple solutions." After the preparation phase, towards the end of 2002, the campaign was launched at a press conference and unveiled a website bearing the slogan, "The greenhouse effect affects you, how do you affect it?". The campaign was dramatized through the use of folktales and children's songs. Leaflets were distributed throughout the campaign to convey the central message.
Co-participation	Not present
Media mix	Broadcast media
Target audience	The entire Swedish population
Preliminary research	Yes

Main results	Climate change is a complex issue that can be framed in several ways. Oversimplification is not valuable for helping people make conscious decisions.

What to take home

⇒ Campaigns are mainly led by institutions and governmental agencies based on a tailored media mix
⇒ Campaigns are usually directed to general audiences
⇒ Campaigns' main achievements highlight the importance of participation, trustworthiness, and risk narratives

Case Studies

Case studies encompass several cases with different characteristics. In this section, we summarize their main features. Of 125 papers, 45 are about case studies. We define a case study as a structured account of a specific risk communication episode, distinguished by its temporal and geographical parameters, encompassing one or more discernible communication actions undertaken by a clearly defined actor.

The following table illustrates the frequency distribution of communication objectives across the 45 papers analyzed in our literature review. The communication actions described in these papers may have multiple goals. Communication actions often serve multiple purposes simultaneously, adding complexity to the analysis.

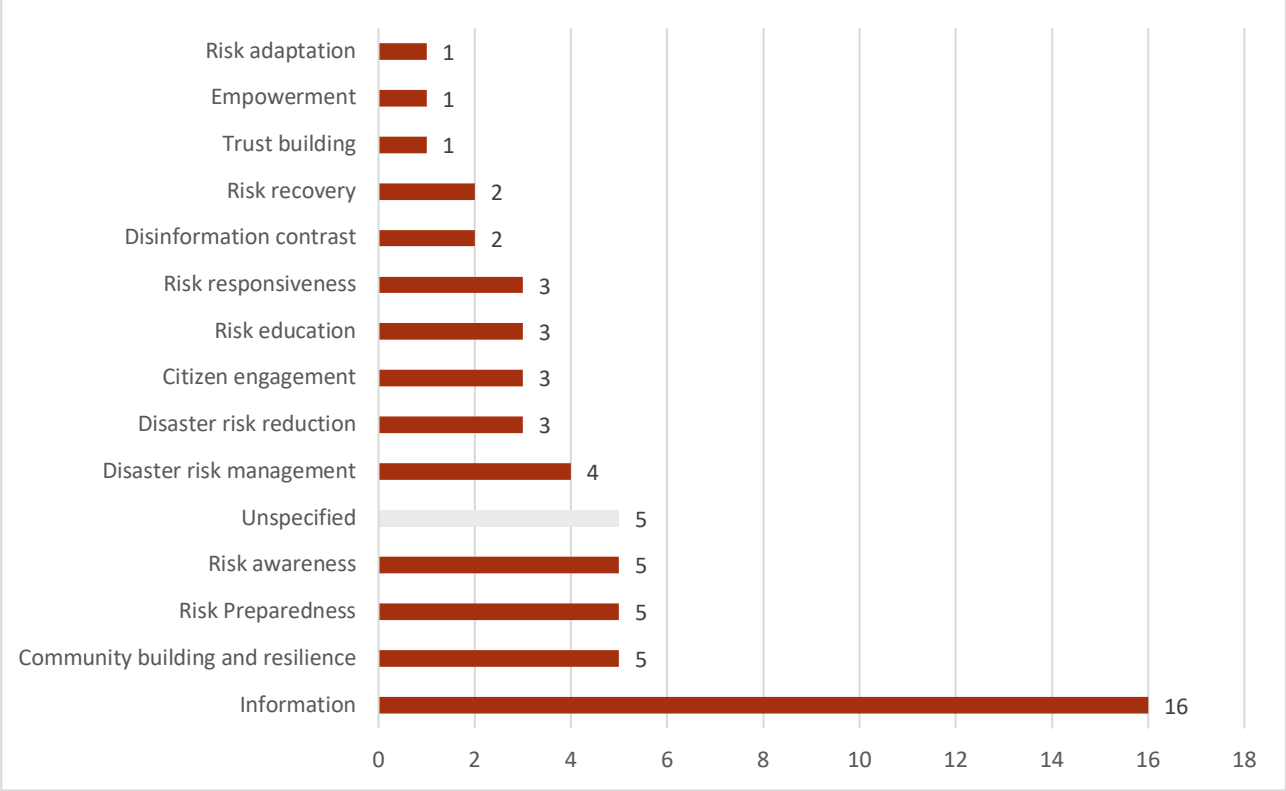
The most common communication objective observed among the papers was *information*, with 16 papers addressing this aspect. Communication is crucial in disseminating essential information for effective disaster risk management and public awareness.

Aside from disseminating information, other objectives included *community development and resilience*, *risk preparedness*, and *risk awareness*, each with five papers devoted to exploring these aspects of communication. These objectives underline the multi-layered nature of risk communication to foster community cohesion and propose practical solutions to prevent or minimize risk impacts.

Furthermore, the analysis revealed that communication actions were also aimed at objectives such as *disaster risk management*, *risk reduction*, *citizen engagement*, *risk education*, *risk responsiveness*, and *disinformation contrast.* Even though some of these objectives appeared less frequently, they remain essential for understanding the breadth of communication strategies employed in disaster risk situations.

Results are presented in Figure 13.

FIGURE 13 - CASE STUDIES: MAIN GOALS



While several papers emphasize the development of community-related initiatives in risk prevention and management as primary objectives within their case studies, only six papers explicitly state that these changes

were aimed at collective advancements and community improvement. It can be inferred that much of the focus in risk information and communication is primarily directed toward affecting individuals' perceptions and behaviors. Informed individuals, however, may play a pivotal role in boosting community engagement.

We have defined case studies as inherently linked to specific contexts. Nevertheless, only a few papers clearly articulate the relationship between communication decisions and the public agenda. Only seven articles provide insights into how the described actions and initiatives are associated with the public's awareness of discussions regarding risks and disasters.

In one instance, the scientific community, during a public climate change event, called for a more coherent approach to risk communication (Kiwanuka-Tondo & Pettiway, 2017). In another case, communication initiatives stemmed from the publicity generated by several strategic documents released by a governmental environmental agency (McCarthy, 2007). In four instances, previous or recent natural disasters compelled governments and agencies to reconsider their approaches to more effective and targeted risk communication (Andrade et al., 2020; Tagliacozzo & Magni, 2018; Mason et al., 2017; Amato et al., 2012). Media pressure played a role in just one case, prompting the Italian Civil Protection to expedite its communication efforts regarding volcanic risks following heightened public interest sparked by a National Geographic feature (Paradiso, 2012).

Only two papers provide information about the sources of financing (Stovall et al., 2023; Graham et al., 2022). Government agencies and public institutes are the main actors in risk communication.

Data presented in Table 10 represent the initiators of risk communication activities identified in the case studies literature review. In one case, we identified two main actors. The most common initiators are government agencies and national research institutes, which are mentioned in nine articles each. Thus, governmental and national research institutions about the environment, science, and technology are vital in promoting risk communication.

Additionally, emergency departments and civil protection are mentioned in four articles, demonstrating their crucial role in emergency management and communication aimed at risk reduction or preparedness. Non-governmental organizations (NGOs) and other stakeholders and promoters are also mentioned in four articles.

Local governments and municipalities are mentioned in three articles, while universities and professional associations are mentioned in two. Furthermore, one paper each identifies community managers, the political executive, the government, and scientists as initiators.

Private actors, media, and platform operators are not among the leading promoters of risk communication processes. Thus, there is a paradox. Although risk communication is highly mediatized, the case studies about it do not make explicit the linkage and possible partnerships between canonical risk communication actors (such as civil protection or emergency management agencies) and media experts, regulators, or governance managers.

TABLE 10 - CASE STUDIES: MAIN ACTORS

Main actors and promoters	Number of papers
Government agencies	9
Unspecified	9
National research institutes	5
Emergency departments and Civil protection	4

NGOs	4
Several stakeholders and promoters	4
Local government and municipalities	3
University	3
Professional associations	2
Community managers	1
Political executive and government	1
Scientists	1

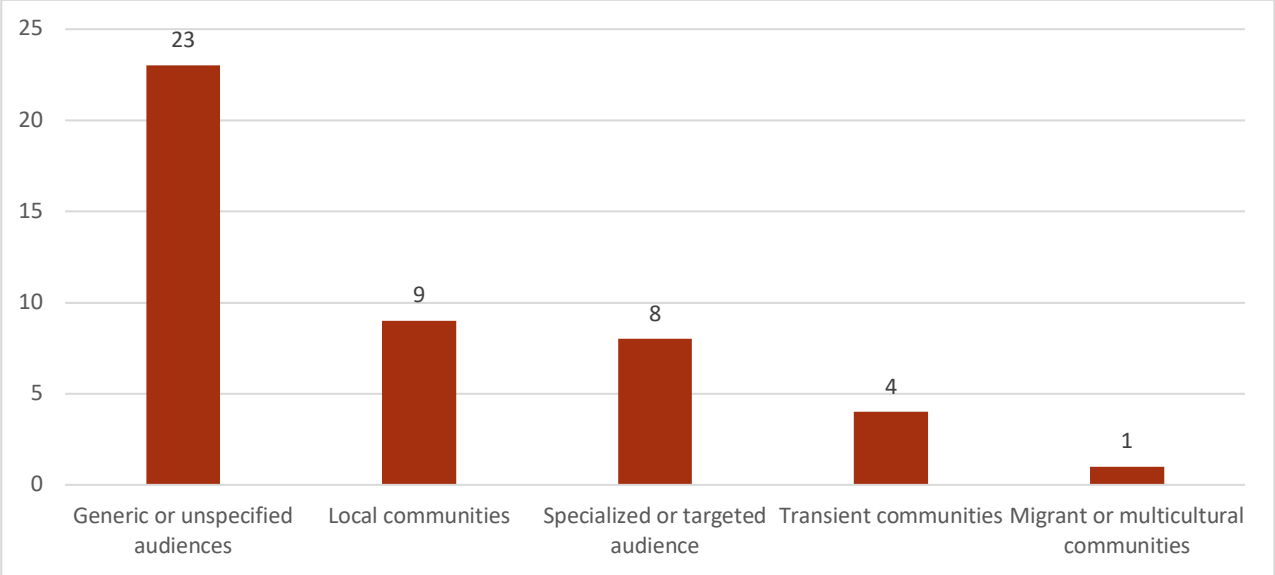
The data presented in Figure 14 summarize the target audiences for risk communication identified in case studies. The broadest category, represented by *generic or unspecified audiences*, encompasses 23 case studies. In many risk communication contexts, the target audience may be more general, as risk socialization through communication is a process designed to involve as many citizens as possible.

Conversely, nine case studies identified *local communities* as the target audience. More tailored and targeted risk communication operations are intended to involve specific communities. In those cases, we may suppose that cultural resonance is a significant "glue" to keep communities and local audiences together. Risk memories and shared narratives may act as substantial enhancers.

Eight case studies aimed risk communication at a specialized or targeted audience. Those audiences may be context-related (e.g., University students who live on the campus during natural disasters) (Ozanne et al., 2020; Abukhalaf & von Meding, 2020) or be able to decode more specialistic information, as the scientific communities or government representatives. In just one case, this specialized communication is intended as an internal process within the organization (Link & Stötter, 2015).

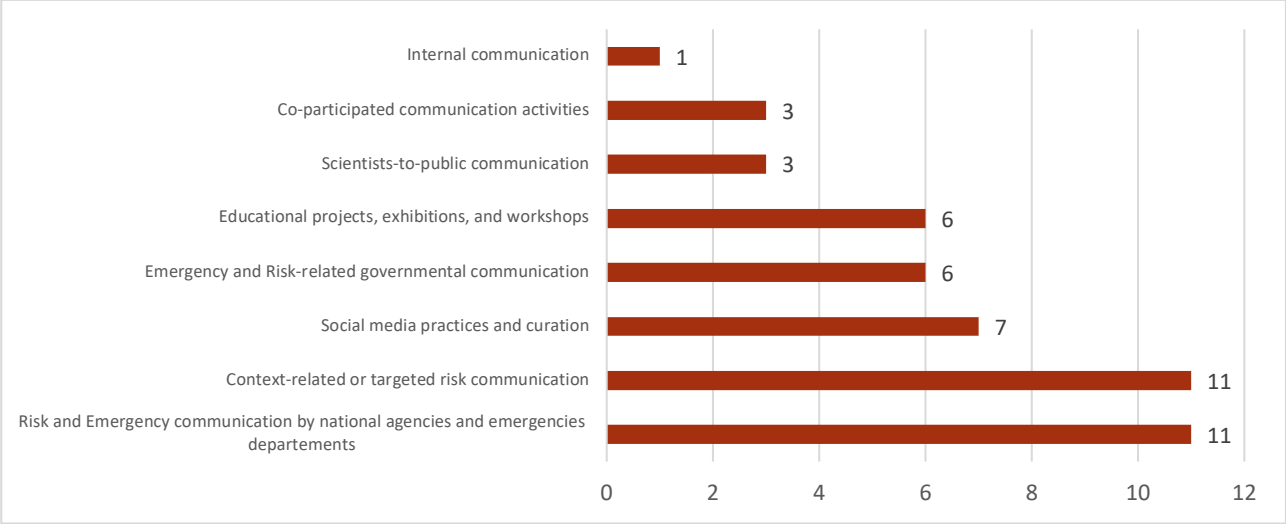
Furthermore, it's interesting to note that *transient communities* and migrant or *multicultural communities* were identified in four case studies (Shepherd & van Vuuren, 2014) and one case study, respectively. In particular, several communication initiatives involve risk communication by local authorities aimed at tourists and touristic operators. These initiatives intercept audiences not familiar with specific risks, such as the one due to glacier tourism in Iceland (Matti et al., 2023; Bird & Gísladóttir, 2020) or tsunami preparedness in Indonesia (Irwanti et al., 2023). Despite the importance of addressing the needs of transient or multicultural communities in risk communication contexts, these initiatives are still limited in the research, suggesting that risk communication is mainly a generic process aimed at information transmission.

FIGURE 14 - CASE STUDIES: TARGET AUDIENCES



The main themes discussed in the case studies highlight the particular focus on the role of national agencies and emergency departments. Eleven papers report national agencies (including governmental ones) and emergency departments' activities promoting standard or emergency risk communication. It is noteworthy that context-related or targeted communication was mentioned significantly, suggesting that tailoring messages to specific contexts plays a crucial role in risk communication analysis. Additionally, the results underscore the interest in using social media as a communication tool, with seven mentions. Governmental communication related to emergencies and risks was equally significant, indicating the theoretical and empirical effort in analyzing the effectiveness of public institutions in crisis management. Educational projects, exhibitions, and workshops received six mentions, emphasizing the importance of community awareness and preparedness. On the other hand, direct communication from scientists to the public and participatory communication activities were mentioned less frequently (three papers each). Finally, although internal communication within agencies and emergency departments was mentioned only once, it is critical in ensuring a coordinated and effective response to crises.

FIGURE 15 - CASE STUDIES: MAIN THEMES



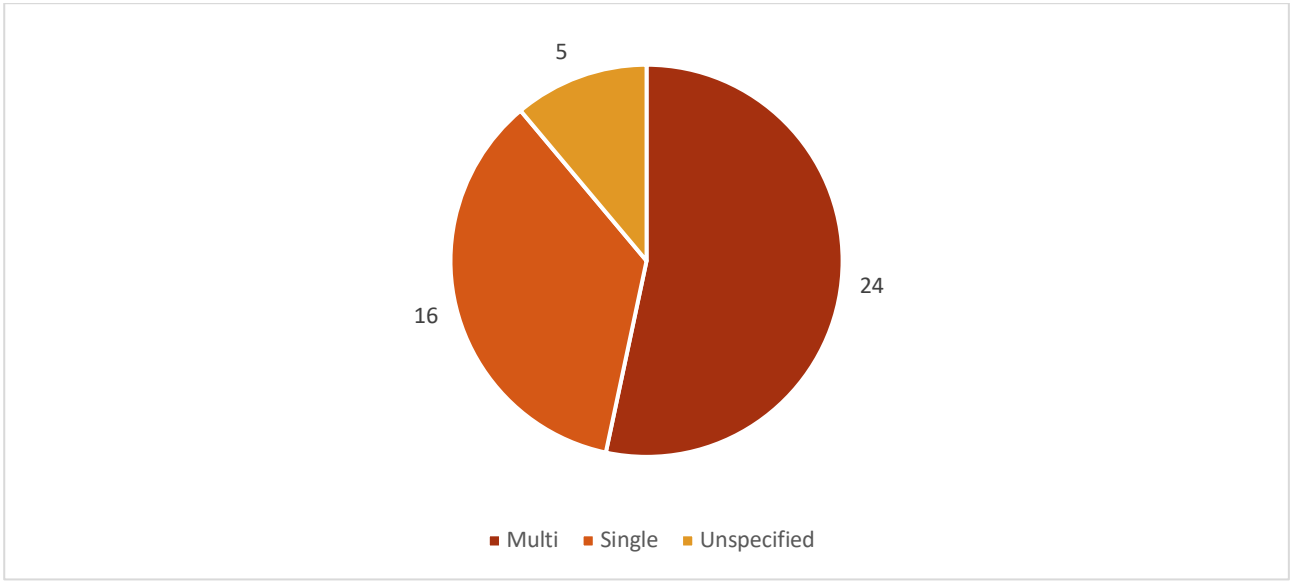
The analysis of 45 papers in the case study reveals a diverse range of communication strategies and a well-curated mix of media channels. Among these, five articles lack specifics regarding the nature of media or the employed

communication channels. These instances typically involve case studies documenting unique approaches to communication by agencies or specific individuals, or they gather professional insights and other forms of communicative experiences.

Sixteen papers exclusively focus on a single media approach. For instance, some papers delve into the use of social media or detail particular communication experiences facilitated by broadcast media or face-to-face interactions.

Lastly, 16 papers provide a comprehensive account of multiple media experiences. These scenarios encompass situations where information sharing via social media or broadcast media is complemented by face-to-face communication during in-person events or workshops. Furthermore, there are instances where authorities employ both broadcast strategies and personal media for their communication efforts.

FIGURE 16 - CASE STUDIES: MEDIA MIX



Out of 45 papers, seventeen of them incorporate references to community engagement. These initiatives primarily focus on assessing the community's role as a contextual factor in creating effective risk communication tools. Four of these papers emphasize the importance of community listening and adopting a community-based approach in the design process.

Moreover, six papers delve into specific community engagement experiences. Additionally, several papers explore utilizing community resources to gather real-time data and reports, with three emphasizing this aspect. Two papers provide insights into community workshops, shedding light on the interactive nature of community involvement.

In addition to these findings, one paper elaborates on information-sharing processes, while another paper examines how communities interact with content posted on social network sites (Pignone et al., 2022).

Case Studies Main Findings

The main findings underscore the crucial role of effective risk communication by national agencies and emergency departments during risk events and in the post-event or recovery phase (Tagliacozzo & Magni, 2018; Atkinson, 2014). Strategies for facilitating the return of individuals to affected areas are significantly influenced by the availability of information concerning damages, infrastructure, and utilities. These insights collectively reduce uncertainty and fulfill specific information requirements (Manandhar et al., 2021; Mason et al., 2017; Veil & Husted, 2012). Inter-organizational communication should be fostered to significantly improve risk communication (Fu & Lai, 2021). Nevertheless, certain studies have shown that collaboration between agencies, particularly governmental ones, and the scientific community can be intricate. In some instances, governments

are primarily responsible for disseminating general information, while scientists engage in technical processes (Badri et al., 2018).

Fokaefs and Sapountzaki (2021) have observed that uncertainty in seismic crisis communication can be attributed to several factors, including (a) a lack of knowledge and precise data, particularly in the immediate aftermath of an event (see also Andrade et al., 2019); (b) the inherent variability inherent in seismic events; (c) disparities between expert knowledge frameworks and diverse public perceptions; (d) technological challenges; and (e) coordination and governance hurdles.

Effective online communication should adhere to organizational guidelines (Stovall et al., 2022; Kinsky et al., 2022; Amato et al., 2012) and mirror stakeholder engagement strategies (Meltzer et al., 2018; Kiwanuka-Tondo & Pettiway, 2017; Paradiso, 2012; McCarthy, 2007). Moreover, online strategies should reflect institutional authority (Feldpausch-Parker & Peterson, 2017). Conversely, there is the potential for individuals to initiate uncontrolled communication efforts (Chatfield & Reddick, 2015).

To place individuals on a central stage, whether in developing communication initiatives or disseminating information, represents a promising approach to countering disinformation (Fallou et al., 2022) and enhancing risk awareness and preparedness (Sansoulet et al., 2019). However, in interpreting and decoding information, governments occasionally adhere to a one-way information dissemination model (Yudarwati et al., 2022). In reality, scientific knowledge should be conveyed engagingly, taking into account the characteristics of the target audiences and stakeholders (Henriksen et al., 2018). Physical and cultural proximity can significantly enhance risk awareness (Cooper et al., 2021). Therefore, involving people in risk communication initiatives can transform them from passive recipients into active collaborators in the risk management process (Sun & Yamori, 2018), which, in turn, clarifies their responsibilities (Agrawal et al., 2022).

Lastly, it's important to note that the applicability of these results varies depending on location-based or experience-based communities. On the one hand, traditional risk communication strategies like campaigns, information dissemination, and operator education are ineffective in engaging transient communities, such as tourists who aren't directly impacted by risks (Bird & Gísladóttir, 2021). On the other hand, the very same methods worked for vulnerable populations such as medical tourists (Mason et al. 2019). However, these strategies have shown efficacy when targeting more stable communities during risks, such as university communication in emergencies (Abukhalaf & von Mendig, 2020).

What to take home

- ⇒ Case studies report different risk communication activities
- ⇒ Governmental agencies, emergency management institutions, and risk-related operators are among the most prolific actors in risk communication
- ⇒ Organizational coordination, trustworthiness, and designing strategies tailored to target audiences prove to be important elements in understanding case studies' effectiveness
- ⇒ Case studies' main findings are not generalizable, as they depend on the nature of the risk and the communities' peculiar traits

Tools

Out of 125 papers examined, 73 delve into tools to enhance risk communication. Tools differ from case, emphasizing describing the object itself rather than contextual dimensions. Most of these tools are geared towards either disseminating information effectively or improving the sharing of critical information. Specifically, various communication resources, such as visual aids and digital platforms, have been developed to present risk information clearly and engagingly. Notably, 40 of these tools are explicitly designed to inform users, focusing on enhancing data sharing and facilitating the visualization of risks.

Additionally, there are ten tools with the primary objective of raising risk awareness. Some of these tools are tailored to enhance individuals' knowledge about their local environment or the nature of different risks. Others contribute to boosting citizen engagement (comprising seven tools) or fostering community cohesion and resilience (also involving seven tools).

These tools predominantly serve two overarching purposes: disaster risk reduction (6 tools) and risk preparedness (7 tools). They aim to prepare citizens to confront risks head-on and minimize their potential impact. Furthermore, risk mitigation (4 tools) and protective actions (3 tools) are pivotal objectives, empowering citizens to recognize and adopt appropriate behaviors and practices.

In addition to the goals mentioned above, there are tools designed to facilitate risk management (3 devices) and recovery (3 instruments), as well as those focused on risk prevention (2 tools) and countering disinformation (1 tool).

It is important to note that the main objectives of these tools have been derived from the statements of the authors and the descriptions provided for each tool. Some tools may serve multiple goals; a comprehensive list is available in Table 11.

TABLE 11 - TOOLS: MAIN GOALS

Main goals	Number of papers
Information	40
Risk awareness	10
Citizen engagement	7
Community building and resilience	7
Disaster risk reduction	6
Risk preparedness	7
Risk mitigation	4
Protective actions	3
Risk management	3
Risk recovery	3
Risk prevention	2
Disinformation contrast	1

Of the 73 papers examined, 39 do not identify the promoters behind the described tools. This lack of clarity is particularly evident when referencing research to understand better tools, such as risk visualization maps, which often lack specific authorship attributions or can be used by different actors. To address this issue, we have defined "promoters" as all the entities involved in the tool's design, both during the project's development stage and consultative phases, where the authors explicitly described and identified their roles.

To enhance clarity, we categorized promoters into a single "type." Consequently, when a tool is developed or created with contributions from two or more similar actors (e.g., two national research institutes), we list only the type of organization mentioned without indicating the frequency. Only one paper presented various organizations falling under the same classification (governmental organization). In two instances, we identified different types of promoters collaborating on the same tool.

The list provided in Table 12 encompasses various actors actively involved in the design and consultation processes related to risk communication tools. These entities include meteorological associations, governmental agencies, research institutes, national agencies, local governments, scientists, broadcasters, various stakeholders, professionals, universities, environmental advocacy associations, nonprofit organizations, and risk managers. Their participation underscores the significant role played by the scientific community and the distinct nature of risk communication tools, which draw from technical expertise (meteorological associations), scientific knowledge (scientists and national research institutes), and governmental engagement.

TABLE 12 - TOOLS: MAIN PROMOTERS

Main Promoters	Number of papers
Meteorological associations	9
Governmental agencies	8
Research institutes	4
National agencies	4
Local government	3
Scientists	2
Broadcaster	1
Different stakeholders	1
Professionals	1
University	1
Environmental advocacy associations	1
No profit organizations	1
Risk managers	1

Only six papers are directly linked to the public agenda. These papers primarily focus on tools that have undergone discussion and redesign in the aftermath of disasters, as previous versions were found to be ineffective.

Notably, none of the papers delve into financing and budgetary considerations, describing tools only in their concrete applications.

The distribution of target audiences' frequencies reveals how risk communication efforts are spread across various societal segments. The generic/unspecified category constitutes the most significant group: 50 papers describe tools addressed to this wide-ranging audience. This generic audience can encompass individuals with different demographics and social characteristics. This audience is often the initial engagement point for addressing risk-related issues and it is justified by the nature of the tools analyzed. In fact, informational tools, whether warning message systems or risk visualization tools, are primarily aimed at this group. As a result, these tools and the information they convey should be designed to be accessible and understandable by a wide-ranging audience.

In contrast, local communities represent a specific audience, with 14 papers describing tools designed to convey information to this kind of audience. Local communities are primarily bound by the nature of risks or their physical environment. Farmers, risk or environmental professionals, decision-makers, families and caregivers, key retailers, low-income communities, and students constitute specific target audiences but with lower frequencies. These results suggest that risk communication tools are still far from being personalized or targeted on particular needs. To share general information to general audiences, then, seem to be the primary goal of the tools emerged from the literature review. Target audiences are listed in Table 13.

TABLE 13 - TOOLS: TARGET AUDIENCES

Target audiences	Number of papers
Generic/unspecified	50
Local communities	14
Farmers	2
Risk or environmental professionals	2
Decision-makers	1
Families and caregivers	1
Key retailers	1
Low-income communities	1
Students	1

The data presented in Table 14 provides an overview of the distribution of tools and mediums employed in risk communication, as identified through an extensive literature review. Graphic tools for visualizing risks emerge as the most frequently used, with 24 instances documented in the literature. Visual aids are recognized for effectively conveying complex risk information in an accessible manner. The use of maps, interactive visualization techniques, and specific tools like the Spaghetti Plot graph or the Cone of Uncertainty is discussed, emphasizing their appropriate graphical application.

Following closely in prevalence are warning messages and systems, with 13 mentions, underscoring their pivotal role in alerting and informing individuals about potential risks. These warnings are disseminated through various media, including personal and combined media approaches. Websites, written documents, and extended texts

are also commonly used, with 5, 4, and 4 instances, respectively, underscoring the importance of more in-depth, narrative communication forms.

Social media posts and content received five mentions, illustrating the growing significance of digital media in risk communication strategies. Social media have been included in the review when reading the abstracts suggested that (a) they were considered as a tool (for example, describing their concrete applications) and (b) content production may be attributed to particular agencies or institutions. As specified in the exclusion criteria, papers based on grassroots content production on social media have not been included in the review. Long and short films receive four mentions. This trend highlights the importance of effectively using dynamic imagery to convey intricate content, even adopting a narrative approach based on first-hand testimonies.

Furthermore, other communication tools and methods, such as communication models, online games, ad hoc platforms, and workshops, are mentioned less frequently. This diversity underscores the vast array of approaches to address diverse risk communication needs. So, conveying general risk information is the fundamental goal, and general audiences can be considered the principal receivers of risk communication tools. Then, we may suppose that tools that can be adapted and targeted on the basis of the nature of the risk and its stage are more effective in complying with risk communication demands.

TABLE 14 - TOOLS

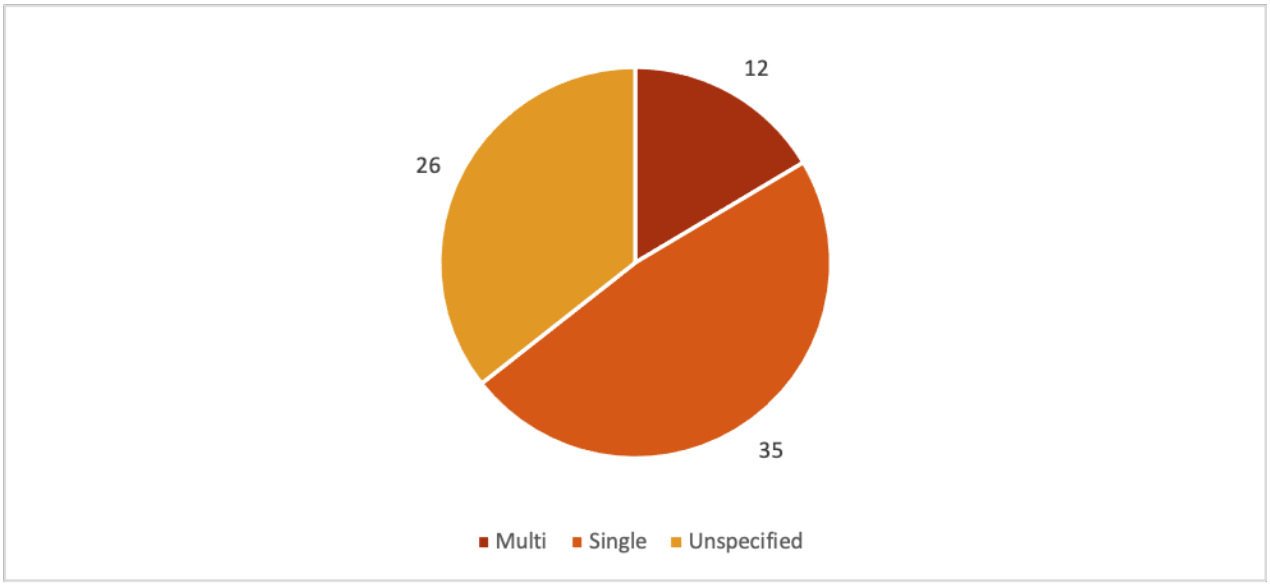
Tool	Number of papers
Graphic tools for risk visualization	24
Warning messages and systems	13
Social media posts and content	5
Websites	4
Written documents and extended texts	4
Long or short films	4
Communication model	3
Online game	2
Ad hoc platform	2
Technological and risk specific devices	2
Workshops	2
Audio archive	1
Brochure	1
Exhibitions	1
Forecasting presentation	1
Guide	1
Online collaborative document	1

Statistic visualization	1
Storyline	1

The nature of the media mix described in the 73 articles retrieved from the literature review emphasizes the complexity and distinctiveness of the tools employed. Twenty-six articles do not specify the medium used to convey the device. Indeed, maps or visual tools can be displayed on various media while maintaining the same format.

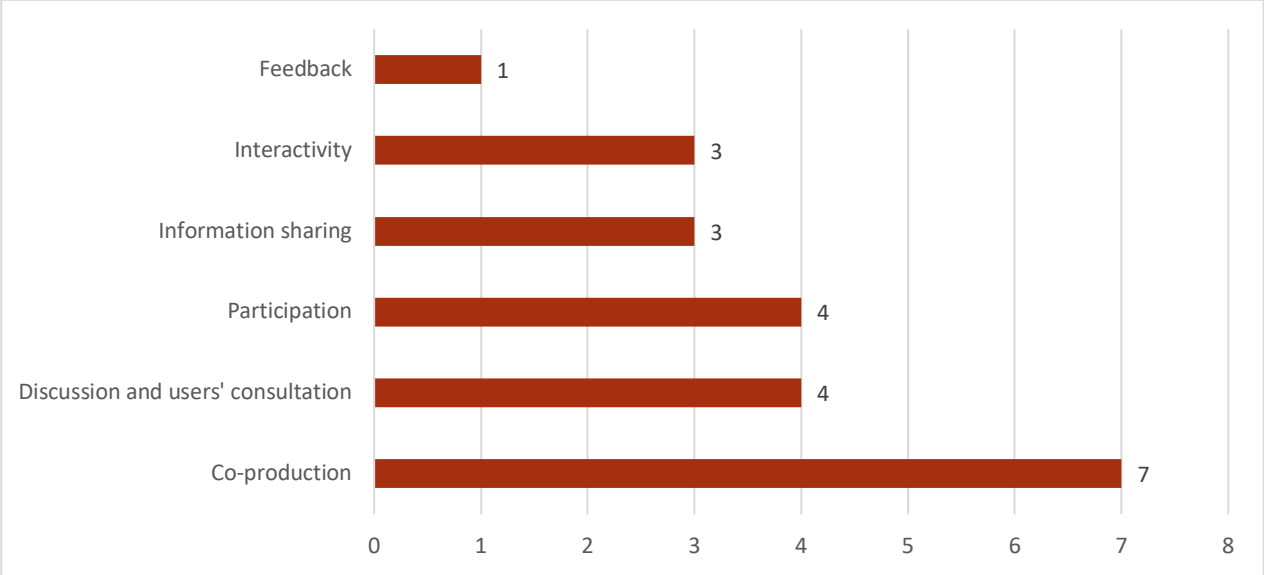
In 35 articles, tools are described as designed for use on a single medium. This is the case, for example, with websites or custom platforms. Finally, 12 tools are designed to be used across multiple media. The media mix is described in Figure 17.

FIGURE 17 - TOOLS: MEDIA MIX



Twenty-two papers describe tools involving users or based on a participative approach. Although several tools are participative by nature (as in the case of social media), we decided to record participation when explicitly discussed by the authors. Co-production emerges as a prominent approach, mentioned in 7 instances, underscoring the increasing emphasis on collaborative efforts between experts and the public in shaping risk communication initiatives. In those cases, citizens are asked to co-create meaningful content, as in the examples of the archives or shared memories. Furthermore, discussions and user consultations are included in 4 instances, highlighting the significance of engaging the target audience in dialogues and decision-making processes. Generic participatory approaches are mentioned four times. They comprise references to generic citizen participation, participatory workshops, and involvement in in-person games. Information sharing and interactivity appear three times each, indicating the importance of personal flows of information dissemination and the integration of interactive elements in communication strategies. Finally, feedback is mentioned once, intended as a specific feature of digital tools. Participatory approaches are presented in Figure 18.

FIGURE 18 - TOOLS: PARTICIPATION



Effective Tools in Risk Communication: An Overview of Relevant Results

As tools vary in formats and applications, we summarize the main findings from the literature review. The underlying logic is the possibility to trace similarities or divergent results, considering the nature of the tools. It must be underlined that generalizations are rarely possible as methods and populations leading the empirical research are too different to be compared without qualitative or quantitative assessments, which are outside the goals of this review. However, trends may be discernible. This complexity in results is because various tools have different strengths and weaknesses, and the outcomes of one device may not be directly comparable to the effects of another tool. By analyzing the results of the various tools, it may be possible to identify similarities and differences between them, which will help provide a better understanding of the underlying logic.

Generally speaking, graphic and visual tools are valuable shortcuts to convey risk information in all phases. Graphical models, maps, and infographics can summarize forecasts, warnings, and post-disaster messages. They are emblematic of place-based information and can exemplify, in a pretty intuitive way, the link between risk occurrences and their location (Gomez-Zapata et al., 2021; Sutton & Fisher, 2021; Houston et al., 2019; Richards, 2018; Chiang & Li, 2017). In some cases, maps and graphic tools are “standard” devices commonly used in risk visualization. In other cases, some authors propose interactive visualization models or models based on crowdsourced data and experiences.

Although visual tools may seem relatively unproblematic – even due to the possibility of being shared in the same format via different media channels – research shows some questionable aspects. The main results show a consensus about using visual tools to share risk information (VanDyke et al., 2020; Nave et al., 2010) and to exemplify climate change impact (O’Neill et al., 2013). However, their practical applications can be discussed.

Several analyses show that people may find some aspects of graphic communication challenging to interpret (Evans et al., 2022; VanDyke et al., 2020; Reed & Senkbeil, 2020; Broad et al., 2007). While they are easy-to-use tools for risk and weather communication professionals, ordinary people may find forecasts and maps challenging to read (Reed & Senkbeil, 2020; Bica et al., 2020; Kain & Covi, 2013). Uncertainty-related information, the area impacted by the risk, and the risk’s intensity are some aspects that may result in unclear or under-explained graphs (Leonard et al., 2014). Exposure to infographics may affect people’s beliefs, although they can read charts by resorting to confirmation bias (Retchless & Ross, 2022). Risk literacy is fundamental in correctly interpreting graphs (Bica et al., 2020) and more straightforward solutions in risk visualization (Kause et al., 2020). User-

centered design and participative or interactive approaches may enhance visualization tools (Luke et al., 2018; Stephens et al., 2017; Cao et al., 2017; Richards, 2015; Lieske et al., 2014).

An interesting point of view is the one presented by Olman and DeVasto (2021): the authors claim that risk visualization tools may have a political effect, as they may cross boundaries and empower different agents. Moreover, they can affect decision-making as they have a powerful impact on users' agency (Richards, 2020; Richards, 2015).

Misinformation and disinformation affect visual information, too, and static images are more likely to be manipulated than videos (Dootson et al., 2021). Using stock images or photos from old events, misattributed locations, or sensationalized visuals may generate distrust, as people can become accustomed to perceiving manipulations.

Early warnings and alerts are essential to raise risk awareness and foster protective measures (Carr et al., 2016). Vulnerability characteristics should be taken into account: gender, health conditions, literacy, and risk education are some of the traits to be considered in targeting the warnings (VanderMolen et al., 2022; Rana et al., 2021). In specific contexts, such as urban communities in developing countries, messages should be carefully targeted to the audience's characteristics (Rana et al., 2021).

Infrastructural constraints impact warning design: adequate resources to monitor the environment and collect real-time data are fundamental in sharing reliable and timely information (Sheresta et al., 2021). Post-alert messages present the same issues. A complex evaluation should consider how people make sense of data, how organizations communicate during crises, and the timing and accuracy of messages (McBride et al., 2020).

Although several institutions and emergency management agencies propose guidelines to compose warning messages, these warnings should be tailored to the context to enhance public understanding of alert messages (Intrieri et al., 2020; Sutton & Woods, 2016). Testing messages is fundamental to improving knowledge of the most compelling features for people's mobilization and willingness to follow instructions; in specific situations, warning messages instruct people on what to do, such as when they are asked to leave or secure their homes during extreme weather events and natural disasters. High-impact messages or fear appeals may have a different impact on alert acceptance or protective actions (Morss et al., 2018; Perreault et al., 2014). Cooperation between institutions and constant monitoring of risks and target audiences' abilities are fundamental in designing adequate warnings to cope with uncertainty (Bosstrom et al., 2016; Demeritt et al., 2016).

Social media has proven effective in disseminating warnings (Hu et al., 2019). Warnings are a significant presence on the social media feeds of organizations and institutions (Eachus & Keim, 2020). Governments may share real-time information and promote citizen engagement using social network sites (Song et al., 2015). Although some experiences have attempted to assess the impact of more social media-friendly formats or languages in risk communication, such as humor, conventional messages are more effective, even when considering trust and audience commitment (Kim et al., 2023). Establishing clear social media guidelines can provide a useful framework for utilizing social media (Scott & Erret, 2018).

Websites can summarize the digital presence of emergency management institutions and risk communication agencies. Websites are often repositories of toolkits and information on risk and risk prevention practices. Some websites, such as the governmental ones described by So and colleagues (2020), are designed for a general (imagined) audience. These websites are far from effective in communicating risk, as they present a mismatch between the materials' quality and the actual audience's literacy level. Other experiences, such as the Italian website POLARIS, benefit from integrating the website into the social media feeds of the agency, as well as from establishing a connection with broadcast media and journalists (Salvati et al., 2016).

These results represent only a subset of the insights derived from our literature review. Risk communication requires tailored solutions. In particular, tools should be designed to address the specific nature of risks:

earthquakes and storm, for instance, requires different knowledge and different approaches to preparedness, which should be conveyed with different practical and narrative tools. Moreover, the sociocultural context in which risk communication operates is also relevant. Some countries, for example, may face resistance to information sharing or be less oriented to comply with governmental requests. Each risk community requires its own set of tools to convey information and mitigate potential harms effectively.

Furthermore, the sociocultural diversity across localities and communities underscores the importance of adapting communication methods to resonate with the target audience. It must be noted that audience characteristics, although relevant, are underrepresented in our literature review, as we designed inclusion criteria to investigate risk communication processes development and application. In conclusion, the literature underscores that general results leading to a "one-size-fits-all" approach to risk communication cannot be identified.

What to take home

- ⇒ Various communication resources, such as visual aids and digital platforms, have been developed to present risk information clearly and engagingly
- ⇒ Graphic and visual tools are valuable shortcuts to convey risk information in all phases
- ⇒ Social media has proven effective in disseminating warnings. Warnings record a significant presence on the social media feeds of organizations and institutions
- ⇒ The sociocultural diversity across localities and communities underscores the importance of adapting communication methods to resonate with the target audience

Exploring Success and Inhibiting Factors

This section will recap the main elements that constitute potential success factors or limitations for risk communication. These elements have been identified in the literature review based on the insights of various authors, who highlight potential strengths or weaknesses in the application of risk communication tools or initiatives, in more or less explicit terms. Not all papers provide such specifics. We have selected only those articles where the connection between these factors and risk communication applications was clear.

We have chosen to categorize these factors into overarching areas. These macro areas were identified through an iterative process, combining inductive and deductive evaluations. On the one hand, we organized the elements into macro areas based on similarities observed after systematically reviewing and aggregating selected text fragments from the literature review. On the other hand, these macro areas were outlined considering the theoretical approaches identified in the papers and described in the summary paragraph dedicated explicitly to the theoretical framework, emphasizing the circular relationship between the interpretative perspective and the attention given to the description of communication actions and their outcomes.

The results will be organized to encapsulate the characteristics of these macro areas best, acknowledging that we are dealing with sections with permeable boundaries where practical or conceptual incursions are possible. Furthermore, we noted how these areas could synthesize strengths and weaknesses regarding the applications described in the literature review. Therefore, within the same area, aspects that can boost the success of initiatives and compromise their effectiveness can be found.

For example, concerning the media environments for dissemination, some may identify the interactivity allowed by social network sites as an effective tool for informal information sharing. In contrast, others argue that this bi-directionality leads to uncontrolled information spread.

The identified areas are listed below.

Organizational Dimension. In this category, we outline the pros and cons related to the organizational aspect. The link to the literature is identified through references to organizational communication. This dimension underscores how the conditions of organizations promoting risk communication can impact its success. Factors such as staff, budget, and organizational coordination can all play a role in determining the success or jeopardizing the feasibility of actions.

Case-Specific. This section compiles success factors and inhibitors specific to each case. These are practical insights that primarily stem from the nature of the subject matter discussed in the paper. For example, specific tools related to specific locations may help identify unique strengths or weaknesses significantly generalizable.

Audience Characteristics and Abilities. In this category, we highlight factors related to the audience based on insights from theoretical frameworks emphasizing the link between audience capabilities or attitudes and risk cognition and processing. It should be noted that this dimension is likely underrepresented in the analysis of results compared to its presence in the broader literature on risk and risk communication. This underrepresentation is due to the descriptive nature of the chosen review type and the delineation of the study field, as previously mentioned, which does not involve quantitative assessments. Undoubtedly, audience-related factors are pivotal in both the literature and the development of risk communication models. However, in presenting the results of this literature review, we will focus on those generalizable factors related to the relationship between audiences and the illustrated tools.

Media Environments. This category, reinforcing communication theories identified in the literature, describes the relationship between risk communication and the complex media ecosystem in which it operates. Channels, features, and media-related aspects are potential variables that influence the processes, not only because they

shape practices and narratives but also because they impact the skill requirements placed on organizations or influence the narrative dimension.

Trustworthiness and Source Credibility. As highlighted by sociological theories of risk, trust (and its construction) impacts the formation of modern risks. Therefore, literature has raised questions regarding the nature of the source and its credibility and how these factors can either inhibit or significantly amplify risk communication.

Formal and Technical Aspects. Technical and formal aspects are related to the case studies or tools under analysis. Unlike case-related factors that require a specific contextual framework, these technical aspects have been isolated considering their formal dimension. For instance, text length or the transmission of numerical data can lead to significant generalizations.

Risk Nature and Stage. This area, emerging from the literature, allows us to explore how tools and their potential for success are linked to the stage of risk. As explored in the general results, the nature of risks impacts the choice of tools and their practical application. Nevertheless, we assume that generalizations can be made, particularly regarding the functionality of the tools and the planning of their dissemination based on the main findings from the literature review.

Narrative Devices and Content Organization. This area partly draws on isolated theoretical frameworks (particularly framing theories) and finds various parallels in the literature. It's important to note how content organization affects risk communication strategies, highlighting how narrative devices can serve as tools for clarifying risk communication or as obstacles to further functionality.

Citizen Participation and Community Engagement. If the analysis of theoretical frameworks employed in the examined papers emphasized the role of participation and the need for engagement in risk communication tools, the study of success and risk factors can be seen as ambivalent. On the one hand, we will explore the conditions that promote or inhibit the use of participatory tools. On the other hand, we will note if the literature analysis reveals these factors as either amplifiers or hindrances to risk communication.

By identifying these categories, we will address the remaining research questions:

> ***RQ2****: What are the success factors in designing and implementing communication campaigns and/or actions related to the communication of natural/environmental risks and/or climate change-related risks?*
>
> ***RQ3****: What are the inhibiting factors regarding the success of communication campaigns and/or actions related to the communication of natural/environmental risks and/or climate change-related risks?*

Relevant elements will be presented while maintaining the specificity of the areas of investigation through which we have illustrated the results earlier (campaigns, case studies, tools). Not all articles contain elements related to what has been identified. When selecting relevant information from the papers, we assessed how much emphasis the authors themselves placed on success/inhibition dimensions (even if not always explicitly stated) and how closely these elements were tied to the empirical dimension of the case under examination.

Given the different number of cases, the results will be presented in narrative form for campaigns and tabular form for tools and case studies.

Campaigns

Only three out of seven papers comprehensively examine the key elements contributing to the success of communication campaigns. Consequently, our discussion will present key findings narratively, as the limited data precludes broad generalizations.

The success of campaigns can be attributed to several factors, including organizational resources, timing, target audiences, trustworthiness, and source credibility. How information is structured and presented also plays a significant role in achieving campaign objectives.

For instance, the "Make it Better" campaign, designed to illustrate the impact of climate change through health-related information, achieved success by framing climate change as a primary health concern. This campaign effectively engaged a previously untapped target audience, namely parents (Sanderson et al., 2020). Furthermore, the campaign's strategy of providing information to the target audience and professionals represented a noteworthy organizational improvement.

The element of trust in the campaign promoters cannot be understated, as highlighted by Fontana et al. in 2012.

When examining earthquake campaigns in Israel, two critical factors emerge. First, citizens' willingness to take action and sense of agency are pivotal to campaign success. People must understand that they can play a role in mitigating and preventing risks. Second, the timing of the campaign is equally important. For instance, the campaign's airing during major earthquakes in other countries and during minor seismic events, as well as during crises and emergencies like the military operations "Cast Lead" and "Protective Edge" in Israel, effectively established a connection with the audience (Shenhar et al., 2016).

Only two papers comprehensively examine factors hindering risk communication campaigns effectiveness.

Sanderson and colleagues (2020) have outlined several inhibiting factors that impact the potential of the risk communication campaign discussed in their paper. These findings may have broader implications for other risk communication campaigns. Specifically, they report the following inhibiting factors:

- *Budget Constraints*: Limitations in funding constrain the campaign's effectiveness. For instance, budget constraints prevent translating campaign social media accounts and websites into languages other than English.
- *Cultural Resonance and Citizen Activism*: Building cultural resonance and fostering citizen activism cannot be achieved through a single-issue campaign; these aspects must be cultivated over time.
- *Timing*: The timing of the campaign is crucial. Launching campaigns in August, for example, does not facilitate the recruitment of interested professionals.
- *Data Translation*: Translating data into a successful campaign is not always straightforward. Sometimes, explaining and identifying a clear link between data and campaign issues is challenging.
- *Engaging Multicultural Audiences*: Engaging multicultural audiences can be difficult, both in terms of identification and involvement.

Shenhar and colleagues (2016) have also noted that trustworthiness can be a contested issue. Audiences may perceive a disconnect between risk communication promoted by authorities and institutions and their ability to manage crises effectively. Additionally, despite the significant financial investments made by governments in risk communication campaigns, citizens lack adequate tools and guidance to enhance their personal and familial preparedness (Shenhar et al., 2015).

Case studies

The strength factors and potential limitations highlighted in the case studies help clarify numerous issues related to the various areas under examination. Specifically, given the contextual dimension's relevance, case studies emphasize how risk communication processes are inherently complex.

In particular, the organizational dimension clarifies its role and relational processes in risk promotion. On the one hand, it is emphasized that risk communication cannot be a compartmentalized process but can instead achieve enhanced results if external cooperation with organizations is promoted, aiming to establish a repository of best practices and the sharing of past experiences and forms of internal cooperation. This collaboration can involve professionals from different sectors, including social scientists and communication experts, to plan long-term risk communication strategies. On the other hand, internal limitations within organizations become evident, not only in crises and emergencies. Factors such as inflexible staff, a lack of specialized personnel, a weak communication culture, and budget constraints all influence the design and maintenance of risk communication tools.

Regarding the target audiences, it is necessary to understand and study their characteristics and media habits to better tailor communication offerings.

The choice of channels and adaptation to complex media systems impact practices and the potential of tools. For example, social media effectively promotes real-time information and alerts. Still, it should also be evaluated how bidirectional mechanisms are influenced by the possibility of inputting information from non-credentialed sources and how misinformation can pollute such environments.

The credibility of sources is of extreme importance in risk communication. On the one hand, scientists are considered credible sources. On the other hand, the multitude of opinions they can express, thanks to disintermediation processes, can cause confusion, or generate distrust in the entire category. Government involvement in risk and emergency communication should be seen as ambivalent. By default, the government appears to have suitable tools for conveying central and official information. However, government information, especially from executives with clear political recognition or polarization, can often be perceived as propaganda or not in the public interest.

Narrative mechanisms synthesize all the complexity of risk communication. On the one hand, the uncertainty and difficulty of data about what needs to be communicated drive communicators to find solutions in line with the cultural and cognitive sensitivities of the audiences. The conveyed information must be factual but should also suggest emotional cues.

Finally, participatory mechanisms are essential to ensure shared responsibility between citizens and institutions in preventing or managing risks. However, the absence of coordination between central institutions and local organizations and cultural and political resistance can jeopardize the proposed initiatives.

Success and inhibiting factors detected in the analysis of case studies are presented in Tables 15 and 16.

TABLE 15 - CASE STUDIES: SUCCESS FACTORS

Area	Success factors
Organizational	Foster cooperation between scientists and emergency agencies (Graham et al., 2022)
	Involve communication and social sciences experts in disaster risk reduction frameworks (Graham et al. 2022)
	Promote inter-organizational collaboration (Fu & Lai, 2021)
	The communication team is equipped to work off regular business hours (Ozanne et al., 2021)
Case-related	Organizations such as Universities should invest in mass texting services (Ozanne et al., 2021)
Audience characteristics and abilities	Organizations are aware of their main stakeholders' media habits (Ozanne et al., 2021; Steelman & McCaffrey, 2013)
Media environment	Media practices are oriented towards transforming followers into a community (Stovall et al., 2023)
	Social media are not enough: organize press releases to fulfill traditional media requests (Stovall et al., 2023; Veil & Husted, 2012)
	Guarantee a high publication rate of posts or information in a continuative way on several platforms (Pignone et al., 2022)
	The uncertainty produced by the recovery process boosts the greater usage of means, which lowers the risk of misinterpretations by offering greater and richer social cues, such as face-to-face communication (Tagliacozzo & Magni, 2018)
	The combination of several communication channels helps reduce potential inconsistencies and misunderstandings (Tagliacozzo & Magni, 2018)
	Informal messaging (e.g., Whatsapp) can be used by the government to convey official information (Badri et al., 2018)
	When posting on social network sites, multimedia content (photos and video) has a positive effect on stakeholders' engagement (Meltzer et al., 2018)
	One-to-one tutoring tools (even mediated ones) help expand older adults' self-efficacy in risk management (Sun & Yamori, 2018)
	The popularity of a website affects content visualization. According to Newell and Dale (2015), popularity can be dependent upon many factors, such as attractiveness (aesthetics), ease of use, credibility, trust and reputation of the originators, as well as status
Trustworthiness and source credibility	Scientists are considered a trusted source (Graham et al., 2022; Sansoulet et al., 2019)

	Working with emergency management over time enhances trust in experts (Manandhar & Siebeneck, 2021)
Formal and practical aspects	Design compulsory legal tools to inform people about site-specific risks (e.g., attach a covenant to the land title in risk-prone areas, as householders can be advised on hazards) (Agrawal et al., 2022)
	Use English to engage with foreign or transient communities (Matti et al., 2022)
Risk nature and stage	Emergency agencies should cooperate with other significant stakeholders in non-crisis activities (Graham et al., 2022)
	Effective risk communication happens "post facto", as it is possible to change the conversation about hazards (Agrawal et al., 2022)
Narrative devices and content organization	Factual information is delivered (Stovall et al., 2023)
	Warning messages are designed to resonate with local communities (Henriksen et al., 2018)
Citizen participation and community engagement	Citizens are recognized as co-producers of risk and scientific information and communication according to their capabilities (Stovall et al., 2023; Andreastuti et al., 2023; Henriksen et al., 2018)
	Emergency agencies should create (or cooperate with) local or regional experts (Graham et al., 2022; Manandhar & Siebeneck, 2021; Henriksen et al., 2018)

TABLE 16 - CASE STUDIES: INHIBITING FACTORS

Area	Inhibiting factors
Organizational	Organizations are not always able to identify and clear bottlenecks in communication processes (Stovall et al., 2023)
	Communication experts can make unintended mistakes (Stovall et al., 2023)
	Lack of full-time professionals dedicated to risk communication and social media management (Todesco et al., 2022; Tagliacozzo & Magni, 2018)
	Including social sciences experts in communication training requires planning and long-term collaboration (Todesco et al., 2022)
	Conflicting priorities between stakeholders and risk framing result in a development pathway reliant on specific communication channels. These communication channels are planned to keep the status quo (Agrawal et al., 2022)
	Local emergency management organizations may experience challenges due to a lack of timely response from central institutions (Manandhar & Siebeneck, 2021)
	Organizations (e.g., Universities) may provide accurate and centralized information, but single departments or individuals may share divergent information (Ozanne et al., 2020)
	The lack of official guidelines and policies about post-disaster recovery solutions impacts social media use (Tagliacozzo & Magni, 2018)
	Public sector organizations' internal rules and beliefs affect how social media are considered: in some cases, they may be deemed as not useful, in other cases, social media use is forbidden during working time, etc. (Tagliacozzo & Magni, 2018)
	Budget and resources allocation do not complain about communication and social media management (Tagliacozzo & Magni, 2018; Takahashi et al., 2015)
	Organizations do not have a solid and recognizable identity (Takahashi et al., 2015)
	Organizational plans are not suitable to face big-sized disasters (e.g., the Hurricane Katrina) (Veil & Husted, 2015)
	Staff frequent turnover makes it impossible to gain sufficient institutional knowledge about risk communication (Veil & Husted, 2015)
	Organizations lack extensive and organized partnerships (Veil & Husted, 2015)
Case-related	Alert systems are not helpful if not followed by an action plan to improve community awareness (Andreastuti, 2023)
	Professionals (e.g., foreign tourism employees) are not informed about local initiatives for risk communication (Matti et al., 2022)
	Transient communities (e.g., foreign tourism employees) have limited interaction with local communities (Matti et al., 2022)

	Risk communication in the case of Svínafellsheiði was inhibited by the lack of written emergency procedures (Matti et al., 2022)
Audience characteristics and abilities	Communication platforms are not always targeted at users' habits (Abukhalaf & von Meding, 2020)
Media environment	Reduced ability to address misinformation and disinformation (Stovall et al., 2023)
	Organizations may struggle to maintain politeness and resolve media policy breaches (Stovall et al., 2023)
	In some countries, social media are indicated for media people or tourists but not for impacted communities due to the scarce Internet penetration or infrastructure or local digital divides (Yudarwati et al., 2022; Tagliacozzo & Magni, 2018)
	The interactive nature of social media can be a threat since organizations may lose control over the information and be vulnerable to misinformation (Yudarwati et al., 2022; Agrawal et al., 2022; Ozanne et al., 2020).
	Different social media are used similarly, without declining content according to the platform (Todesco et al., 2022)
	Social media interactivity is limited or unexplored (Todesco et al., 2022)
Trustworthiness and source credibility	Governmental communication about risks may be seen as an instrument to coopt and manipulate the public. Control over communication can also be seen as a strategy to maintain the Government's legitimacy (Yudarwati et al., 2022)
	Scientists are not trained to face public discussions, answering in a clearly and concisely to citizens' doubts and uncertainties (Todesco et al., 2022)
	Organizations tend to ignore information from unofficial sources via social media due to anonymity and crescent disinformation. Anyway, ordinary citizens (local sources) may have information hard to obtain from emergency management agencies (Manandhar & Siebeneck, 2021)
	Independent scientists may announce unofficial risk predictions on broadcast, generating panic and confusion (Fokaefs & Sapountzaki, 2021)
	Untrusted sources share misleading information (Abukhalaf & von Meding, 2020)
	Post-disaster situations are not adequately explained by official spokespersons, giving room to mistrust in the government's actions and speculations (Andrade et al., 2019)
	People perceive a lack of cultural awareness (Veil & Husted, 2015)
Formal and practical aspects	Data and more specific information are not available to risk communicators (Veil & Husted, 2015)
Risk nature and stage	Long time gaps between the occurrence of a natural disaster (e.g., volcanic eruptions) may reduce awareness but can be helpful in preparing authorities and citizens (Graham et al., 2023; Abukhalaf & von Meding, 2020)

	Risk awareness may be influenced by mitigation measures that create complacency in the public; these measures may develop the belief that future disasters are impossible, as everyone is better prepared. Then, risk communication must be continuous (Agrawal et al., 2022)
	Wrong timing in programming communicative actions (Abukhalaf & von Meding, 2020)
Narrative devices and content organization	Risk outcomes are not always definite or clear (Stovall et al., 2023)
	Different stakeholders frame risks in a dissimilar way, according to their interests (Agrawal et al., 2022)
	Risk communication is shaped by technical risk knowledge that is not easily comprehensible to the authorities and people in need (Agrawal et al., 2022; Feldpausch-Parker & Peterson, 2015)
	Communication is standardized and lacking in adaptability (Abukhalaf & von Meding, 2020)
	Linguistic barriers should be considered (Abukhalaf & von Meding, 2020)
	Over-communication during risks and emergencies (Abukhalaf & von Meding, 2020) should be avoided
	The lack of social clues (e.g., facial expression, tone of voice) exposes online communication to frequent misunderstanding, especially in sensitive phases, such as post-disaster risk intervention (Tagliacozzo & Magni,2018)
	Organizations may be perceived as uncaring when they do not publicly acknowledge the outrage of victims (Veil & Husted, 2015)
	Rather than acknowledging concerns and offering explanations, the organization brusquely informs the public and the media of the reasons behind its actions (Veil & Husted, 2015)
Citizen participation and community engagement	Limited consideration of local sensitives and needs (Stovall et al., 2023; Shepherd & Van Vuuren, 2015)
	Scientists and local communities do not always build a common vocabulary to tell and understand risks (Todesco et al., 2022)
	Information deficit determines that risk knowledge is not shared between state and non-state actors (Agrawal et al., 2022)
	Participative models do not always work in highly politicized communities (de Leon, 2021)
	In some countries (especially the North Europe ones), citizens are not supportive of uploading content on dedicated platforms, as they believe that is something that authorities or trained staff should do (Henriksen et al., 2018)

Tools

Regarding risk communication tools, the results are influenced by the nature of the device. Primarily, as seen in analyzing case studies, the organizational context in which tools are developed or activated affects their effectiveness. Having an in-house staff capable of producing content facilitates content control and accuracy. To ensure greater efficiency in the case of crises or emergencies, the team must be redundant and capable of continuously handling communication tasks. Organizations must be able to conduct ongoing research and integrate communication into risk management processes from the outset.

The tools must be designed considering the skills of the audience and its composition. Physical infrastructure (internet access, phone line maintenance, broadcast network coverage) is crucial for adequately disseminating and applying these tools. Therefore, the nature of the tools must respect audience characteristics, expected usage, and the effective capacity to transmit relevant information.

Risk communication and alert messages must be prominent and relevant. Excessive appeals to emotions and fear are ineffective in providing protective behavior instructions. While data is fundamental for effective risk communication, excessive use of percentages and overly specialized language are ineffective in communicating risks.

If audience engagement is seen as a factor of effectiveness in promoting proactive behaviors, the success of participative initiatives depends on engaging the public in extensive public education campaigns. The success and risk factors related to these tools are summarized in Tables 17 and 18.

TABLE 17 - TOOLS: SUCCESS FACTORS

Area	Success factors
Organizational	Agencies proactively address the issues of problematic images during events by deploying incident photographers, capturing videos from helicopters and responding vehicles, and disseminating this content to meet real-time information needs about the severity, status, and progression of hazards (Dootson et al., 2021)
	To face frequent turnover issues, organizations should train excess staff and select members who are likely to work and remain in the community during risks (Sheresta et al., 2021)
	Regular research to improve the knowledge of audiences' opinions and characteristics should be conducted (Saha et al., 2021)
	Risk communication is more effective when integrated into risk reduction strategies and/or research projects from the beginning (Hicks et al., 2017)
Tool-related	Personalization of risk maps and interactive viewers adds value because different perspectives provide a more diverse view of the same issue, which offers more opportunities for user engagement (Stephens & Richards, 2020)
	Post-alert messaging should use simple words and non-colloquial expressions (McBride et al., 2020)
	A combination of graphics and explanatory text makes the briefings appealing to the general public. A briefing should provide all the necessary information in one place to be distributed to residents. Forecasters may also use briefings to establish a personal

	tone and sense of urgency regarding an event, as well as prioritize information, risks, and impacts differently than they might use other products (Carr et al., 2016)
	Hazard maps should be clear, with symbols that detail hazards and potential risks (Nave et al., 2010)
	Standard graphical elements (e.g., black lines in hazard maps) may provide additional information (Broad et al., 2010)
Audience characteristics and abilities	Identifying audiences, understanding their needs, and motivating them to participate in the risk communication process will make risk communication more effective (Hicks et al., 2017; Demuth et al., 2017)
Media environment	In some cases, in-person interaction and word-of-mouth dissemination of information are more effective in educating communities than written materials, although various methods are often used in conjunction (VanderMolen et al., 2022)
	Visual information, including video or televised messages, is effective in promoting risk-related information (Cameron et al., 2021; Perreault et al., 2014; Lieske et al., 2014)
	Messages should be crafted according to specific channel requirements (such as restrictions to character length) and use simple terminology (McBride et al., 2020)
	Campaigns can have a positive impact on teaching audiences about earthquake risk and preparedness (Herovic et al., 2020)
Trustworthiness and source credibility	In-house produced content reduces the need for the verification of user-generated content from community or media and reduces reliance on the use of old or stock images (Dootson et al., 2021)
	Visual media can bridge the gap between an emergency warning and the absence of environmental cues (e.g., smoke, fire, rain, wind). The credibility of an agency may be questioned when a community is warned of a severe event and does not see any environmental cues (Dootson et al., 2021)
Formal and practical aspects	Listeners' uncomfortable feelings triggered by AI voices may be transformed into valuable cues for influencing their perception and attitude (Ni et al., 2023).
Risk nature and stage	Earthquake quiet periods are the ideal times for conducting education and training campaigns about earthquake planning and emergency response (Herovic et al., 2020)
Narrative devices and content organization	Personal stories make content more relatable (Cameron et al., 2021)
	Visually locating stories in defined locations contributes to an appeal to place from a design perspective, as it creates connections between climate change narratives and the stories of vulnerable residents (Stephens & Richards, 2020). Locating risks in detailed maps may help decision-makers and raise risk awareness (Nave et al., 2010)
	Some people may consider narrative messages more effective than technical bulletins in terms of intent to evacuate, self-relevance and richness of the message, and perceived authority of the messenger (Lejano et al., 2018)

	The messages should be salient, relevant, and presented in a manner appropriate to the context and setting (Hicks et al., 2017)
	Using emotions in risk communication may help guide thinking and behavior (Hicks et al., 2017)
	When staging narratives presentation of risks, the scenario should be realistic, representative, and relevant for emergency managers. It does not need to be the "worst possible" event (de Bruijn et al., 2016)
	Adopting a storyline approach to risk communication may improve gap identification in risk knowledge and facilitate communication with different stakeholders (de Bruijn et al., 2016)
Citizen participation and community engagement	Participatory action at a broad scale can enhance commitment to risk communication programs and incorporate best practices into new programs and initiatives (Jiang et al., 2023)
	Narratives about specific risks based on shared memories may provoke discussions and impact on risk preparedness (Holmes & McEwen, 2020)
	Communication activities that boost people activity must be engaging, trustworthy, and appealing (Saha et al., 2021)
	Workshops are effective methods to foster people's engagement in protective behavior (Heidenreich et al., 2020)

TABLE 18 - TOOLS: INHIBITING FACTORS

Area	**Inhibiting factors**
Organizational	Lack of staff or frequent turnover may result in an organization's inability to deal with risk communication (Shrestha et al., 2021)
	A shortage of resources may prevent the agency from producing and disseminating visual content in real-time or from having the skills to verify visual content (Dootson et al., 2021)
	Limited budget does not allow to plan communication strategies or to buy resources (Shrestha et al., 2021)
	Disaster risk reduction or management experts work independently, lacking coordination, information, or knowledge about previous projects (Shrestha et al., 2021; Bostrom et al., 2016)
	As in the case of social networks, people can directly communicate with those who disseminate alerts. Municipalities should consider if they have adequate human and economic resources (Intrieri et al., 2020)
Tool-related	Some graphic elements in maps or graphical risk visualization models (e.g., dots or lines) may create confusion (Evans et al., 2022; Broad et al., 2017)

	Although they are present in everyday life, people tend to consider AI as an out-group member, limiting their effectiveness in conveying risk communication (Ni et al., 2023)
	Non-standardized visual representation methods in typical graphics and models (such as the Spaghetti Plot) may generate confusion and misunderstandings (Bica et al., 2020)
	Game experiences may clash with everyday life, resulting in a loss of credibility of the tool (Asplund, 2020; Asplund et al., 2019)
Audience characteristics and abilities	Audiences may find graphics and maps challenging to interpret (Cameron, 2021; Reed & Senkbeil, 2021), especially when it comes to aspects related to uncertainty (Evans et al., 2022)
	Audiences do not always pay attention to the legends that explain graphics (Evans et al., 2022) or have difficulties understanding them (Reed & Senkbeil, 2021; Carr et al., 2016).
	When it comes to maps or risk visualization tools, audiences may expect interactive features similar to the functionalities on their phones (Evans et al., 2022)
	Audiences may perceive risk communication as lacking in cultural sensitivity or geographic specificity (VanderMolen et al., 2022; Asplund et al., 2019)
	Some people may experience unfamiliarity with emergency communication apps, or they may lack access to the Internet or problems with phone reception (VanderMolen et al., 2022; Perreault et al., 2014)
	Language proficiency and translation effectiveness should be considered (VanderMolen et al., 2022; Asplund et al., 2019)
	Audiences may not understand the significance of the warnings (Rana et al., 2021)
	In multicultural contexts, all community members should be aware of the importance of warnings (Rana et al., 2021)
	Audiences or risk managers are not aware of all the communication channels used in risk communication (Shrestha et al., 2021; Van Dyke et al., 2018)
	In some countries, women and illiterate people cannot understand, interpret, or translate technical information (Shrestha et al., 2021)
Media environment	Popular culture may misrepresent risks and pose challenges for effective risk communication (Herovic et al., 2020)
	The channel choice must be made during quiet times. Still, organizations should consider the needs and constraints that could occur in critical conditions to avoid those channels (for example, an institutional Facebook profile) being activated and maintained only when the alert is less severe. When channels are opened during mild or severe alerts, people rely on those channels even for future warnings (Intrieri et al., 2020)

	Warning messages longer than 160 characters are inaccessible for most mobile phone text plans (Perreault et al., 2014)
Trustworthiness and source credibility	The dissemination of disinformation can undermine the credibility of the media and the legitimacy of government risk management policies (Jiang et al., 2022)
	Distrust in the government may affect the reception of warning systems and alerts (Rana et al., 2021)
	During a natural disaster, the gap between supply and demand for real-time information allows problematic visuals to be amplified (Dootson et al., 2021)
	Advice from non-experts may have negative consequences (Herovic et al., 2020)
Formal and practical aspects	The format of weather forecasts on TV (especially the short length) affects people's comprehension. Forecasts are usually placed at the end of newscasts, and meteorologist is typically not on camera, and this may introduce limitations to effective communication of complex weather situations (Reed & Senkbeil, 2020)
	Too long written texts or handbooks can be challenging to read. On the other hand, too short texts present negative implications, too (Ferrer et al., 2018)
	Personalized warnings may be less effective in hazardous scenarios where a large geographical area is affected by the same threat, or the response strategy is the same for everyone living in the exact location (Cao et al., 2017)
	The lack of specificity about the location of hazard impact makes warning messages less effective (Sutton & Woods, 2016)
	The lack of clarity about the content (for example, about the damages) may undermine the effectiveness of messages (Sutton & Woods, 2016)
	To manage uncertainty, emergency managers prefer to describe a conservative worst-case scenario, although over-warnings may present downsides (Bostrom et al., 2016)
Risk nature and stage	-
Narrative devices and content organization	Risk communication materials are criticized when they do not have a clear purpose or confused messages (Cameron et al., 2021)
	Statistics, including those describing uncertainties (probabilistic estimates), are difficult to understand (Kause et al., 2020)
	Percentages are difficult to understand unless they clearly indicate a baseline or a reference point (Kause et al., 2020)
	Acronyms may be unfamiliar (Kause et al., 2020)
	Viewers may be overwhelmed by the amount of information displayed (Kause et al., 2020; Demuth et al., 2016; Nagasaka et al., 2018)
	Storyline and narrative approaches are time-consuming as they need a lot of research and attention to small details (de Bruijn et al., 2016)

	Storyline and narrative approaches are not always feasible for generalizations (de Bruijn et al., 2016)
	Storyline and narrative approaches cannot be applied in large areas where different risk scenarios are possible (de Bruijn et al., 2016)
	Language affects the effectiveness of warning messages: for example, when reading the word “advice”, people may believe that the threat is less severe or not so urgent and that protective measures are optional (Sutton & Wood, 2016)
Citizen participation and community engagement	The absence of a public education campaign affects citizens’ participation in risk preparedness and response initiatives (Shrestha et al., 2021)
	Tools that allow high degrees of agency can lead to inaccurate risk assessments that might negatively affect the decisions (Richards, 2019)
	Workshops and engagement initiatives success depend on the people present and their involvement (de Bruijn et al., 2016)
	Weak risk knowledge and perceptions affect people’s participation in grassroots initiatives (Salvati et al., 2016)

What to take home

⇒ **Organizational dimension**
- *Pros*: flexible staff and internal communication processes, inter-organizational cooperation, scientists and communication experts' involvement.
- *Cons*: Shortage of staff of budget, lack of cooperation, weak organizational identity, lack of communication culture.

⇒ **Case-Specific**
- *Pros*: personalization, visual clues, targeted tools.
- *Cons*: unfamiliar elements, clash between reality and risk representation.

⇒ **Audience characteristics and abilities**
- *Pros*: targeted communication, defined audiences.
- *Cons*: demographic characteristics, reduced attention towards fundamental elements, cultural awareness, and sensitivity.

⇒ **Media environment**
- *Pros*: mixed media approaches, face-to-face reinforcements.
- *Cons*: misinformation and disinformation, missing media policies, misrepresentation of risks by popular culture, messages not tailored on media characteristics or affordances.

⇒ **Trustworthiness and source credibility**
- *Pros*: using scientists to convey risk information, producing in-house content, offering visual proofs.
- *Cons*: too many voices, distrust in risk authorities, overlap between governmental propaganda and risk communication.

⇒ **Formal and technical aspects**
- *Pros*: using data, using emotional clues to generate attention.
- *Cons*: inappropriate formats, relying only on worst-case scenarios, risk communicators are not aware of data and technical information.

⇒ **Risk nature and stage**
- *Pros*: exploit quiet time to enhance risk socialization, starting conversations about risks post-events.
- *Cons*: long time gaps between risk occurrences, wrong timing in programming communicative actions, creating a false sense of security in awareness campaigns.

⇒ **Narrative devices and content organization**
- *Pros*: deliver factual information, design messages that resonate with local audiences, use personal stories, design short, clear and coherent messages.
- *Cons*: statistics and technical information are difficult to decode, too much information may be overwhelming, narrative approaches are not feasible for generalizations, organizations miss sensitivity.

⇒ **Citizen participation and community engagement**
- Pros: foster participation to enhance risk preparedness and awareness, share risk memories to enhance public debates on risk.
- *Cons*: risk experts and local communities do not share a common language, cultural resistance to participation, too much agency may affect risk assessment, sporadic campaigns have a limited impact on engagement, politicized communities do not engage in participatory initiatives.

Towards a Toolkit: Insights from the Literature Review

The analysis of success factors and potential inhibitors for risk communication has highlighted how risk communication takes shape in complex environments. Although the variety of risk communication approaches discussed in the literature review does not allow for consistent or stringent generalizations, the analysis of success and inhibitory elements, as identified by the authors, helps identify some recurring aspects to consider in developing risk communication strategies.

The basic assumption is that trends can be isolated for consideration in formulating and analyzing risk communication tools. These guiding principles, it should be noted, are relative to the criteria and objectives of this literature review.

Therefore, the principle of intentionality regarding the production and distribution of content, used in the abstract selection phase and borrowed from the literature that inspired the definition of campaigns used in this review, implies a series of practical considerations.

First and foremost, it is emphasized that campaigns or risk communication tools originate in specific organizational contexts. For this reason, what happens within organizations is relevant to understanding risk communication. In designing effective tools, consideration must be given to how manageable they can be by the organization's staff and how adaptable they can be in relation to internal competencies. At the same time, risk communication must be understood as a piece of more complex and articulated mosaics. This complexity means that different actors involved in disseminating risk communication must find a common language, adopting centralized strategies adaptable to local objectives and peculiarities.

The characteristics of the audiences, obviously highly relevant, must be monitored by organizations. Identifying protective, informational, or resilience-building tools related to risk communication must accompany ongoing research on the audiences. Although the individual, psychological, and sociocultural characteristics of audiences that facilitate adherence to prosocial or proactive behaviors regarding risks are beyond the scope of this review, it is specified that the composition and features of the recipients of risk communication are fundamental for the comprehensive design and dissemination of effective tools.

The media environment must be considered when designing tools. Even the media spaces where risk communication occurs must be suitable for the organizations proposing the tools and their users. Consider social media, for example. On the one hand, they are considered capable of conveying messages in real time and with a broad reach. On the other hand, the physical availability of infrastructure and the literacy of audiences influence the effectiveness of these tools. Therefore, in mountainous or rural areas, or to disseminate messages to specific segments of the population, additional support tools will be needed, ranging from broadcast media to personal media, printed materials, or face-to-face conversations. The literature demonstrates the relevance of communications that occur in multimedia contexts.

Knowledge of the tools used and principles focused on clarity, and informational economy characterize message formats and internal narrative organization. The principle of clarity and credibility should guide the choice of "visible" sources regarding risk communication.

Finally, the implementation of co-participated strategies, alongside centralized communication strategies, can facilitate the adoption of proactive behaviors. These actions must be designed considering the cultural and sociopolitical dimensions that characterize the target social groups. Below, the main operational guidelines emerging from the analysis of success factors or inhibitors described in the previous section will be summarized.

- Improve cooperation between organizations involved in risk management
- Include experienced professionals in the social sciences in the risk communication tool design processes
- Envisage a flexible staff capable of managing complex communication tools
- Include communication expenses in the organizations' budget

- Consider communication needs from the beginning of the risk management processes
- Continuously monitor audiences and their needs
- Evaluate the pros and cons of each media channel used
- Harness the affordances of platforms or media features by tailoring messages to the medium's characteristics
- Avoid the cacophony of voices from scientists and perceived authoritative sources
- Consider the level of politicization in society before linking risk communication to government sources
- Provide data and use clear language
- Always provide detailed explanations for numerical data or visual risk communication
- When necessary, adopt storytelling forms based on the experiences of local communities
- Develop participation strategies capable of overcoming cultural and political resistance
- Consider the capacity and resilience of physical infrastructure in emergency phases
- Consider the stage of the risk and the timing of tools or campaigns sharing strategies

What to take home

⇒ Campaigns or risk communication tools originate in specific organizational contexts
⇒ Organizations should monitor the characteristics of the audiences
⇒ Media channels must be suitable for the organizations proposing them and inserted in the audiences' path of media consumption
⇒ Knowledge of the tools used and principles focused on clarity and informational economy characterize message formats and internal narrative organization
⇒ Co-participated strategies can facilitate the adoption of proactive behaviors

What's Next?

The literature review has highlighted areas necessary for understanding risk communication strategies and developing effective practices. However, these same areas are still not fully explored in the literature regarding risk communication. Although these issues have emerged – with varying degrees of clarity – from the literature analysis, the absence of papers specifically dedicated to these themes suggests the possibility of further exploration of various areas.

Risk communication aimed at specific groups – such as multicultural communities, non-residents, and communities differentiated by gender and age groups – deserves further investigation and experimentation. If the purpose of risk communication is to share information most effectively, greater customization of products or communication channels could prove advantageous for immediately transmitting relevant information, such as alerts, and for long-term processes of risk literacy and protective behaviors.

Another issue worth exploring concerns organizational processes. As strongly emphasized by the factors of strength and indications about limitations in risk communication, internal processes, from those related to budget to those involving the internal human capital of organizations, impact the adoption of tools and their potential for development. An analysis of internal processes within organizations responsible for producing valuable information for risk communication would be indicated to understand whether and how the cultures of organizations, internal relationships, and the management of organizational coordination with other institutions and organizations responsible for risk communication influence the development or application of tools. Ethnographic analysis or in-depth interviews with key informants within organizations are potential research techniques to explore this area.

Success or inhibition factors suggest a particular role of the political dimension, especially regarding the attribution of source credibility and the management of participatory processes. However, even due to its purely technical nature, risk communication experiences collected in the literature review seem to operate in a void. Indeed, few papers explore risk communication expressions considering the social and political context in which they occur. Government centralization and different risk communication strategies in the face of various political systems or regimes would provide significant clues about the extra-individual causes that lead to the acceptance or systematic underestimation of alerts and messages.

As emerged from the literature review, government agencies or national entities responsible for risk research or prevention are among the main actors in risk communication processes. Yet, a range of private actors ranging from platform managers to companies engaged in climate-awareness operations could, with their contribution, significantly impact risk awareness management or at least contribute to mitigating problems arising from risk communication in capitalist-oriented spaces. How could the involvement of these entities affect the possibilities of risk communication in alternative areas? What is the credibility of such initiatives in the eyes of the public?

Furthermore, experts and individuals with specific communication training are indicated by several analyzed contributions as essential for successfully implementing communication strategies. However, their actual involvement remains relatively unexplored, especially in relation to phases other than follow-ups to specific events that have seen the use of designed tools.

Finally, despite the literature review indicating the relevance of bi-directionality in defining risk communication, participatory processes are relatively marginal in the analyzed papers. Part of this inclination derives from the need for centralized information regarding some of the risks analyzed or the phase in which these tools are applied. Participation is suitable for generating shared preparation or risk memory-building strategies, while its contribution in emergency phases is still being defined. A more comprehensive analysis of participatory processes in different risk phases could facilitate the adaptation of grassroots initiatives by better-aligning tools with the cultural predispositions and social characteristics of communities.

What to take home

- ⇒ Risk communication aimed at specific groups (multicultural communities, non-residents, and communities differentiated by gender and age groups) needs further investigations
- ⇒ Internal organizational processes knowledge would be indicated to understand whether and how the cultures of organizations, their relationships, and the management of organizational coordination with other institutions influence the development or application of tools
- ⇒ Political dimension, especially regarding the attribution of source credibility and the management of participatory processes, should be identified
- ⇒ Experts' role should be investigated to enhance their participation in all risk communication stages
- ⇒ Participation is suitable for generating shared preparation or risk memory-building strategies, while its contribution in emergency phases is still being defined

References

Abukhalaf, A. H. I., & Von Meding, J. (2020). Communication challenges in campus emergency planning: The case of hurricane Dorian in Florida. *Natural Hazards*, *104*(2), 1535-1565.

Agrawal, S., Ambury, H., Parida, D., & Joshi, N. (2022). Understanding risk communication in practice: Insights from municipalities in Alberta, Canada. *International Journal of Disaster Risk Reduction*, *79*, 103175.

Amato, A., Arcoraci, L., Casarotti, E., & Di Stefano, R. (2012). The INGVterremoti channel on YouTube. *Annals of Geophysics*, *55*(3), 403-408.

Anderson, S., Allen, P., Peckham, S., & Goodwin, N. (2008). Asking the right questions: Scoping studies in the commissioning of research on the organisation and delivery of health services. *Health Research Policy and Systems*, *6*(1), 1-12.

Andrade, E. L., Barrett, N. D., Edberg, M. C., Rivera, M. I., Latinovic, L., Seeger, M. W., ... & Santos-Burgoa, C. (2020). Mortality reporting and rumor generation: An assessment of crisis and emergency risk communication following. *Journal of International Crisis and Risk Communication Research*, *3*(1), 15-47.

Andreastuti, S. D., Paripurno, E. T., Subandriyo, S., Syahbana, D. K., & Prayoga, A. S. (2023). Volcano disaster risk management during crisis: Implementation of risk communication in Indonesia. *Journal of Applied Volcanology*, *12*(1), 3.

Asplund, T. (2020). Credibility aspects of research-based gaming in science communication: The case of The Maladaptation Game. *JCOM-Journal of Science Communication*, *19*(1).

Asplund, T., Neset, T. S., Käyhkö, J., Wiréhn, L., & Juhola, S. (2019). Benefits and challenges of serious gaming: The case of "The Maladaptation Game". *Open Agriculture*, *4*(1), 107-117.

Atkin, C. K. (1981). Mass media information effectiveness. In R. E. Rice & W. J. Paisley (Eds.), *Public Communication Campaigns*. Beverly Hills: Sage.

Badri, M., Lubis, D. P., Susanto, D., & Suharjito, D. (2018). Communication risk of stakeholders in preventing forest and land fires in Riau Province. *Jurnal Ilmiah Peuradeun*, *6*(2), 179-198.

Beck, U. (1986). *Risk Society. Towards a New Modernity*. London: Sage.

Benford, R. D., & Snow, D. A. (2000). Framing processes and social movements: An overview and assessment. *Annual Review of Sociology*, *26*(1), 611-639.

Bica, M., Weinberg, J., & Palen, L. (2020). Achieving accuracy through ambiguity: The interactivity of risk communication in severe weather events. *Computer Supported Cooperative Work (CSCW)*, *29*, 587-623.

Bird, D. K., & Gísladóttir, G. (2020). Enhancing tourists' safety in volcanic areas: An investigation of risk communication initiatives in Iceland. *International Journal of Disaster Risk Reduction*, *50*, 101896.

Bostrom, A., Morss, R. E., Lazo, J. K., Demuth, J. L., Lazrus, H., & Hudson, R. (2016). A mental models study of hurricane forecast and warning production, communication, and decision-making. *Weather, Climate, and Society*, *8*(2), 111-129.

boyd, d. (2010). Social network sites as networked publics: Affordances, dynamics, and implications. In Z. Papacharissi (Ed.), *A Networked Self*. London-New York: Routledge.

Broad, G. M., Ball-Rokeach, S. J., Ognyanova, K., Stokes, B., Picasso, T., & Villanueva, G. (2013). Understanding communication ecologies to bridge communication research and community action. *Journal of Applied Communication Research*, *41*(4), 325-345.

Broad, K., Leiserowitz, A., Weinkle, J., & Steketee, M. (2007). Misinterpretations of the "cone of uncertainty" in Florida during the 2004 hurricane season. *Bulletin of the American Meteorological Society*, *88*(5), 651-668.

Cameron, L., Rocque, R., Penner, K., & Mauro, I. (2021). Evidence-based communication on climate change and health: Testing videos, text, and maps on climate change and Lyme disease in Manitoba, Canada. *Plos One*, *16*(6), e0252952.

Cao, Y., Boruff, B. J., & McNeill, I. M. (2017). Towards personalized public warnings: Harnessing technological advancements to promote better individual decision-making in the face of disasters. *International Journal of Digital Earth*, *10*(12), 1231-1252.

Carr, R. H., Montz, B., Semmens, K., Maxfield, K., Hoekstra, S., & Goldman, E. (2016). Motivating action under uncertain conditions: Enhancing emergency briefings during coastal storms. *Weather, Climate, and Society*, *8*(4), 421-434.

Charrière, M. K., Junier, S. J., Bogaard, T. A., Mostert, E., Malet, J. P., & van de Giesen, N. C. (2017). The impact of an exhibition on risk awareness of the general public in mountainous areas. *International Journal of Disaster Risk Reduction*, *25*, 36-59.

Chatfield, A. T., & Reddick, C. G. (2015). Understanding risk communication gaps through e-government website and twitter hashtag content analyses: The case of Indonesia's Mt. Sinabung eruption. *Journal of Homeland Security and Emergency Management*, *12*(2), 351-385.

Chiang, Y. C., & Ling, T. Y. (2017). Exploring flood resilience thinking in the retail sector under climate change: A case study of an estuarine region of Taipei City. *Sustainability*, *9*(9), 1650.

Cool, C. T., Claravall, M. C., Hall, J. L., Taketani, K., Zepeda, J. P., Gehner, M., & Lawe-Davies, O. (2015). Social media as a risk communication tool following Typhoon Haiyan. *Western Pacific Surveillance and Response Journal: WPSAR*, *6*(Suppl 1), 86.

Coombs, W. T. (2007). Protecting organization reputations during a crisis: The development and application of situational crisis communication theory. *Corporate Reputation Review*, *10*, 163-176.

Cooper, V., Fairbrother, P., Elliott, G., Walker, M., & Ch'ng, H. Y. (2020). Shared responsibility and community engagement: Community narratives of bushfire risk information in Victoria, Australia. *Journal of Rural Studies*, *80*, 259-272.

Cottle, S. (1998). Ulrich Beck, Risk Society and the Media: A Catastrophic View?. *European Journal of Communication*, *13*(1), 5-32.

Couldry, N. (2012). *Media, Society, World: Social Theory and Digital Media Practice*. London: Polity.

Couldry, N., & Hepp, A. (2013). Conceptualizing mediatization: Contexts, traditions, arguments. *Communication Theory*, *23*(3), 191-202.

Covello, V. T. (1992). Risk communication: An emerging area of health communication research. *Annals of the International Communication Association*, *15*(1), 359-373.

De Bruijn, K. M., Lips, N., Gersonius, B., & Middelkoop, H. (2016). The storyline approach: a new way to analyse and improve flood event management. *Natural Hazards*, *81*, 99-121.

de Leon, I. Z. P. (2021). The purok system of San Francisco, Camotes: A communication perspective of community-based Haiyan response. *International Journal of Disaster Risk Reduction*, *61*, 102379.

Demeritt, D., Nobert, S., Cloke, H. L., & Pappenberger, F. (2013). The European Flood Alert System and the communication, perception, and use of ensemble predictions for operational flood risk management. *Hydrological Processes*, *27*(1), 147-157.

Demuth, J. L., Morss, R. E., Lazo, J. K., & Hilderbrand, D. C. (2013). Improving effectiveness of weather risk communication on the NWS point-and-click web page. *Weather and Forecasting*, *28*(3), 711-726.

Dootson, P., Thomson, T. J., Angus, D., Miller, S., Hurcombe, E., & Smith, A. (2021). Managing problematic visual media in natural hazard emergencies. *International Journal of Disaster Risk Reduction*, *59*, 102249.

Douglas, M. (1991). *Come percepiamo il pericolo: antropologia del rischio*. Milano: Feltrinelli.

Douglas, M. & Wildawsky, A. (1982). *Risk and Culture*. Berkley: University of California Press.

Eachus, J. D., & Keim, B. D. (2020). Content driving exposure and attention to tweets during local, high-impact weather events. *Natural Hazards*, *103*(2), 2207-2229.

Entman, R. M. (1993). Framing: Toward clarification of a fractured paradigm. *Journal of Communication*, *43*(4), 51-58.

Evans, S. D., Broad, K., Cairo, A., Majumdar, S. J., McNoldy, B. D., Millet, B., & Rauk, L. (2022). An Interdisciplinary Approach to Evaluate Public Comprehension of the "Cone of Uncertainty" Graphic. *Bulletin of the American Meteorological Society*, 103, E2214–E2221.

Fallou, L., Corradini, M., Bossu, R., & Cheny, J. M. (2022). Preventing and debunking earthquake misinformation: Insights into EMSC's practices. *Frontiers in Communication*, *7*, 993510.

Feldpausch-Parker, A. M., & Peterson, T. R. (2015). Communicating the science behind carbon sequestration: A case study of US Department of Energy and Regional Partnership websites. *Environmental Communication*, *9*(3), 326-345.

Fokaefs, A., & Sapountzaki, K. (2021). Crisis Communication after Earthquakes in Greece and Japan: Effects on Seismic Disaster Management. *Sustainability*, *13*(16), 9257.

Fontana, M., Rossetti, M., & De Amicis, M. (2012). Risk management, a proposal for communication strategies. *Annals of Geophysics*, *55*(3), 433-438.

Fu, J. S., & Lai, C. H. (2021). Determinants of organizational performance in disaster risk reduction: A preliminary study of global humanitarian NGOs. *Journal of Contingencies and Crisis Management*, *29*(3), 232-247.

Fuchs, C., & Mosco, V. (2016). *Marx in the Age of Digital Capitalism*. London: Brill.

Geertz, C. (1973). *The Interpretation of Cultures*. New York: Basic Books.

Gillespie, T. (2018). *Custodians of the Internet: Platforms, Content Moderation, and the Hidden Decisions that Shape Social Media*. New Haven: Yale University Press.

Gomez-Zapata, J. C., Parrado, C., Frimberger, T., Barragán-Ochoa, F., Brill, F., Büche, K., ... & Zapata-Tapia, C. (2021). Community perception and communication of volcanic risk from the Cotopaxi volcano in Latacunga, Ecuador. *Sustainability*, *13*(4), 1714.

Graham, O., Edwards, S., & Robertson, R. (2022). More than a warning: Expanding the role of communication in Eastern Caribbean volcano science. *Frontiers in Earth Science*, *10*, 907559.

Griswold, W. (2012). *Cultures and Societies in a Changing World*. Thousand Oaks: Sage.

Hall, S., 1980. Encoding/decoding. In S. Hall, D. Hobson, A. Lowe, & P. Willis (Eds) *Culture, Media, Language*. London: Hutchinson.

Heidenreich, A., Masson, T., & Bamberg, S. (2020). Let's talk about flood risk: Evaluating a series of workshops on private flood protection. *International Journal of Disaster Risk Reduction*, *50*, 101880.

Henriksen, H. J., Roberts, M. J., van der Keur, P., Harjanne, A., Egilson, D., & Alfonso, L. (2018). Participatory early warning and monitoring systems: A Nordic framework for web-based flood risk management. *International Journal of Disaster Risk Reduction*, *31*, 1295-1306.

Herovic, E., Sellnow, T. L., & Sellnow, D. D. (2020). Challenges and opportunities for pre-crisis emergency risk communication: Lessons learned from the earthquake community. *Journal of Risk Research*, *23*(3), 349-364.

Hicks, A., Armijos, M. T., Barclay, J., Stone, J., Robertson, R., & Cortés, G. P. (2017). Risk communication films: Process, product and potential for improving preparedness and behaviour change. *International Journal of Disaster Risk Reduction*, *23*, 138-151.

Holmes, A., & McEwen, L. (2020). How to exchange stories of local flood resilience from flood rich areas to the flooded areas of the future. *Environmental Communication*, *14*(5), 597-613.

Houston, D., Cheung, W., Basolo, V., Feldman, D., Matthew, R., Sanders, B. F., ... & Luke, A. (2019). The influence of hazard maps and trust of flood controls on coastal flood spatial awareness and risk perception. *Environment and Behavior*, *51*(4), 347-375.

Hu, X., Zhang, X., & Wei, J. (2019). Public attention to natural hazard warnings on social media in China. *Weather, Climate, and Society*, *11*(1), 183-197.

Intrieri, E., Dotta, G., Fontanelli, K., Bianchini, C., Bardi, F., Campatelli, F., & Casagli, N. (2020). Operational framework for flood risk communication. *International Journal of Disaster Risk Eduction*, *46*, 101510.

Irwanti, M., Nuriman, D., Lestari, P., & Sigit, R. (2023). Risk communication strategy in dealing with the tsunami disaster. *Sibatik Journal: Jurnal Ilmiah Bidang Sosial, Ekonomi, Budaya, Teknologi, dan Pendidikan*, *2*(2), 675-682.

Jiang, H., Zhang, Y., Guo, W., Cheng, W., & Peng, J. (2022). Online collaborative documents as media logic: The mediatization of risk response in the post-pandemic era. *Frontiers in Psychology*, *13*, 892569.

Jones, L. M., & Benthien, M. (2011). Preparing for a "Big One": The great southern California ShakeOut. *Earthquake Spectra*, *27*(2), 575-595.

Kain, D., & Covi, M. (2013). Visualizing complexity and uncertainty about climate change and sea level rise. *Communication Design Quarterly Review*, *1*(3), 46-53.

Kamrin, M.A. (2014). Risk communication. In P. Wexler, *Encyclopedia of Toxicology (Third Edition)*. London: Academic Press.

Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., ... & Ratick, S. (1988). The social amplification of risk: A conceptual framework. *Risk Analysis*, *8*(2), 177-187.

Katz, E. & Lazarsfeld, P. F. (1955). *Personal Influence. The Part Played by People in the Flow of Mass Communication*. New York: Free Press.

Kause, A., Bruine de Bruin, W., Fung, F., Taylor, A., & Lowe, J. (2020). Visualizations of projected rainfall change in the United Kingdom: An interview study about user perceptions. *Sustainability*, *12*(7), 2955.

Kim, J., Liu, B. F., Atwell Seate, A., Lee, S., & Hawblitzel, D. (2023). All joking aside? Comparing the effects of a humorous vs. a non-humorous message strategy in building organization–public relationships and community resilience. *Journal of Applied Communication Research*, 1-19.

Kinsky, E. S., Chen, L., & Drumheller, K. (2021). Crisis and emergency risk communication: FEMA's Twitter use during the 2017 hurricane season. *Public Relations Review*, *47*(4), 102094.

Kiwanuka-Tondo, J., & Pettiway, K. M. (2017). Localizing complex scientific communication: a SWOT analysis and multi-sectoral approach of communicating climate change. *Communication Design Quarterly Review*, *4*(4), 74-85.

Latour, B. (2007). *Reassembling the Social: An Introduction to Actor-Network-Theory*. Oxford: Oxford University Press.

Leiss, W. (1996). Three Phases in The Evolution of Risk Communication Practice. *The Annals of the American Academy of Political and Social Science*, *545*(1), 85-94.

Lejano, R. P., Casas, E. V., Montes, R. B., & Lengwa, L. P. (2018). Weather, climate, and narrative: a relational model for democratizing risk communication. *Weather, Climate, and Society*, *10*(3), 579-594.

Leonard, G. S., Stewart, C., Wilson, T. M., Procter, J. N., Scott, B. J., Keys, H. J., ... & McBride, S. K. (2014). Integrating multidisciplinary science, modelling and impact data into evolving, syn-event volcanic hazard mapping and communication: A case study from the 2012 Tongariro eruption crisis, New Zealand. *Journal of Volcanology and Geothermal Research*, *286*, 208-232.

Lieske, D. J., Wade, T., & Roness, L. A. (2014). Climate change awareness and strategies for communicating the risk of coastal flooding: A Canadian Maritime case example. *Estuarine, Coastal and Shelf Science*, *140*, 83-94.

Link, S., & Stötter, J. (2015). Internal communication a prerequisite for risk governance: Hazard zone planning in South Tyrol, Italy. *Environmental Hazards*, *14*(2), 87-102.

Luke, A., Sanders, B. F., Goodrich, K. A., Feldman, D. L., Boudreau, D., Eguiarte, A., ... & Matthew, R. A. (2018). Going beyond the flood insurance rate map: insights from flood hazard map co-production. *Natural Hazards and Earth System Sciences*, *18*(4), 1097-1120.

Manandhar, R., & Siebeneck, L. K. (2021). Information management and the return-entry process: Examining information needs, sources, and strategies after Superstorm Sandy. *International Journal of Disaster Risk Reduction*, *53*, 102015.

Mason, A. M., Drew, S., & Weaver, D. (2017). Managing Crisis-induced uncertainty: First responder experiences from the 2011 Joplin-Duquesne Tornado. *International Journal of Disaster Risk Reduction*, *23*, 231-237.

Matti, S., Ögmundardóttir, H., Aðalgeirsdóttir, G., & Reichardt, U. (2022). Communicating Risk in Glacier Tourism: A Case Study of the Svínafellsheiði Fracture in Iceland. *Mountain Research and Development*, *42*(2), D1-D12.

McBride, S. K., Bostrom, A., Sutton, J., de Groot, R. M., Baltay, A. S., Terbush, B., ... & Vinci, M. (2020). Developing post-alert messaging for ShakeAlert, the earthquake early warning system for the West Coast of the United States of America. *International Journal of Disaster Risk Reduction*, *50*, 101713.

McCarthy, S. S. (2007). Contextual influences on national level flood risk communication. *Environmental Hazards*, *7*(2), 128-140.

McGuire, W. J. (2013). McGuire's Classic Input-Output Framework for Constructing Persuasive Messages. In R.R. Rice & C. H. Aktin (Eds.), *Public Communication Campaigns*. London-New York: Sage.

McQuail, D. (2005). *Mass Communication Theory*. London: Sage.

Meltzer, M., Ștefănescu, L., & Ozunu, A. (2018). Keep them engaged: Romanian county inspectorates for emergency situations' Facebook usage for disaster risk communication and beyond. *Sustainability*, *10*(5), 1411.

Morss, R. E., Cuite, C. L., Demuth, J. L., Hallman, W. K., & Shwom, R. L. (2018). Is storm surge scary? The influence of hazard, impact, and fear-based messages and individual differences on responses to hurricane risks in the USA. *International Journal of Disaster Risk Reduction*, *30*, 44-58.

Nave, R., Isaia, R., Vilardo, G., & Barclay, J. (2010). Re-assessing volcanic hazard maps for improving volcanic risk communication: application to Stromboli Island, Italy. *Journal of Maps*, *6*(1), 260-269.

Ni, B., Wu, F., & Huang, Q. (2023). When Artificial Intelligence Voices Human Concerns: The Paradoxical Effects of AI Voice on Climate Risk Perception and Pro-Environmental Behavioral Intention. *International Journal of Environmental Research and Public Health*, *20*(4), 3772.

Nichols, T. (2017). *The Death of Expertise: The Campaign Against Established Knowledge and Why It Matters*. Oxford -New York: Oxford University Press.

Norman, D. (2013). *The Design of Everyday Things: Revised and Expanded Edition*. New York: Basic Books.

O'Neill, S. J., Boykoff, M., Niemeyer, S., & Day, S. A. (2013). On the use of imagery for climate change engagement. *Global Environmental Change*, *23*(2), 413-421.

Olman, L., & DeVasto, D. (2021). Hybrid collectivity: Hacking environmental risk visualization for the Anthropocene. *Communication Design Quarterly Review*, *8*(4), 15-28.

Ozanne, L. K., Ballantine, P. W., & Mitchell, T. (2020). Investigating the methods and effectiveness of crisis communication. *Journal of Nonprofit & Public Sector Marketing*, *32*(4), 379-405.

Paisley, W. (1989). Public communication campaigns: The American experience. In R. E. Rice & C. K. Atkin. *Public Communication Campaigns*. Newbury Park: Sage.

Paradiso, M. (2012). Information and communication technologies and environmental safety: The case of Naples-Vesuvius, Italy. *Journal of Urban Technology*, *19*(4), 45-58.

Perreault, M. F., Houston, J. B., & Wilkins, L. (2014). Does scary matter?: Testing the effectiveness of new National Weather Service tornado warning messages. *Communication Studies*, *65*(5), 484-499.

Pflugfelder, E. H. (2019). Risk selfies and nonrational environmental communication. *Communication Design Quarterly Review*, *7*(1), 73-84.

Pignone, M., Amato, A., Nostro, C., Casarotti, E., Meletti, C., Quintiliani, M., & Lauciani, V. (2022). Public earthquake communication in Italy through a multi-source social media platform: The INGVterremoti experience (2010–2022). *Frontiers in Earth Science*, *10*, 1003867.

Rainear, A. M., Lachlan, K. A., Oeldorf-Hirsch, A., & DeVoss, C. L. (2018). Examining Twitter content of state emergency management during Hurricane Joaquin. *Communication Research Reports*, *35*(4), 325-334.

Rana, I. A., Bhatti, S. S., & Jamshed, A. (2021). Effectiveness of flood early warning system from the perspective of experts and three affected communities in urban areas of Pakistan. *Environmental Hazards*, *20*(3), 209-228.

Reed, J. R., & Senkbeil, J. C. (2020). Perception and comprehension of the extended forecast graphic: A survey of broadcast meteorologists and the public. *Bulletin of the American Meteorological Society*, *101*(2), E221-E236.

Retchless, D. P., & Ross, A. D. (2022). Effects of temporal framing and hazard experience on receptivity to hurricane risk messages: A survey of US Gulf Coast residents. *Frontiers in Communication*, *7*, 1020935.

Rice, R. E., & Atkin, C. K. (2009). Public communication campaigns: Theoretical principles and practical applications. In J. Bryant & M. Oliver (Eds.) *Media Effects: Advances in Theory and Research*. Hillsdale, NJ: Lawrence Erlbaum.

Rice, R.R. & C.H. Aktin (2013). *Public Communication Campaigns*. London-New York: Sage.

Richards, D. (2015). Testing the waters: Local users, sea level rise, and the productive usability of interactive geovisualizations. *Communication Design Quarterly Review*, *3*(3), 20-24.

Richards, D. P. (2018). Not a cape, but a life preserver: The importance of designer localization in interactive sea level rise viewers. *Communication Design Quarterly Review*, *6*(2), 57-69.

Richards, D. P. (2019). An ethic of constraint: Citizens, sea-level rise viewers, and the limits of agency. *Journal of Business and Technical Communication*, *33*(3), 292-337.

Rowel, R., Sheikhattari, P., Barber, T. M., & Evans-Holland, M. (2012). Introduction of a guide to enhance risk communication among low-income and minority populations: a grassroots community engagement approach. *Health promotion practice*, *13*(1), 124-132.

Saha, S., Pradhan, S. G., & Siwakoti, A. (2021). Communicating to reduce disaster risk through radio in Nepal: A case study of Milijuli Nepali and Kathamaala. *Progress in Disaster Science*, *10*, 100161.

Salvati, P., Pernice, U., Bianchi, C., Marchesini, I., Fiorucci, F., & Guzzetti, F. (2016). Communication strategies to address geohydrological risks: The POLARIS web initiative in Italy. *Natural Hazards and Earth System Sciences*, *16*(6), 1487-1497.

Sanderson, M., Doyle, H., & Walsh, P. (2020). Developing and implementing a targeted health-focused climate communications campaign in Ontario: # MakeItBetter. *Canadian Journal of Public Health*, *111*, 869-875.

Sansoulet, J., Pangrazi, J. J., Sardet, N., Mirshak, S., Fayad, G., Bourgain, P., & Babin, M. (2019). Green Edge Outreach Project: A large-scale public and educational initiative. *Polar Record*, *55*(4), 227-234.

Scott, K. K., & Errett, N. A. (2018). Content, accessibility, and dissemination of disaster information via social media during the 2016 Louisiana floods. *Journal of Public Health Management and Practice*, *24*(4), 370-379.

Shenhar, G., Radomislensky, I., Rozenfeld, M., & Peleg, K. (2015). The impact of a national earthquake campaign on public preparedness: 2011 campaign in Israel as a case study. *Disaster Medicine and Public Health Preparedness*, *9*(2), 138-144.

Shenhar, G., Rozenfeld, M., Radomislensky, I., & Peleg, K. (2016). Comparison of two successive earthquake awareness campaigns in Israel: improved methodology or a cumulative effect?. *Disaster Medicine and Public Health Preparedness*, *10*(1), 74-79.

Shepherd, J., & van Vuuren, K. (2014). The Brisbane flood: CALD gatekeepers' risk communication role. *Disaster Prevention and Management*, *23*(4), 469-483.

Shoemaker, P.J., & Reese, S.D. (1991). *Mediating the Message*. New York-London: Longman.

Shrestha, M. S., Gurung, M. B., Khadgi, V. R., Wagle, N., Banarjee, S., Sherchan, U., ... & Mishra, A. (2021). The last mile: Flood risk communication for better preparedness in Nepal. *International Journal of Disaster Risk Reduction*, *56*, 102118.

Silverstone, R. (1999). *Why Study the Media?*. London: Sage.

So, M., Franks, J. L., Cree, R. A., & Leeb, R. T. (2020). An evaluation of the literacy demands of online natural disaster preparedness materials for families. *Disaster Medicine and Public Health Preparedness*, *14*(4), 449-458.

Song, M., Kim, J. W., Kim, Y., & Jung, K. (2015). Does the provision of emergency information on social media facilitate citizen participation during a disaster?. *International Journal of Emergency Management*, *11*(3), 224-239.

Stake, R. E. (1995). *The Art of Case Study Research*. Thousand Oaks: Sage.

Steelman, T. A., & McCaffrey, S. (2013). Best practices in risk and crisis communication: Implications for natural hazards management. *Natural Hazards*, *65*, 683-705.

Stephens, S. H., & Richards, D. P. (2020). Story mapping and sea level rise: Listening to global risks at street level. *Communication Design Quarterly Review*, *8*(1), 5-18.

Stephens, S. H., DeLorme, D. E., & Hagen, S. C. (2017). Evaluation of the design features of interactive sea-level rise viewers for risk communication. *Environmental Communication*, *11*(2), 248-262.

Stovall, W. K., Ball, J. L., Westby, E. G., Poland, M. P., Wilkins, A., & Mulliken, K. M. (2023). Officially social: Developing a social media crisis communication strategy for USGS Volcanoes during the 2018 Kīlauea eruption. *Frontiers in Communication*, *8*, 976041.

Sturloni, G. (2018). *La comunicazione del rischio per la salute e l'ambiente*. Milano: Mondadori Università.

Sun, Y., & Yamori, K. (2018). Risk management and technology: Case studies of tsunami evacuation drills in Japan. *Sustainability*, *10*(9), 2982.

Sutton, J., & Woods, C. (2016). Tsunami warning message interpretation and sense making: Focus group insights. *Weather, Climate, and Society*, *8*(4), 389-398.

Tagliacozzo, S., & Magni, M. (2018). Government to Citizens (G2C) communication and use of social media in the post-disaster reconstruction phase. *Environmental Hazards*, *17*(1), 1-20.

Takahashi, B.; Edwards, G.; Roberts, J. T.; & Duan, R. 2015. Exploring the Use of Online Platforms for Climate Change Policy and Public Engagement by NGOs in Latin America, *Environmental Communication*, 9(2), 228-247.

Todesco, M., De Lucia, M., Bagnato, E., Behncke, B., Bonforte, A., De Astis, G., ... & Neri, A. (2022). Eruptions and Social Media: Communication and Public Outreach About Volcanoes and Volcanic Activity in Italy. *Frontiers in Earth Science*, *10*, 926155.

Tuchman, G. (1978). *Making News: A Study on the Construction of Reality*. New York: Free Press.

Uggla, Y. (2008). Strategies to create risk awareness and legitimacy: The Swedish climate campaign. *Journal of Risk Research*, *11*(6), 719-734.

Van Dijck, J., Poell, T., & De Waal, M. (2018). *The Platform Society: Public Values in a Connective World*. Oxford – New York: Oxford University Press.

VanderMolen, K., Kimutis, N., & Hatchett, B. J. (2022). Recommendations for increasing the reach and effectiveness of heat risk education and warning messaging. *International Journal of Disaster Risk Reduction*, *82*, 103288.

VanDyke, M. S., Armstrong, C. L., & Bareford, K. (2021). How risk decision-makers interpret and use flood forecast information: assessing the Mississippi River Outlook email product. *Journal of Risk Research*, *24*(10), 1239-1250.

Veil, S. R., & Husted, R. A. (2012). Best practices as an assessment for crisis communication. *Journal of Communication Management*, *16*(2), 131-145.

Yin, R. K. (2013). Case study research: Design and methods. Thousand Oaks, CA: Sage.

Yudarwati, G. A., Putranto, I. A., & Delmo, K. M. (2022). Examining the Indonesian government's social media use for disaster risk communication. *Asian Journal of Communication*, *32*(1), 1-20.