

Disaster Risk Communication: Evidence-Based Practices across Cultures and Hazards

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ABSTRACT

Disaster risk communication has become an indispensable component of disaster risk reduction, emergency preparedness, and resilience building as societies face increasingly frequent and complex natural, technological, and public health hazards. This review synthesizes evidence-based practices in disaster risk communication across diverse cultural settings and hazard contexts, examining the theoretical foundations, communication models, cultural influences, and practical strategies that shape effective risk communication. The review highlights risk communication as a dynamic, two-way process that extends beyond information dissemination to include community engagement, trust building, public participation, and behavior change throughout the disaster management cycle. Evidence demonstrates that the effectiveness of risk communication is strongly influenced by cultural values, language, literacy, message framing, trust in information sources, and the credibility of messengers. Tailored, culturally sensitive communication strategies that incorporate local knowledge, participatory approaches, and trusted community networks consistently outperform standardized, one-size-fits-all messaging. The review further examines communication requirements across natural disasters, technological and industrial accidents, and public health emergencies, emphasizing the importance of hazard-specific messaging and adaptive communication channels. Mass media, digital platforms, interpersonal networks, visual communication, and plain language each play complementary roles in disseminating timely and accessible information while countering misinformation. The paper also discusses approaches for evaluating communication effectiveness, including experimental and observational studies, behavioral metrics, and equity-focused assessments. Cross-cultural case studies provide valuable lessons regarding successful communication practices and persistent implementation challenges. Finally, the review identifies research gaps related to standardized evaluation methods, culturally responsive communication models, and cross-hazard comparative analyses. Strengthening institutional preparedness, cross-sector collaboration, community participation, and evidence-informed communication strategies will enhance disaster resilience, reduce vulnerability, and improve public decision-making across diverse populations and hazard environments.

Keywords: Disaster Risk Communication, Risk Perception, Community Engagement, Disaster Preparedness and Cultural Context.

INTRODUCTION

Disasters are occurring with greater frequency and intensity, exposing populations increasingly vulnerable to their detrimental effects [1]. Climate change-related stresses, migration, rural-urban links in developing economies and geophysical shifts are just a few factors amplifying the risks associated with natural hazards. Technological disasters, man-made accidents, public health incidents, pandemic threats and other anthropogenic crises compound exposure to harms from biophysical hazards and climate extremes [2]. To communicate risks effectively, societies depend on institutions charged with managing these threats [3]. Communication scholars and emergency management professionals advocate the central importance of risk communication for disaster preparedness, management and contingency planning in diverse languages and cultural contexts. Marris cautions that during hazard events, there is an inherent difficulty in transmitting risk information, namely because of the presumed complexity of risks associated and the lack of trust in hazard organizers or agencies responsible for disseminating such data [4].

Evidence suggests, moreover, that cultural differences complicate risk-perception processes. The assumption of a universal framework for disaster-related information sharing within a risk hazard contingency cycle may proceed precisely because widely applicable strategies continue to be advocated by social scientific specialists, in the risk communication field especially [1]. Risk communication constitutes an exchange of information and opinions concerning hazards involving human and social populations and institutions exposed to dangers from incidents emerging from, but not limited to, natural calamities [2]. Flexible risk-communication plans govern the transmission of alerts about, or warnings given, when hazards are imminent, impending, speculative or newly emerging from entities already damaging human environments, economies and societies. Such plans aim to inform all stakeholders about the situation and, if necessary, trigger and guide suitable preventive, precautionary and preparedness initiatives [2].

Theoretical Foundations of Disaster Risk Communication

Disaster risk communication is defined as a two-way exchange of information regarding the threat with those at risk [3]. It involves disclosing the risk assessment, early warning, crisis communication, and post-disaster communication; building trust between experts and affected communities; and promoting public engagement and behavior change [2]. The literature indicates a growing recognition of the importance of establishing robust communication systems, yet many of the practical aspects still remain unaddressed. The written text “Engaging Communities in Emergency Risk and Crisis Communication” reviews a number of systematic reviews and primary studies investigating community engagement in emergency risk communication [4]. It determines the activities and contextual factors that foster community engagement. It emphasizes the importance of tailored approaches and community-specific messages that address the particular background, capacities, expectations, and culture of the affected population. Participation also influences risk perception and shapes responses [5]. Disaster and emergency risk and crisis communication are influenced by culture and specific local contexts. The “Engaging Communities in Emergency Risk and Crisis Communication” prepared by Margaret Novak and co-authors reports that place-based, informal, and community-oriented communication that accommodates the immediate cultural and socio-political environment is critical for enhancing disaster resilience [6]. Local context including the characteristics of vulnerable and marginalized populations, established social networks, institutions, and cultural traits can either facilitate or hinder communication [7]. Since disasters strike locally, disaster risk communication must consider local contexts throughout all phases of preparation and response. Recent studies indicate that the integration of community engagement into risk communication strategies improves disaster response and resilience around the globe [1].

Risk Perception and Cultural Context

The consequences of disasters, epidemiological emergencies, and accidents are felt by a growing percentage of the world’s population [8]. Environmental changes, increasing urbanization, and climate change drive up the stakes. The consequence of these global events has lifted the profile of risk communication. This is particularly true across the Mediterranean where earthquakes and floods endanger lives [9]. Risk perception how individuals and communities receive and interpret hazard information affects communication systems and strategies [10]. Studies across cultures demonstrate the importance of embedding messages in local contexts, language, or dialects. Every group adopts different information consumption styles: some scrutinize each piece of information, others focus only on headlines. Norms mould hazard perception and influence protective behaviour; for some, structural damage alone indicates danger while for others population safety remains paramount [11]. Trust in authorities, recognised spokespersons, and media shapes how communities consider and consume information. Need for personal-touch interactions increases when trust wanes. The more localized the channel and message, the greater the likelihood of gathering information from diverse sources and acting on available warnings [3].

Communication Theories in Hazards

Disaster risk communication is critical to mitigate adverse impact of hazards, yet communication theory remains under-applied within emergency risks [4]. Communication theorists have long noted that a large part of an individual’s risk perception is shaped by cultural, social, and political factors [5]. Their studies identified a broad range of communication principles and strategies that, although developed independently of emergency risks, have been successfully adapted. Key insights on those principles and approaches, particularly from the social diffusion, health, and security domains, are summarized [1] within this section together with insights [2] from the risk-subject literature 4. None are optimal for all countries or hazards since the socio-political dynamics of each specific situation and audience remain paramount. Such a basic articulation within a specific cultural and hazard context represents a vital step before detailed planning. Each theory-based communication principle specified within the following paragraphs describes particular processes or aspects of such a macro-level articulation [5]. Communication theorists identify three types of information exchanged in response to emergencies: hazard exposure, risk reduction measures, and collective action opportunities [6]. The last type has been shown to be particularly relevant to natural disasters. Initiating or perceiving a risk action prompts individuals to seek supplementary information on the hazard and its mitigation. When the requested details are scarce or non-existent, people generally turn to other risk actions since safe-guarding one’s wellbeing takes priority [7].

Risk Communication across Cultures

The process of risk communication varies considerably across cultures. These variations arise from differences in language, literacy, norms, attitudes, preferences, practices, and beliefs that manifest in diverse ways [8]. To be successful, risk-communication strategies must account for such distinct characteristics. In this regard, maintaining a focus on the social and cultural dimensions of risk remains essential for establishing strategies and approaches that are both effective and ethical in planning, response, recovery, and mitigation [2]. The role of language, literacy, and message framing in communication has received attention in many contexts. Language is the primary means by which individuals express themselves and interact; it is also through words that individuals acquire their view of the world [9]. Concepts of risk are embedded in language, which means that different cultures employ different constructs, either explicitly or implicitly [10]. The specific cultural context shapes how messages are coded and decoded. Individuals living in an English-speaking culture may receive important alerts about hazards such as tsunamis, earthquakes, or tornadoes, yet still lack comprehension of the information being conveyed and the degree of danger being communicated, leading to tragedy [1, 5].

Language, Literacy, and Message Framing

The linguistic context surrounding disasters remains understudied, especially outside the English-speaking world. A wealth of scholarship, particularly in Japan, examines the deeper meanings expressed by the Japanese *chû kanji*, and although some phonetic languages, such as Thai and Chinese, remain based primarily on characters, only a fraction of research focuses on how the written language relates to hazard awareness and communicative expectations [6]. Word choices create different understandings of threatening events, and whether “quakes” (the slight shifts that precede collapse) or “disasters” (the full-blown breakdown of normality) are used can change how the populace assesses an incoming danger [7]. Early learning materials emphasize evacuation for children; educational recommendations for adults stress retention and proper anticipatory behaviour in the time remaining. Formal certificates of proficiency in literacy remain privileges in some cultures. Literacy entails being able to read the print, or glyphs, on safety materials [8]. It also involves being socialized in how documents function. Training supports comprehension of risk communications on websites, pamphlets, and warning labels. Safety instruction frequently integrates literacy practice, yet remains outside research agendas. People educated in lower-teaching-syllable languages, such as Chinese, can attain higher proficiency faster than those educated within wordier languages, like French or German [9]. Among the six major languages employed in Africa, one-third are syllable-based. Therefore, the developmental and pedagogical implications of choice of written language and teaching system receive excessive attention and meanwhile neglect important regional variations within. Although men still enjoy more schooling globally and school affiliation usually shapes communicative competencies, gendered patterns too can vary regionally [10]. Local variations may be even greater in areas like Asia, where some countries enjoy far greater socio-political and communicative stability than others, and the diverse content learned frequently differs around the globe. A distinction exists between hearing sounds and meaning them [11]. Similarly, phonetic languages differ in how (or if) participants ponder, think, or translate aloud, both collectively and individually. Participatory approaches like storytelling consider the audience by engaging them in the very construction of knowledge, allowing them to embody its lessons, and closely connecting to pre-existing frames and experience [1]. Also called co-constructed narratives or adaptive tales, these sequences incorporate components such as inciting events (the hazard), expectation of normality (happiness), and reactive steps (survival techniques). Timelier points often get told [2]. Additional reinforcement may arise through songs or riddles about survival options and decisions taken, coupled with appropriate local signposting or iconography. Use of the mother tongue, locally-dominant language, or a second widely used internationally demonstrates respect and encourages receptivity [1].

Trust, Credibility, and Messenger Effects

Trust in information, its source, and the credibility of those who deliver it, constitute pivotal factors in the dissemination of risk messages particularly for multi-hazard environments where diverse cultural communities perceive risks differently [6]. Empirical evidence shows that trust in individual information sources varies in the wake of specific large-scale hazardous events [4]. Furthermore, unsolicited messenger recommendations from friends or family are often influential in the decision to use commercial messaging and browser tools designed to limit online tracking [6]. Models for mathematics disaster education that substantively explain risks improve the quality of social networks and increase the confidence of users seeking relevant disaster information [7]. A regularly maintained set of supporting materials that project the personal style of the principal investigator and the culture of a research community therefore strengthens proposals and informs reviewers about the collectivity engaged [7]. Following a major urban earthquake, the recommendations of trusted authorities have been shown to significantly increase individual-level recommendations on emergency behaviours in the same distress domain, indicating broader community refraction of influence across social networks [8].

Community Engagement and Participatory Approaches

Community engagement is a core element of emergency risk communication. Active participation through discussion, open forums, educational presentations, and household mapping of evacuation routes is beneficial [1].

The mobilization of trusted community member such as health-care providers and local leaders fosters coordination and enhances trust [2]. A focus on the local context during all phases of emergencies is vital. Individual preparedness and response are influenced by risk perception; thus, communication is more effective when messages target specific audiences and are delivered through multiple channels [3]. Access to required resources and technology affects both participation and response capacities. Most studies in the review focused on a wide range of events, particularly flooding [4].

Hazard-Specific Communication Considerations

Changes in public behaviour during emergencies are strongly related to the character of the hazard. Different communicative approaches are consequently necessary for different degrees of urgency and kinds of action required [4]. Agents must consider specific public behaviours and adopt different modes of action according to the chemical hazard, biological hazard, natural disaster, or other relevant situations [5]. The following sections summarise the hazard-specific concerns regarding the dissemination of risk communication messages surrounding technological, natural, or public health emergencies [2]

Natural Hazards

Natural hazards pose significant threats to human life, property, and ecosystems. Earthquakes, cyclones, floods, droughts, landslides, tsunamis, and volcanic eruptions result in considerable economic loss, extra-ordinary fatalities, disability, and homelessness [3]. Formulating a suitable disaster risk communication strategy thus remains important. Information is needed regarding the hazard, its probability, timing, location, duration, intensity, and potential effects; the incident or meteorological conditions controlling the hazard should also be considered for effective planning [4]. When earthquakes occur, warning alerts can be transmitted in the form of electromagnetic signals conveying information on the impending earthquake. Data on earthquake magnitude and expected damage can also be disseminated via electronic media like television radio; or fax. Hazard susceptibility maps, inundation maps, flash flood maps, vulnerable area maps, tsunami hazard maps, rain-gauge maps, and rainfall prediction maps are widely employed for communication [5]. Through various forms, natural hazard risk can severely affect vulnerable settings and mar economic growth [2]. Common areas of awareness for risk communication also remain important to ensure the interpretation of the hazard, understanding probable vulnerabilities, and recognizing community-based coping strategies to manage the hazard. Understanding risk communication strategies remains essential for consistency between key information, the local context, and messaging [1].

Technological and Industrial Hazards

Technological and industrial hazards, including the accidental release of highly hazardous substances from industrial activities, can have a profound impact on human life and environmental integrity, as evidenced by major industrial accidents around the globe [2]. While technologically induced hazards differ fundamentally from natural hazards, there are parallels in risk communication [3]. On the one hand, the hazard itself is part of the culture of socio-economic life and development; on the other hand, risk messages may be subject to cultural effects [8]. The major global climate change event and associated challenges, such as rise in sea-level and flooding events, have increasingly attracted the attention of various levels of governments. A case study analysis of flood-induced technology risk messages during ongoing tropical cyclones in Bangladesh reveals that these messages carried useful information and guidelines for mitigating flood disaster among coastal and nearby riverbank communities[9].The effectiveness of risk-communication messages, however, varies across communities with differing socio-economic status and geographical settings [2]. Messages disseminated through formal communication channels, such as newspapers and the internet, reach the attention of educated elites and affluent classes, whereas less-educated and rural-population groups remain uninformed or poorly guided [1]. Effective communication, therefore, needs to address the entire population, particularly uneducated groups [1].

Public Health Emergencies

When reporting risk and protective measures, it is necessary to take into account that pandemic scenarios differ across locations and over time, and that socioeconomic and sociocultural contexts also affect the salience of specific messages [1]. Individualistic or collectivist attitudes, for instance, influence the relevance of one's own behavior (self-hygiene) and of that of others (social distancing) in various communities [2]. Message framing should, therefore, reflect cultural values. "We protect and save ourselves" resonates with people who favor individualism, while "Protecting others saves us" aligns better with a collectivist worldview. Communities with greater trust in the government seem to increase adherence to protective measures [3].

Channels and Formats for Effective Communication

Ample evidence demonstrates how channels and formats can confer greater communicative effectiveness [4, 5]. Mass media, digital platforms, and social networks can efficiently reach target populations at risk, and often provide a means for two-way communication that facilitates interaction and audience participation [6]. However, these channels proliferate misinformation. In addition to traditional and social media, localized communication channels are therefore essential to convey clear and trustworthy risk information [7]. Community organizations, educational institutions, and frontline workers constitute reliable sources of contextualized information, while interpersonal

communication between trusted individuals and community members often increases both the reach and receptivity of risk messages [8]. In addition to channel choice, format selection can strongly influence communicative effectiveness. The incorporation of visual communication can enhance reach and comprehension among diverse population segments, including visual learners and communities with low literacy levels [5]. Plain language simplifies messages, increases comprehension, and can help to transmit high-stakes information in time-constrained situations [6]. Adaptation lies at the heart of effective communication. Audiences, channels, and formats should be continually matched to changing levels of risk, urgency, culture, and hazard [5, 6].

Mass Media and Digital Platforms

Mass media and digital platforms play a critical role in risk communication, especially in crises where misinformation spreads rapidly via social media [7]. Effective communication requires coherence to prevent misinterpretation, which can lead to severe consequences. Global guidelines, such as those from WHO, inform national disaster management plans, as seen in India's case [8]. Addressing cultural differences is vital, as they influence how risks are interpreted and responses are made, yet often remain overlooked at both global and local levels. Integration of risk communication strategies across various levels and considering local cultural contexts are essential for effective disaster preparedness and response [2, 9]. Combining different media can improve the efficiency of information dissemination during disasters. Cell phones, SMS, microblogs, news portals, and TV are important in conventional disaster pre-warning due to their high effectiveness. During earthquakes, when network bases may be paralyzed, oral communication becomes crucial for emergency information [10]. Oral communication effectiveness depends on source positioning; governments can optimize this to improve dissemination speed. TV is highly trusted and effective, especially in the evening. Governments should focus on TV to spread warning information during serious disasters [11]. Analyzing dissemination characteristics helps ensure warning information is delivered reliably and quickly, reducing casualties and property damage [9].

Localized and Interpersonal Channels

Effective disaster risk communication involves selecting appropriate channels that suit the distrusted communities. Localized or interpersonal channels, such as community-based organizations and local governmental agencies, are often preferred over mass media channels in crisis situations [1]. When risk communication messages are disseminated through trusted agencies or professionals, recipients are less likely to be skeptical of the content. In the case of earthquake risk communication in Japan, family remains a preferred recipient of emergency warnings even 20 years after the Great Hanshin earthquake [2]. In addition to the choice of channels, the contents of the messages need to reflect the culture, structures, and concerns of these communities [3]. For example, in the context of Covid-19, Hong Kong government messages emphasized physical distancing and the wearing of masks because travel was an important part of local culture, while in the UK, avoiding family gatherings, an issue of less concern, was prioritized in government announcements [4]. Therefore, risk communication strategies and local channel options should be tailored to identify trusted agencies, stakeholders, and focal concerns in actual situations [2]. Filling the gap between scientific knowledge and culturally sensitive communication models requires the collaboration of practitioners and researchers across different fields of expertise [5]. Messages prepared on an ad-hoc basis may lack co-ordination across sectors, making it difficult to establish effective communication networks. Emergency management policies emphasising allocation of pre-defined channels, focal issues, and perspective differences among sectors can facilitate the speedy preparation of effective risk communication messages [6]. Hazards are commonly associated with a range of concerns that differ across cultural communities and that can broadly be classified as economic, environmental, political, religious, or social. The relevant issues are further defined by risk-hazard combinations, and form focal points guiding communication strategies and specifying trusted channels and sources of expertise [7]. Emergency risk communication messages are characteristically of short duration and high uncertainty, necessitating clear, concise options on focal issues at the initial stage [4].

Visual Communication and plain Language

Visual communication and plain language represent crucial components of effective disaster-risk communication, as they enhance the rapid understanding of complex information and decision-making by targeted audiences [5]. Various scientific studies have reported the importance of visualisation methods in improving public comprehension of probabilistic weather forecasts and informing pre- and post-disaster decisions regarding natural hazards [6]. Designing visual communication tools, such as isotype charts, increases accessibility and usability by helping non-experts interpret information correctly, enhancing knowledge, and guiding decision-making [7]. The expression of uncertainty through coherent and intelligible representations, together with feedback characterising past events, also improves comprehension [8]. Cognition-oriented and credible technical guidance, grounded in an understanding of user cognition and psychological aspects, remains a necessary consideration, and the development of technical guidance based on rigorous analysis of behaviour during crises aligns with this objective [7].

Evaluation and Evidence-Based Practice

The effectiveness of disaster communication, defined as a two-way exchange of meaningful messages, can be evaluated on the basis of two broad criteria: first, whether or not the messages have been understood, and second,

whether or not the understanding results in preparedness and disaster risk reduction [8]. Different approaches can be used to assess the quality of communication in each dimension; evaluating the effects of the messages poses greater challenges [9]. Experimental studies are essential to determine the influence of specific disaster risk messages on target audiences regarding understanding and subsequent behaviour. The results enable assessment of; *inter alia*, the effectiveness of messages, messenger and media credibility, emotional reactions, and perceived responsibility and controllability [10]. Desirable challenges relate to issues of equity in interventions undertaken to prevent hazards. Experimental studies may also focus on methods of adapting risk messages to vulnerable groups, taking into account gender, age, disability and literacy concerns [11]. Where consideration of vulnerable groups is impracticable, vulnerable areas could be prioritised [10].

Metrics for Effectiveness

Communication is considered effective when it produces intended change. Defining, measuring, and interpreting change clarifying which changes are important or desirable, for whom, and over what timeframe poses challenge and complication [1]. Some changes happen immediately, such as on-the-spot information acquisition and attitudes towards an event. Other changes often depend on previous ones [2]. For example, disaster risk decisions like evacuation depend on awareness of a hazard and its consequences [1]. Changes can occur in different areas including awareness, understanding, knowledge, perception of effectiveness, concern, trust, motivation for action, and ultimately action [3]. The more dense the cross-relationships across areas, the more possible the notion of communication-induced change. The temporal pattern might differ from one area to another [8].

Experimental and Observational Studies

Experimental and observational studies on risk communication offer insights into the effectiveness of specific practices and are represented in two systematic reviews since 2009 that focus on largescale emergencies and disaster communication [4]. The first addresses interventions rigorously, identifying 43 experiments with increasing frequency across a range of hazards [5]. Recommendations call for clear, low-ambiguity language; careful evaluation of message frequency; use of entertainment media; low-explicitness framing; social-deliberation procedures; person-based exemplars delivered visually; and computer simulations [6]. The second review includes observational studies to investigate the determinants of a wider array of communication practices across diverse incidents and locations, emphasizing the role of metadata in study design [7]. This systematic review draws on a broader theoretical foundation, encompassing three risk-communication principles that serve for postincident improvement: attention to cultural frameworks; alignment with public interests; and connection to long-term consequences [8]. Specific recommendations highlighted the importance of threat interpretation, rather than mere hazard description; careful attention to media publications and usage; and frequent monitoring of the audience's evolving information mix [1].

Ethical and Equity Considerations

Disasters underscore the need for effective environmental risk communication that incorporates community values, needs, and concerns [4]. Communication is a two-way process. It shares information on local hazards, vulnerability, and exposure in a way that is clear and easy to understand [2]. Understanding how community context shapes risk communication enables deeper appreciation of citizen concerns. Contextualized communication, however, does not necessarily improve understanding among the least literate or those with limited access [5]. High-context messages lack breadth, yet convey the meaning necessary for making preliminary choices in situations of limited understanding and capability, such narrower sets of information are often required [1]. Hazard character and context affect civil society and citizen awareness of emergent risks. Programs promoting inclusivity and participation, therefore, must consider such differences and avoid overly broad and naïve assumptions about risk representation [3]. Emergency planners and communicators are obliged to reflect the broader scope of disaster preparedness and management. Risk-reduction strategies, communication campaigns, and hazard-reduction measures require emphasis. Avoiding ambiguous terms like awareness further restricts the scope of messages [4]. Beyond the inclusion of key characteristics that guide the design of communication materials across a wide spectrum of environmental hazards messages need to communicate far more basic information than is often assumed [6].

Policy Implications and Implementation

Understanding risk communication practices from various cultures and perspectives contributes valuable insights for more effective strategies [1]. Sociological and anthropological analyses of cultural effects on perception and behaviour indicate that policies and plans requiring collective responses under communal uncertainty benefit from much deeper consideration of multiple perspectives about hazards and risks. There is much to learn from the way India's extensive experience of hazardous transportation and industrial activity has influenced its framework for preparations and responses to chemical hazards [1]. Disparities in vulnerability between different populations under hazardous circumstances prompt examination of differential communication practices and political engagement. The regional character of many environmental hazards calls for cross-national learning centred on effective dissemination of opportunities for systematic comparative analysis [2]. The major observable differences between natural (including biological) phenomena and complex chemical and technological hazards highlight the need for sector-specific extractions from the vast literature available [6]. Organisational and participatory arrangements

through which the overall consideration of hazardous circumstances can be amplified, beyond the conventional boundaries of formal arrangements, permit development of systems for regulation and monitoring, training, and education involving multiple sectors, disciplines, and approaches, adapted by different countries to fit local circumstances and attributes [2]. Infrastructures for facilitation, mapping, and interactive systems enable hazards and related risks across a significant range of inland, coastal, and high-altitude environments to be brought together for consideration in diverse formative and responsive scenarios in which constituents of user-defined need and requirement can be amplified and institutional intelligibility preserved [7].

Institutional Preparedness

Preparedness for disasters remains a key challenge for national, local, institutional, and household entities worldwide. Strengthening adherence to scientifically established mitigation measures can likely reduce both the incidence and severity of disasters [8]. Specific evidence and recommendations concerning the degree to which institutions should maintain stocks of sanitizing agents (e.g., hand sanitizers, disinfectants) and personally protective equipment (e.g., face masks) reinforce preparedness for accidental environmental degradation and human disease emergence, as each either reduces the risk of contamination or mitigates the ensuing spread of infectious disease [1]. Conversely, flexibility is crucial since endemic agents can shift and require different preparedness measures. Such a strategy captures many of the recommendations made following the 1976 swine flu pandemic and again in the 2009 swine flu pandemic, where stocks of vaccines and antivirals, while seemingly optimal, turned out to be inappropriate for specific emergent activity [9]. One challenge of pandemic preparedness is maintaining the initial preplanned state when neither environmental degradation nor major infectious diseases are extant. Hence, institutional preparedness cycles akin to the well-established hazard cycle are useful, identifying windows for hazard-specific preparation, but relevant to each prevention, preparedness, response, and recovery cycle [10].

Cross-Sector Collaboration

Within the context of the Sendai Framework for Disaster Risk Reduction 2015 to 2030, there is an unprecedented need for coordinated efforts to reduce disaster risk and strengthen resilience across different sectors and disciplines [11]. Under the theme “Investing in Inclusive and Effective Disaster Risk Reduction”, the station “Designing for Disaster Risk Reduction” at the 2019 International Conference of the International Society for the Systems Sciences held in Cardiff, UK, focused on cross-sector collaboration and the generation of design knowledge to support disaster risk reduction initiatives [10]. The station was guided by the observation that communication has a fundamental role to play in disaster risk management and disaster risk reduction and that the ability to articulate and share what is known about a system has the potential to improve decision-making and action 5. The importance of cross-sector collaboration in disaster risk reduction underpinned the initiative [9]. Design contribute to enhance disaster risk communication through a better understanding of the topic and of what could be possible solutions, with an emphasis on collaboration across disciplines and with government, private sector, non-governmental organizations, and community [1]. A better design of disaster risk communication has to engage with all these stakeholders and design could help to identify and organize the different knowledge that each stakeholder have. Governance is crucial since it helps to make sure that everybody is included in the conversation [1].

Capacity Building and Training

Disaster risk communication training enhances skills in understanding, prevention, and mitigation, preparing stakeholders to effectively share information and engage communities during crises [11]. Multidisciplinary workshops strengthen hazard communication between science, engineering, policy, and affected users. Students develop messages using diverse methods while focusing on stakeholders’ languages, needs, and influencing factors [5].

Case Studies and Comparative Insights

Drawing from multiple case studies across geographic and cultural contexts, certain insights about the design and delivery of disaster risk communication emerge [5]. Effective dissemination of information and instructions during the 2011 Great East Japan Earthquake, the 2010–2011 flooding disaster in Bangkok, and the 2005 and 2011 earthquakes in Christchurch, illustrate how it is possible to provide information through multiple media while retaining clarity and maximal coverage; modifying content to account for intricate hazards; supporting feedback; and clarifying uncertainties using simple language [6]. Conversely, during the 2015 Mount Sinabung eruption hazard near Jakarta; the 2008 earthquake in Sichuan; and a dengue outbreak in Syangia, some provincial and municipal governments failed to use tailored information channels to reach priority flood-prone districts, let alone sought feedback on clarity, adequacy, and redundancies in the content already circulated [7]. Moreover, despite the international standardization of public health risk messaging following the H1N1 pandemic, ambiguity continues to mark pest outbreaks in Tuberous Sclerosis Complex 1 while increasingly complex strains of STDF are co-circulating [8]. Similarly, a comparative examination of communication practices across clean water safety events; localized, multi-hazard officer training; and mega-city flood situations in the National Capital Region (NCR) of Villa and Ottawa demonstrates how influencing community-level stakeholder action and minimizing the communication burden on person-to-person messengers remain major challenges [2]. Emergency response to the 1994 Latur

earthquake in India; the 2013 East Japan Earthquake and Tsunami; Guidance for Media Content on the July 2017 United States Famine Response; supply and population movement risk assessments; and real-time disaster supply tracking initiatives highlight the contrasting communication demands associated with engineering hazards such as earthquakes and transport hazard involving liquid chemical spill, collapse, or explosion [9]. Industrial systems operating at extreme temperatures or pressures, such as the monsoon rain driving canal overflow and inundation currently besetting Dhaka, assume a distinct role in the technology-hazard space; no fatalities have been reported following the derailment, and although contamination was never believed to threaten the extensive water supply network, concerns over long-distance provisions circulating via wholesale markets cannot be excluded [10]. Specialization studies further highlight the need for distinct information content to guide blockchain-based, on-demand fuel supply-risk, and domestic asset-risk management decisions [11].

Cross-Cultural Lessons from Recent Disasters

Time and again, major disasters have struck widely different communities around the world, and each time, careful review of these events has revealed important and often surprising lessons about the effectiveness of disaster communications [1]. From hurricanes in southern Florida to tsunamis on the shores of Indonesia, floods in North Korea to wildfires in Attica, Greece, a variety of communication practices and policies have been studied, with key findings concerning public risk perception, trust, message framing, and media usage emerging each time [2]. Most importantly, across all of these disparate incidents, 2 obvious general insights concerning the empowerment of communities and the strengthening of both horizontal and vertical networks have been consistently reinforced: citizen participation is critical for effective disaster communication, and bottom-up, community-oriented approaches are often more effective than those based on top-down, authority-centered models [1].

Comparative Analyses across Hazards

Cross-hazard comparisons of risk communication have occurred primarily for natural hazards (e.g., floods, tsunamis, earthquakes, volcanic eruptions, landslides, forest fires) and public health emergencies (e.g., HIV/AIDS, pandemic influenza, Ebola) [11]. Evidence-based meta-analyses are necessary to assess the degree of generalizability of communication recommendations across hazards, thereby reducing the burden on practitioners who currently seek relevant guidance in separate dissemination streams [2, 1].

CONCLUSION

Disaster risk communication is a cornerstone of effective disaster risk reduction, emergency management, and community resilience. The evidence reviewed demonstrates that successful communication extends beyond the simple transmission of hazard information to encompass trust building, public engagement, cultural sensitivity, and collaborative decision-making throughout the preparedness, response, recovery, and mitigation phases of disasters. As the frequency and complexity of natural hazards, technological accidents, and public health emergencies continue to increase, the need for evidence-based and culturally responsive communication strategies has become more critical than ever. The review highlights that risk perception is shaped by social, cultural, linguistic, political, and psychological factors that vary considerably across communities and hazard contexts. Consequently, communication strategies that acknowledge local languages, literacy levels, cultural values, and existing social networks are more effective in promoting protective behaviors and strengthening public confidence than standardized communication approaches. Trustworthy messengers, participatory communication, community engagement, and the integration of local knowledge consistently emerge as essential determinants of successful disaster communication. Evidence further indicates that no single communication channel or format is universally effective. Instead, combining mass media, digital technologies, interpersonal communication, community organizations, visual communication tools, and plain language messaging allows emergency information to reach diverse audiences while minimizing misunderstanding and misinformation. Hazard-specific communication strategies are equally important, as the information needs, urgency, and behavioral responses required during earthquakes, floods, industrial accidents, pandemics, and other emergencies differ substantially. Communication systems must therefore remain flexible, adaptive, and responsive to evolving risks and changing community needs.

Despite substantial advances in disaster risk communication, important challenges remain. Significant disparities persist in access to communication technologies, literacy, institutional trust, and emergency preparedness among vulnerable populations. In addition, standardized methods for evaluating communication effectiveness across cultures and hazard types remain underdeveloped. Future research should prioritize comparative cross-cultural studies, longitudinal evaluations, standardized performance indicators, and the development of communication models that better integrate behavioral science, local knowledge, and emerging digital technologies. Greater attention should also be given to combating misinformation, promoting equity in access to risk information, and strengthening communication with marginalized populations. Ultimately, effective disaster risk communication depends on sustained collaboration among governments, emergency management agencies, scientists, healthcare professionals, community organizations, educators, the private sector, and the public. By integrating scientific evidence with cultural understanding, strengthening institutional preparedness, investing in capacity building, and promoting inclusive, participatory communication systems, societies can improve disaster preparedness, reduce

vulnerability, enhance public trust, and build resilient communities capable of responding effectively to an increasingly complex risk environment.

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