D5.3

Guidelines on current risk communication for HILP

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Abstract

D5.3 reviews current risk communication frameworks, evidence and practices relevant to High-Impact, Low-Probability (HILP) events. It examines established models such as the CERC model and the Total Warning System, alongside communication standards, past-event evidence, cross-case analysis of sixteen HILP events, and psychosocial theories of risk perception and behaviour. The focus is on how communication can support preparedness, response, trust, protective action, recovery and learning before, during and after extreme events. The deliverable identifies key gaps and barriers for HILP risk communication. It proposes practical guidelines for clearer, more actionable, inclusive, coordinated and behaviourally informed communication, organised by preparedness, response, recovery and cross-cutting principles. Further refinement is foreseen with updated guidelines in D5.5.

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Nature of the deliverable[1]

R

Dissemination level

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[1] Deliverable types:
R: document, report (excluding periodic and final reports).
DEM: demonstrator, pilot, prototype, plan designs.
DEC: websites, patent filings, press and media actions, videos, etc.
OTHER: software, technical diagrams, etc.

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Abbreviations

Table 1. List of abbreviations.

Abbreviation	Full term
BBC	British Broadcasting Corporation
BfR	Bundesinstitut für Risikobewertung (German Federal Institute for Risk Assessment)
BOS	Behörden und Organisationen mit Sicherheitsaufgaben
BP	British Petroleum
BSL	British Sign Language
CDC	Centers for Disease Control and Prevention
CDOS	Comando Distrital de Operações de Socorro
CEN	European Committee for Standardization
CERC	Crisis and Emergency Risk Communication
CHMI	Czech Hydrometeorological Institute
COSMO	COVID-19 Snapshot Monitoring
COVID	Coronavirus Disease 2019
CPSM	Centro Previsioni e Segnalazioni Maree (Centre for Tide Prediction and Warning)
DCPEM	Icelandic Department of Civil Protection and Emergency Management
DWD	Deutscher Wetterdienst (German Meteorological Service)
ECMWF	European Centre for Medium-Range Weather Forecasts
EFI	Extreme Forecast Index
ENISA	European Union Agency for Cybersecurity
EPRR	Emergency, Preparedness, Resilience and Response
EU	European Union
FEMA	Federal Emergency Management Agency
FSA	Financial Services Authority
GCS	Government Communication Service
GFDRR	Global Facility for Disaster Reduction and Recovery
GNR	Guarda Nacional Republicana (Portuguese Guard)
GPS	Global Positioning System
GRUATA	Grupo de Resgate em Ambiente Agreste (Portuguese specialist rescue force)
HILP	High-Impact, Low-Probability
IES	Institute of Earth Sciences (Iceland)
ISO	International Organization for Standardization
JESIP	Joint Emergency Services Interoperability Principles
JRC	Joint Research Centre (European Commission)
KATWARN	Katastrophenwarnung (German warning app)
LFB	London Fire Brigade
NGO	Non-Governmental Organisation
NHC	National Hurricane Center
NHS	National Health Service
NINA	Notfall-Informations- und Nachrichten-App (German federal warning app)
NRW	North Rhine-Westphalia
NWS	National Weather Service
OECD	Organisation for Economic Co-operation and Development
P&I	Protection and Indemnity
PCO	Posto de Comando Operacional
PMA	Panama Maritime Authority
PTWC	Pacific Tsunami Warning Center

SADO	Sistema de Apoio à Decisão Operacional (Portuguese decision support system)
SAGE	Scientific Advisory Group for Emergencies
SCA	Suez Canal Authority
SIRESP	Sistema Integrado de Redes de Emergência e Segurança de Portugal
SPEEDI	System for Prediction of Environmental Emergency Dose Info
UNDP	United Nations Development Programme
UNDRR	United Nations Office for Disaster Risk Reduction
WHO	World Health Organization
WMO	World Meteorological Organization

Executive summary

High-Impact, Low-Probability (HILP) events pose particular challenges for risk communication because they are rare, uncertain and often difficult for people to relate to before they occur. Effective communication must therefore do more than provide information: it must support understanding, preparedness, protective action and recovery before, during and after an event. This deliverable reviews evidence from risk perception, risk and crisis communication, warning systems and case studies of HILP and HILP-like events. The findings show that people do not perceive all HILPs in the same way. Judgements are shaped by factors such as familiarity, dread, controllability, trust, social norms and previous experience. Awareness alone is rarely sufficient to generate preparedness or action. The review highlights that communication is most effective when it is treated as a continuous process rather than an emergency function. Preparedness communication should build trust, risk literacy and practical capacity before a crisis. During an event, communication should support rapid understanding and protective action under uncertainty. Recovery communication should continue after the emergency, supporting accountability, learning and future preparedness. The analysis identifies recurring challenges, including uncertainty, fragmented responsibilities, weak translation of technical information into public action, limited local adaptation, misinformation, unequal capacity to act and insufficient engagement with communities. It also shows that communities are active participants in communication and preparedness, not simply recipients of warnings. In HILP events, where official channels may be overloaded or unavailable, communities play a particularly critical role: passing information to those who have not received it, surfacing local needs and risks, supporting vulnerable people, and serving as trusted sources on the ground. Based on these findings, the deliverable proposes guidelines for preparedness, response and recovery communication. Key recommendations include communicating early and transparently, using impact-based messages, engaging communities as active participants, identifying vulnerable groups, relying on trusted messengers, using multiple communication channels and embedding communication within broader risk governance and preparedness activities. Overall, the deliverable concludes that effective HILP risk communication must be proactive, evidence-informed, locally relevant and action-oriented. Its goal is to help institutions and communities move from awareness to preparedness, from warning to protective action, and from recovery to learning.

1. Introduction

High-Impact, Low-Probability (HILP) events are difficult to communicate about because they combine two features that create different but related challenges: they are unlikely or difficult to anticipate, but their impacts can be severe if they occur. These events may include natural hazards, technological accidents, public health emergencies, infrastructure disruptions, cyber incidents, financial crises, cascading disasters and compound events. They may unfold quickly or slowly, be visible or invisible, remain local or cross borders, and affect different groups in unequal ways.

These two features — low probability and high impact — are what make HILP events particularly hard to communicate about. The Tōhoku Triple Disaster in 2011, triggered by the Great East Japan Earthquake, illustrates this well. The earthquake itself was a low-probability, high-impact event; it then triggered a tsunami that killed nearly 20,000 people, which in turn caused the Fukushima Daiichi nuclear accident, triggering the evacuation of over 150,000 people and a prolonged nuclear emergency. Each hazard activated the next, compounding uncertainty, disrupting infrastructure and overwhelming communication systems in sequence. This cascading structure — where the initial event is not the full extent of the risk — is a defining feature of HILPs and one of the central challenges for risk communication.

For AGILE, **HILP risk communication** is not understood as the simple transmission of information from authorities or experts to the public. Risk communication is intended to provide people and organisations with information that helps them make informed judgements and take appropriate action to protect health, safety, livelihoods, infrastructure and the environment. In the HILP context, this means that **communication must be meaningful, understandable and actionable** – and actually reach people. In severe HILP events, the infrastructure on which communication depends may itself be disrupted: blackouts, cyberattacks or cascading infrastructure failures can render electricity, internet and mobile networks unavailable precisely when warnings are most critical. Communication planning must therefore include backup, local and low-technology channels that can function when primary systems fail. Beyond channel resilience, it must also address cascading impacts, uncertainty, vulnerable groups, trust, interagency alignment, public inclusion in information gathering and cross-border coordination.

HILP events raise **specific communication problems before, during and after crises**. Before an event, their rarity and low familiarity can make them feel abstract, distant or implausible, reducing preparedness and political attention. During an event, uncertainty, time pressure, conflicting cues, institutional fragmentation and high consequences can create confusion and urgent information needs. After an event, affected publics still need information about safety, services, accountability, recovery, residual risks and future preparedness. Communication should therefore be understood as a **continuous cycle** across preparedness, response, recovery, evaluation and learning, rather than as a message issued only during an emergency.

Moreover, **different moments in this cycle require different kinds of communication**: a message designed to raise awareness of a developing situation is not the same as one issuing an immediate protective action instruction, and neither is the same as one supporting recovery decisions after the acute phase has passed. Clarity about what a message is intended to achieve, and for whom, is as important as clarity about the hazard itself.

In this context, the present deliverable reviews current risk communication frameworks, evidence and practices relevant to HILP events. It brings together psychosocial theories of judgement, risk perception and behaviour; risk and crisis communication evidence; public warning standards and guidance; integrating models such as the Crisis and Emergency Risk Communication (CERC) model and the Total Warning System; and case-study evidence from past HILP and HILP-like events. The aim is to identify what is known, where gaps and barriers remain, and what practical

guidelines can support clearer, more actionable, inclusive, coordinated and behaviourally informed communication.

The deliverable therefore serves two complementary purposes: it provides a **theoretical and empirical foundation** for understanding how and why risk communication succeeds or fails in HILP contexts; and it **translates that foundation into practical guidelines** for communicators, institutions and policymakers.

The communication principles proposed apply across the full range of HILP event types covered in this review — natural hazards, technological accidents, public health emergencies, cyber incidents, infrastructure disruptions, financial crises, cascading disasters and compound events. They are designed as **cross-cutting principles** that require contextual adaptation (considering also the type of event and its phase), rather than hazard-specific prescriptions.

D5.3 is closely connected to two companion deliverables within WP5: D5.1 (Evidence-Based Planning for HILP and Toolkit), which addresses evidence-based planning and includes a Layered Communication Planning Tool (Tool 4), and D5.2 (Strategic Capacity Development for HILP), which develops a competency framework and pilot training architecture for HILP preparedness, including a dedicated communicative competency domain and a module on communication under degraded conditions.

The present deliverable is structured as follows. Chapter 2 reviews the foundations of HILP risk perception and risk communication evidence. It first examines why HILPs are difficult to judge and perceive, then reviews communication evidence across preparedness, response and recovery. Chapter 3 discusses two integrating models, CERC and the Total Warning System, explaining what they add to HILP risk communication. Chapter 4 presents the HILP case-study evidence and cross-case findings, including recurring communication failures, enabling conditions and case-derived recommendations. Chapter 5 synthesises the main evidence gaps and practical barriers identified across the review and case studies. Chapter 6 translates these findings into practical guidelines for HILP risk communication, organised by preparedness, response, recovery and cross-cutting principles. Chapter 7 concludes the deliverable and identifies next steps.

The purpose of D5.3 is therefore not to provide a final universal model for all HILP communication. **HILP events are too diverse, uncertain and context-dependent for a single communication formula**. Instead, the deliverable provides an **evidence-based and practice-oriented foundation** for improving communication across different hazards, phases, actors and communities. Its central argument is that effective HILP risk communication is not simply more communication. It is communication that is prepared in advance; designed for a clear purpose; matched to the type of event, the audience that needs to act, and what that audience is being asked to do; trusted; locally adapted; coordinated; transparent about uncertainty; inclusive of vulnerable groups; and evaluated by whether it enables understanding and protective action.

2. Foundations: risk perception and risk communication evidence

2.1. Risk Perception of HILP events

High-impact low-probability events (HILPs) combine two challenging features: they are unlikely to happen, but if they do happen, their consequences can be very serious. Both features matter for how people judge, perceive and respond to these events.

In this section, **judgement** means the way people form beliefs or estimates about a risk, for example how likely it is or how severe its consequences might be. **Risk perception** is broader. It includes judgements of likelihood and severity, but also how a risk feels to people: whether it seems frightening, unfamiliar, uncontrollable, unfair or difficult to understand. **Decision-making** refers to the choices people make based on these judgements and perceptions, together with their goals, values and preferences. This chapter reviews theories and evidence that can help explain how people think about and respond to HILPs. It also highlights where theories may be stretched by the rarity, uncertainty and scale of many HILP events.

2.1.1. Judgment of HILPs

People often need to judge a risk before they act on it. In other words, the decision-making process already starts with the judgment of HILPs. They may need to judge and decide whether a risk is likely enough, plausible enough or severe enough to require attention. For example, people may ask themselves: *how likely is flooding tomorrow? How severe would an earthquake be if it happened next week? Is this risk serious enough to prepare for?*

Early models of judgement and decision-making often assumed that people make highly rational decisions based on careful assessment of all available information. However, Simon argued that this is often unrealistic. People usually have limited time, limited information and limited mental capacity. Instead of finding the perfect option, they often look for an option that is "good enough" for their needs. This is known as "satisficing" and is part of the idea of **bounded rationality** (Simon, 1955, 1956, 1957). Tversky and Kahneman later showed that people often use mental shortcuts, or **heuristics**, when making judgements under uncertainty. These shortcuts can be useful because they help people make decisions quickly. However, they can also lead to predictable errors or biases (Tversky & Kahneman, 1974). Although this work was not developed only for risk, it is highly relevant because people often rely on these shortcuts when judging uncertain risks. HILPs are especially difficult to judge because they combine two features that are hard for people to process: low probabilities and large impacts. These are discussed below.

Judgement of low probabilities

People often struggle to interpret the very low probabilities that characterise HILPs (Camerer & Kunreuther, 1989; Sundh, 2024). The same low probability can be understood differently depending on how it is presented (Halpern et al., 1989). For example, people often judge and respond differently to a risk described as "1 in 10,000" compared with the same risk described as "0.01%". Low-probability risks can also produce very different reactions. In some cases, people treat them as negligible and effectively ignore them. In other cases, people give them much more weight than the probability itself would suggest (McClelland et al., 1990). This matters for HILPs because they may be either neglected or overestimated, depending on how people understand and experience them. Judgements of HILP likelihood may be shaped by how people interpret the probability itself, but also by other features of the event – for example, a risk with vivid or frightening consequences may feel more likely simply because it is easier to imagine.

Availability heuristic

The **availability heuristic** refers to the tendency to judge the likelihood or frequency of an event by **how easily examples come to mind** (Tversky & Kahneman, 1973). If an event is easy to remember or imagine, people may judge it as more likely. If it is hard to picture or has not been discussed much, people may judge it as less likely.

Experience can make a risk more available. This may be direct experience, such as living through a flood, or indirect experience, such as hearing about an event through family, friends, social networks or the media. Events that are vivid, dramatic or emotionally powerful may also become more memorable and therefore feel more likely (Lichtenstein et al., 1978).

For HILPs, this means that events with **vivid and memorable examples may be judged as more likely than events that are abstract or difficult to imagine**. For example, events such as 9/11, Chernobyl or the Fukushima Daiichi nuclear disaster may be more mentally available because they are associated with strong images, narratives and collective memory. In the case of Chernobyl, the accident's place in collective memory was shaped not only by its scale but by the failure of communication itself: information was suppressed for days, the true extent of the danger was minimised, and the global community only learned of the accident after three days. The secrecy, the delayed evacuation and the eventual loss of control over the narrative made Chernobyl a defining and mentally available example of HILP communication failure. By contrast, systemic risks with slow, diffuse or cascading consequences may feel less likely because they are harder to visualise and are not associated with these vivid images or strong narratives and collective memories.

There is evidence that people's judgements of rare but serious hazards are shaped in ways that are relevant to availability. Lichtenstein et al. found that people tended to overestimate rare causes of death and underestimate common causes of death (Lichtenstein et al., 1978). This pattern was later replicated by Granger Morgan et al. (Granger Morgan et al., 1983). Lichtenstein et al. also found that vivid and dramatic causes were judged as more frequent than less dramatic causes with similar objective frequencies. Combs and Slovic showed that dramatic causes of death were overrepresented in media coverage, while more common disease-related causes were underrepresented. They also found that **people's judgements of frequency were more closely related to media coverage** than to objective mortality statistics. However, they treated availability as a possible explanation rather than proving causality directly, and they noted that their evidence was correlational (Combs & Slovic, 1979).

More recent work adds an important qualification. It suggests that personal experience and experience through one's social network may be more important than media exposure alone when people judge risk frequency (Hertwig et al., 2005; Pachur et al., 2012). Pachur (2024) reanalysed the original Lichtenstein and Combs datasets, alongside later datasets. The finding that dramatic events receive more media coverage was supported, but the finding that vivid and dramatic causes are consistently judged as more frequent than less dramatic causes did not reliably hold beyond the original dataset. Pachur also suggested that people may rely more on examples from their own social networks than on media coverage when judging risk frequency.

For HILPs, the key point is that **high-impact consequences can shape how likely or plausible an event feels**, especially when those consequences are vivid, concrete, emotionally powerful and easy to imagine. However, availability should not be reduced to media exposure alone. More recent evidence suggests that direct experience and socially mediated experience, including events affecting family, friends or wider social networks, may be particularly important in shaping judgements of rare risks.

At the same time, the evidence should be interpreted carefully. Much of the research on availability and risk perception was not designed specifically around HILP events. It often examines how people perceive hazards that are possible but unlikely, including people who have not directly experienced the event in question. This is different from research on the psychological consequences of disasters or attacks, such as 9/11, which typically focuses on people who were

directly or indirectly exposed and examines outcomes such as distress or post-traumatic stress. These are related but distinct questions: one concerns how rare risks are perceived before or at a distance from the event; the other concerns the psychological consequences of experiencing the event itself.

Therefore, risk perception research can help explain why some HILPs become mentally available, salient or feared, while others remain abstract or neglected. However, it should not be treated as direct evidence of the psychological impacts of HILP exposure, nor as a complete explanation of preparedness behaviour. More HILP-specific research is needed to understand how availability operates across different types of rare, high-impact events, and how direct experience, social experience, media coverage and collective memory interact over time.

Representativeness heuristic

The **representativeness heuristic** refers to the tendency to **judge the likelihood of something by how much it resembles a typical example of a category or process** (Kahneman & Tversky, 1972). In simple terms, if something looks like what people expect a disaster or crisis to look like, they may judge it as more likely. If it does not fit their mental image, they may judge it as less likely. This can lead to errors because people may focus too much on resemblance and too little on other important information, such as prior probability, sample size or randomness.

For HILPs, this suggests that events that fit people's idea of a "typical disaster" may be judged as more likely or plausible than their low probability would suggest. By contrast, HILPs that do not fit familiar disaster images may be judged as less likely. This may be especially relevant for systemic, slow-moving or cascading risks, where the path from cause to harm is unclear or difficult to picture.

There is another issue. Because HILPs are rare, people may base judgements on only a small number of examples. Representativeness may then lead them to treat those few examples as more informative than they really are. However, there is limited direct evidence on representativeness and HILP risk judgement specifically. These ideas should therefore be treated as plausible extensions of existing theory rather than as firmly established findings for HILPs.

Judgement of high impacts

The other defining feature of HILPs is that their potential impacts can be very large. People also struggle with this. Research suggests that, as numbers become very large, people become less sensitive to differences between them (Dehaene et al., 2008; Peters et al., 2008). In other words, very large numbers can start to feel similarly large, even when the difference between them is important. This can lead to **magnitude neglect**, where people do not fully distinguish between very large values. For example, people may not respond very differently to two loss estimates even if one is much larger than the other. Research suggests that presenting large values in more understandable units can sometimes improve sensitivity to the differences between them (Boyce-Jacino et al., 2022).

A related issue is **psychophysical numbing**. This refers to the tendency for each additional loss of life to feel less significant as the total number of lives at risk increases. Fetherstonhaugh et al. found that the same lifesaving intervention could be judged as less beneficial when the total number of people at risk was larger (Fetherstonhaugh et al., 1997). This does not mean people do not care. Rather, it suggests that people find it **difficult to emotionally and cognitively process very large losses**.

Magnitude neglect and psychophysical numbing are related but not identical. Magnitude neglect is about difficulty distinguishing very large numbers. Psychophysical numbing is about the reduced psychological impact of additional losses as the total scale of harm grows. For HILPs, both issues matter. If a scenario presents very large numbers of deaths, economic losses or displaced people, audiences may struggle to distinguish between different levels of impact. A much worse scenario may not feel proportionally worse. Similarly, at the scale of HILPs, increases

in human losses may not produce proportional increases in perceived seriousness or perceived benefit of prevention. These patterns may affect later decisions about preparedness and response.

Interim summary

Judging HILPs is difficult because they **combine very low probabilities with very large possible impacts**. Very low probabilities may be ignored in some cases but given too much weight in others, depending on how they are presented and how easy the event is to imagine. HILPs that are vivid, memorable, recently experienced or socially discussed may therefore feel more plausible than their objective likelihood suggests. More abstract, systemic or unfamiliar HILPs may fail to attract attention at all.

The high-impact side of HILPs creates a different challenge. Very large losses can be hard to compare, and additional losses may carry less psychological weight as the overall scale of harm increases. Together, these patterns suggest that both parts of the HILP definition — low probability and high impact — can make judgement difficult. If a HILP is not judged plausible, salient or serious enough, it may never meaningfully enter decision-making.

2.1.2. Risk perception of HILPs

Dread, unknown risk, affect and experience

The theories above help explain how people judge likelihood and severity. However, risk perception is not only about probability and impact. People also respond to the qualities of a risk: whether it feels frightening, unfamiliar, uncontrollable, unfair or catastrophic.

Early work on the **psychometric approach to risk perception** showed that people's views of risk are shaped by more than numbers. Fischhoff et al. examined how people rated hazards in terms of perceived risk, perceived benefit, acceptable risk and characteristics such as voluntariness, controllability, familiarity, dread, severity and catastrophic potential (Fischhoff et al., 1978). This work showed that each hazard has a particular profile of characteristics that shapes how risky and acceptable it seems (Fischhoff et al., 1978; Slovic & Weber, 2002). Later work showed that many of these characteristics can be grouped into broader dimensions. Two important dimensions are **dread risk** and **unknown risk** (Slovic, 1987; Slovic et al., 1984; Slovic & Weber, 2002).

Dread risk is linked to hazards that seem catastrophic, fatal, uncontrollable, involuntary or unfairly distributed. **Unknown risk** is linked to hazards that are new, unfamiliar, unobservable, poorly understood or delayed in their effects. Risks that score highly on these dimensions are often perceived as more serious or less acceptable, with dread often playing a particularly important role (Slovic, 1987).

This work also connects to research on **affect**, meaning the positive or negative feeling attached to something. People often use these feelings as a shortcut when judging risks and benefits. If something feels good, people tend to judge it as lower risk and higher benefit. If something feels bad, they tend to judge it as higher risk and lower benefit (Finucane et al., 2000; Slovic et al., 2002; Slovic & Peters, 2006). This is known as the **affect heuristic**. Dread is closely linked to affect. A dreaded hazard usually produces strong negative feelings, and these feelings may then shape how people judge the risk. This means that risk perception is not only an analytical process. It is also **emotional and experiential**.

Experience can shape these feelings. Damasio's somatic marker hypothesis suggests that past experiences can attach positive or negative bodily and emotional signals to particular situations or choices (Damasio, 1994; Damasio et al., 1996). Later, when people encounter something similar, these signals can help mark it as dangerous or safe. The affect heuristic draws on this idea: f**eelings attached to a hazard can guide risk judgements** without people needing to analyse all the details.

However, experience does not affect risk perception in only one direction. A strongly negative experience can make a risk feel more serious later. A benign experience, or repeated non-experience, can make a risk feel less threatening. At the same time, a lack of experience can also make a risk feel more unknown, which may increase concern. There are also questions about cause and effect: affect can shape risk perception, but risk perception can also generate affect. Some evidence suggests the relationship goes both ways (Siegrist & Árvai, 2020; van der Linden, 2014).

Evidence from several areas supports the **importance of experience**. Personal experience with extreme weather has been associated with higher risk perceptions of climate change, and direct experience with COVID-19 has been associated with higher risk perception of COVID-19 (Dryhurst et al., 2020; van der Linden, 2015). Experience may be direct, but it may also come indirectly through friends, family, social networks, media or public discussion.

For HILPs, this means that **perception is shaped not only by judgements of low probability and high impact, but also by whether the event feels dreaded, unknown or emotionally powerful**. Many HILPs may have features associated with dread risk: they may seem catastrophic, uncontrollable or involuntary. These qualities may increase perceived risk, especially where they produce fear or concern.

The low-probability nature of HILPs also matters. Because these events are rare, many people may have little or no experience of them. This can make them **feel unfamiliar, poorly understood or unobservable, placing them higher on the unknown risk dimension**. This may increase perceived risk. However, rarity can also work in the opposite direction. If a HILP feels **abstract, distant or difficult to imagine, it may carry little emotional weight and may therefore be perceived as less risky**.

HILPs should therefore not be expected to produce one single pattern of risk perception. Some, such as nuclear accidents, terrorist attacks or pandemics, may be vivid, symbolically powerful and emotionally charged through media coverage, social discussion and collective memory. Others, especially systemic, cascading, slow-developing or highly technical risks, may be harder to imagine and may not generate strong concern.

Risk perception can also change over time. Disaster risk communication research suggests that memory of past events can fade. Risk awareness may decline as time passes since the last event, sometimes described as the “half-time of oblivion” (Hagemeier-Klose & Wagner, 2009). This matters for rare events because long periods without an event can make the risk feel less salient.

Terrorism illustrates this complexity. Sjöberg (2005) found that dread was positively associated with perceived terrorism risk in a Swedish sample, while unfamiliarity was not. Yet overall concern remained relatively low and appeared to decline following 9/11 — consistent with the fading of salience over time discussed above. This suggests that even for threats that score high on dread, **perceived risk is shaped by timing, social context and memory, not by hazard characteristics alone**. Affect associated with HILPs may therefore shift considerably: within the same hazard, concern may spike after a major event or near miss and diminish as the event recedes. This creates a particular challenge for rare, high-consequence risks: they may be perceived as deeply threatening when imagined yet remain cognitively distant in everyday life precisely because they occur so rarely. Low probability and low familiarity can suppress perceived risk even for events that, when made salient, generate strong dread.

Lastly, cultural values and worldviews can also shape how people interpret risk, although the evidence is less direct for HILP events. Cultural approaches argue that risk perception is influenced not only by individual psychology, but also by **values, social organisation, trust in authority and group identity** (Douglas, 1970; Douglas & Wildavsky, 1982). Early cultural theory and later cultural cognition research suggest that people may perceive risks differently depending on whether a risk, or the proposed response to it, aligns with or threatens their group values

(Dake, 1992; Kahan, 2012). However, empirical effects vary across hazards, countries and measures, and some studies find that cultural worldview measures explain only a limited share of variation in risk judgements (Sjöberg, 1998; Xue et al., 2014; Johnson & Swedlow, 2021). The practical implication is therefore not to classify audiences rigidly into cultural types, but to recognise that messages about collective action, regulation, institutional responsibility or cross-border coordination may be interpreted differently across social and cultural contexts. Communication should therefore be **culturally adapted, locally tested and attentive to trust, values and group identity**.

Social amplification of risk

The social amplification of risk framework explains how risks can become more or less prominent as information moves through society (Kasperson et al., 1988, 2022; Pidgeon et al., 2003). Risk information does not travel unchanged: it is interpreted, repeated, contested, or downplayed by individuals, experts, institutions, media, social media platforms, and social networks. Through these processes, a risk may be **amplified**, becoming more visible, concerning, or politically important, or **attenuated**, receiving less attention than expected.

Within this framework, hazards and risk events generate "signals", such as direct experience, official warnings, expert reports, media stories, rumours, or social media content. These signals are processed by different social actors and can generate wider responses, including behavioural change, public concern, stigma, economic impacts, political pressure, regulation, loss of trust, or further contestation (Kasperson et al., 1988, 2022). Classic examples include the wider social and economic effects of the 1982 Tylenol tampering case (Slovic & Weber, 2002) and the role of vaccine communication in shaping vaccine acceptance, hesitancy, and infection risk (Larson et al., 2022).

The framework is useful because HILP **risks can be either under-attended to or over-amplified**. Since HILPs are rare, many people have little direct experience of them, which can weaken attention and preparedness. However, when a HILP is vivid, dreaded, contested, or symbolically powerful, signals from media, institutions, rumours, warnings, or near misses may rapidly amplify concern, political pressure, economic consequences, or loss of trust. Conversely, when a HILP is technical, diffuse, slow-moving, or difficult to visualise, signals may be weak or attenuated, contributing to low-risk perception and under-preparedness. This makes the framework useful for later sections on misinformation, media framing, uncertainty communication, and preparedness, because it shows that communication can influence not only how risks are understood, but also whether they are socially amplified, ignored, contested, or translated into action.

2.1.3. Implications for decision making and preparedness

Risk judgements and perceptions matter because **they shape whether, when and how people act**. A member of the public may need to decide whether to evacuate after a storm forecast. An emergency manager may need to decide how to reduce the impacts of a crisis. A policymaker may need to decide which risks deserve investment in prevention or preparedness.

The theories reviewed above suggest that **HILPs will not all be judged or perceived in the same way**. Although they share the defining features of low probability and high impact, individual HILPs differ in how familiar, vivid, controllable, dreaded, visible, socially salient or culturally meaningful they appear. These qualitative, emotional and social characteristics can shape whether a HILP is seen as plausible and urgent, or instead as distant, abstract or unlikely. Perceptions may also vary across groups and societies, especially where particular hazards are embedded in collective memory, cultural history, previous experience or public debate. As the following sections show, these differences can lead to different patterns of awareness, concern, preparedness and response across different types of HILP events.

HILPs with catastrophic, vivid, concrete or widely discussed consequences may be judged as more plausible or more serious. This may also be true for HILPs that resemble familiar disaster

images. By contrast, systemic, slow-moving, technical, diffuse or hard-to-imagine HILPs may seem less plausible or less urgent. These patterns may also change over time, especially after major events, near misses, warnings or periods of public attention.

This matters for preparedness. HILPs that are seen as plausible, vivid, dreaded or socially salient may be more likely to motivate preparedness by individuals, households, institutions or governments. HILPs that remain abstract or unfamiliar may fail to motivate action, even when their potential consequences are severe.

However, perceived risk is only one part of preparedness. Reviews of disaster preparedness show that action is also shaped by many other factors, including **efficacy beliefs, perceived benefits, trust, responsibility, social norms, barriers, place attachment, and support from authorities or communities** (Ni et al., 2025; Skipor & Bergquist, 2026). This means that even if a HILP is perceived as risky, people may still not prepare. They may doubt that preparedness measures will work. They may feel unable to act. They may face high costs or practical barriers. They may think responsibility lies with government, experts or other institutions.

Efficacy may be especially difficult for HILPs. Because the consequences can be massive, systemic or global, individual or local action may feel too small to matter. For some HILPs, especially those with systemic or global impacts, public preparedness may involve support for institutional planning and policy action as much as household-level behaviour. Hazard-agnostic preparedness may help here, because it focuses on **actions that build resilience across many possible risks**, not only one specific scenario.

Research on preparedness behaviour for HILPs remains limited. Kerr et al. examined **public support for institutional preparedness for global catastrophic risks** in a representative New Zealand sample. The examples included release of a bioengineered infectious disease, bioweapons, nuclear war and rogue artificial intelligence (Kerr et al., 2025). They found that 66% of respondents supported government development of specific plans for extreme risks, while 60% supported establishing a commission or agency to monitor and report on them. **Support was associated with trust in scientists** and did not vary by gender or political ideology. The authors suggested that those who opposed or were indifferent to the proposals may have lacked awareness of extreme risks, doubted their likelihood or severity, doubted government effectiveness, felt fatalistic, or thought other issues deserved more attention. However, these possible explanations were not directly tested. However, as above discussed, the support for global measures is not able to predict individual preparedness behaviour.

Another challenge is that HILP preparedness often requires **accepting a certain cost now in order to reduce the chance or severity of a much larger but uncertain future loss**. The present cost may involve money, time, resources or political capital. The future benefit may never be directly observed, especially if the event does not happen.

Prospect theory helps explain why this can make preparedness difficult to motivate (Kahneman & Tversky, 1979). Prospect theory argues that people judge outcomes as gains or losses relative to a reference point, often the current situation. If the current situation is that the HILP has never happened, or has not happened for a long time, preparedness may feel like a definite present loss. People must give up resources now for a benefit that may never be visible. Not preparing preserves current resources but leaves the possibility of a much larger future loss. Prospect theory also suggests that people often behave differently when facing gains compared with losses. People tend to prefer a certain gain over a larger uncertain gain. But when facing losses, they may be more willing to take risks to avoid a certain loss. Applied to HILPs, this suggests that **people may prefer the implicit gamble of not preparing, rather than accepting the certain cost of preparing now**.

However, reference points can shift. Before a HILP, normality may be the reference point, so preparedness feels like a cost. **After an event, or even a near miss, the possible future loss may become more salient**. Preparedness may then be seen less as a present cost and more as

a way to avoid future harm. This suggests that HILP preparedness may be uneven over time: weak before a major event, but stronger afterwards. Recent HILP research similarly suggests that such events may be neglected before they occur but may lead to overestimation of similar risks after a catastrophe because vivid outcomes and media images increase attention (McMillan et al., 2026). This post-event attention can support higher risk perception, learning and investment, but it may also become reactive or focused too narrowly on the most recent vivid threat.

Prospect theory also argues that people do not simply multiply outcomes by objective probabilities. Instead, they transform probabilities into "decision weights", which can diverge substantially from objective values. Small probabilities can be overweighted, giving unlikely events more influence than expected, or effectively rounded to zero and ignored altogether (Kahneman & Tversky, 1979). This probability weighting is closely related to the description–experience gap: when rare risks are explicitly described, overweighting is more likely; when people rely on personal experience, underweighting is more likely because rare events are rarely encountered in everyday life (Hertwig et al., 2004; Hertwig & Erev, 2009). Overall, prospect theory does not predict one single response to HILPs. However, it shows that **preparedness may depend on how present costs, future losses, reference points and low probabilities are framed and understood**.

As Sundh notes, research on behaviour in the context of HILPs is limited (Sundh, 2024). However, emerging work on black swan and extinction-risk decisions supports the idea that **people's choices about very low-probability, very high-impact losses are highly context-dependent**. Perfors and Van Dam found that participants were risk averse when only one option involved a very low probability of losing everything but became more risk seeking when both options involved some black-swan risk (Perfors & Dam, 2018). This suggests limited sensitivity to differences between very small probabilities. Croft et al. found a similar pattern in financial and health-related black swan tasks (Croft et al., 2022). Maier et al. found that decisions under extinction risk showed both some sensitivity to the structure of the risk and several weaknesses, including loss chasing, opportunity cost neglect and scope insensitivity (Maier et al., 2025). These studies do not directly test HILP preparedness, but they support the broader point that decisions involving very low probabilities and extreme losses are shaped by framing, the presence or absence of zero-risk options, and limited sensitivity to probability and impact size.

A further explanation for non-preparedness comes from social dilemma and rational choice perspectives. For an individual or institution, investing in preparedness **imposes a certain present cost against an uncertain future benefit** that may never materialise. Where a HILP does not occur — as is likely, given its low probability — the cost of preparedness yields no visible return. Meanwhile, risk-taking behaviour may generate consistent positive returns over time. A household that builds on the coast and uses the property for twenty years without experiencing a major flood will have accumulated substantial benefit from accepting that risk. The expected cost of the HILP, discounted by its low probability and distant time horizon, may simply not override the accumulated value of the risky behaviour (Palma-Oliveira, Trump & Linkov, 2020). This creates a **structural tension**: what is individually rational — deferring or avoiding the cost of preparedness — is collectively problematic when low-probability, high-consequence risks require coordinated action before an event occurs.

2.1.4. Concluding remarks and limitations

The theories reviewed in this chapter help explain how HILPs may be judged, perceived and acted upon. However, there are important limitations. Many of these theories were **developed for risks that are less extreme or easier to define**. They often assume that there is a recognisable hazard, some estimate of likelihood and impact, and some possible actions. Some HILPs fit this model, but many do not.

Recent work defining and classifying HILPs emphasises that they are often **context-dependent** shocks. They are not only rare, but also marked by uncertainty, surprise, limited historical

precedent, changing vulnerabilities, and combinations of known and unknown risks (Pescaroli et al., 2025). Their probabilities may be difficult or impossible to estimate from historical data. Their impacts may be uncertain, hard to bound or contested. Their pathways to impact may be unclear because they are cascading and systemic. Some may not be known about at all. These features may stretch existing theories and may mean that **some HILPs are absent from attention and judgement altogether**.

Experience is another limitation. HILPs are rare by definition, and some have never occurred before, at least not in the available historical record or in contexts that resemble today's social and technological conditions. Even where past examples exist, they may not be close analogues because vulnerabilities, exposure and systems have changed (Pescaroli et al., 2025). This means that **HILPs often lack individual experience, shared social experience and collective memory**. This matters because theories such as availability, affect and experience-based risk perception depend partly on experienced or imaginable examples.

A further challenge is that much of the risk perception literature examines specific hazards or causes of death. Many HILPs are different. They may be systemic, cascading or cross-boundary, with impacts emerging through complex chains across different systems. This can make them difficult to imagine and less emotionally vivid. It can also make them difficult to communicate about, because there may be no clear, bounded risk object, impact pathway or behavioural response.

Finally, much of the research on preparedness and decision-making focuses on individuals. But **many HILPs require collective, institutional or policy-level action**. They may involve cooperation across organisations, sectors and countries. Existing psychological theories can help explain some mechanisms behind judgement, perception and response, but they need to be complemented by work on group decision-making, governance and institutional capacity.

Understanding HILPs therefore requires **drawing on existing theories of judgement, risk perception and decision-making, while also recognising their limits**. HILPs are rare, uncertain, systemic, difficult to experience directly, and often cannot be managed through individual action alone.

It is also important to note that much of the evidence on risk perception in this context examines a diverse range of HILP or HILP-like risks, often **outside the specific conditions of a particular community, place or preparedness process**. These findings are therefore useful for identifying general psychological and behavioural mechanisms, but they should not be interpreted as direct evidence of preparedness or prevention behaviour within any specific community or for any specific risk.

These limitations are directly reflected in how the guidelines in Chapter 6 are framed. Rather than prescribing fixed communication approaches derived from theory alone, the guidelines are presented as evidence-informed principles that require contextual judgement — particularly for HILPs that are novel, cascading, cross-boundary, or involve uncertainties for which existing psychological theories offer only partial guidance.

These insights provide a theoretical basis for understanding why HILPs can be difficult to communicate about. They show that people do not respond to risk information only by weighing likelihood and impact in a technical sense. Their responses are also shaped by how familiar, vivid, controllable, frightening, socially salient or personally relevant a risk feels. HILPs are particularly challenging because they can be both difficult to imagine before they occur and highly emotionally charged once they become visible or start unfolding. The following section therefore **turns from risk perception theory to the evidence base on risk communication**. It examines what is known from previous research and practice about how risks are communicated before, during and after crises, and how communication can support preparedness, understanding and appropriate action.

Box 1: Key takeaways – Risk Perception of HILP Events

Both features of HILPs — low probability and high impact — create distinct cognitive challenges that are not resolved by providing more technical information.

- People do not assess probabilities neutrally. Very low probabilities are sometimes ignored, sometimes overweighted, depending on how familiar and vivid the risk feels. HILPs that are associated with dramatic events, strong images or collective memory will feel more plausible than those that are systemic, diffuse or technically framed.
- Risk perception is emotional and social, not only analytical. Whether a hazard feels dreaded, uncontrollable, unfamiliar or unfairly distributed affects how seriously it is taken, often independently of the underlying probability.
- People with no direct experience of a HILP tend to underweight it. This description-experience gap means that repeated non-experience can make even documented risks feel distant or abstract.
- Large numbers are hard to process. Very high impact scenarios may fail to register proportionally, and the perceived benefit of preparedness can shrink as the scale of possible harm becomes harder to imagine.
- Preparedness is psychologically costly before an event. When the risk has never materialised, preparing can feel like a definite present loss in exchange for an uncertain future benefit. Reference points shift after events or near misses, which is why risk communication cannot rely on crisis-moment motivation alone.
- Risk perception is not static. Attention spikes after major events and near misses, then declines. Communication must sustain salience across long periods without reinforcing fatalism.

2.2. Evidence base for risk communication in HILP events

The previous section explained why High-Impact, Low-Probability (HILP) events are difficult to judge, perceive and act upon. This section turns from risk perception theory to the **evidence base on risk communication**. It focuses on what empirical studies, risk and crisis communication research, guidance documents and lessons from practice suggest about how communication can support preparedness, protective action, trust, recovery and learning before, during and after extreme events.

The evidence reviewed in this chapter is also supported by practice-oriented guidance from international organisations, public warning standards and institutional crisis communication manuals. These guides are not treated as a separate evidence stream here because they largely translate empirical and behavioural principles into operational recommendations. Across UNDRR/WMO, WHO, CEN, ISO, OECD, JRC, GFDRR, UNDP, the European Stability Mechanism and the UK Government Communication Service, the same core themes recur: communication should be timely, credible, clear, actionable, inclusive, coordinated, transparent about uncertainty and connected to the public's capacity to act (UNDRR & WMO, 2023; WHO Regional Office for Europe, 2024; CEN, 2023; OECD, 2016; Rossi et al., 2018; GFDRR, 2021; UNDP, 2024; ESM, 2024; GCS Behavioural Science Team, 2022).

Across the reviewed literature, one conclusion is consistent: **risk communication does not work through information alone**. People do not simply receive risk information, understand it and act accordingly. They interpret information through emotions, prior experience, social norms, perceived responsibility, trust in authorities, perceived ability to act, available resources and cues from peers, media, the wider environment, and the rational judgment of the possible actions (Kasperson et al., 1988; Rogers, 1975, 1983; Witte, 1992; Griffin et al., 1999; Lindell & Perry, 2012; Reynolds & Seeger, 2005; Agyepong & Liang, 2022; Palma-Oliveira et al., 2022). For HILP events, this means that communication must do more than raise awareness. It must help make rare, uncertain and potentially cascading risks meaningful before they occur, and it must provide timely, credible and actionable guidance once events begin to unfold.

Lim (2022) provides a useful synthesis of behavioural drivers that recur across major theories that can explain disaster risk reduction and climate change adaptation behaviours. The study groups these drivers into four broad domains: **risk perception, coping appraisal, social norms, and perceived protection responsibility**. These domains are discussed in more detail below, but their relevance for HILP communication is already clear:

Awareness of a risk is not sufficient to motivate preparedness or protective action. People also need to believe that effective action is possible, that they are capable of carrying it out, that others support or expect such action, that the necessary resources are available, and that responsibilities are clearly shared between individuals, communities and institutions.

Cluster	Theories/ models	Protective motivation theory (PMT)	Extended parallel process model (EPPM)	Protective action decision model (PADM)	Theory of planned behavior (TPB)	Risk Information Seeking and Processing (RISP) model	Person-relative-to-event (PrE) theory
	Primary outcome variables	Disaster risk protection behaviors	Protection motivation	Protective response, information search	Behavioral intentions, behaviors	Information seeking and processing	Disaster risk behaviors
Risk perception	Perceived risk likelihood	×	×	×	×	×	×
	Perceived risk impact	×	×	×	×	×	×
	Risk knowledge					×	
	Negative emotions		×	×		×	
Coping appraisals	Self-efficacy	×	×	×	×	×	×
	Controllability				×		
	Response efficacy	×	×	×			
	Resource constraints	×		×			
	Response knowledge			×		×	
Social norms perceptions		×			×	×	
Perceived protection responsibility				×			×

Figure 1. Overlapping factors in major theories of behaviour for explaining disaster risk reduction behaviours (Lim, 2022).

Protection Motivation Theory reinforces the same point. Communication should **combine threat appraisal with coping appraisal**. People need to understand that a threat is serious and relevant, but they also need to **believe that the recommended action is effective and feasible**. Without this second element, threat-based communication may increase fear, avoidance, denial or disengagement rather than protective behaviour (Rogers, 1975, 1983; GCS Behavioural Science Team, 2022). This principle applies across the full communication cycle: before events, messages should make preparedness feel possible and worthwhile; during events, warnings should pair threat information with clear protective guidance; after events, communication should explain what actions reduced harm and how future preparedness can be improved.

The evidence reviewed below is organised by phase: **preparedness, response and recovery**. Within each phase, findings are grouped around the main topics that recur across the literature, such as participation, risk literacy, efficacy, trust, warning content, uncertainty, inclusion, coordination, public behaviour, collective resilience and learning.

Table 2. Evidence organised by phase, consolidated findings and indicative sources.

Phase / theme	Consolidated finding	Indicative sources
Preparedness / pre-crisis communication	Build risk culture, preparedness capacity, trust, risk literacy and community involvement before a threat materialises. Especially relevant for HILP risks, where rarity weakens experience-based risk perception.	Lim (2022); Stewart (2024); Lejano et al. (2021); Herovic et al. (2020); Sun (2020); Iwahori (2020); Wood & Miller (2021); UNDRR & WMO (2023); Jan et al. (2025); Anthony et al. (2023)
Warning and crisis communication during events	Enable rapid comprehension, personalisation and protective action under uncertainty. Recurrent findings emphasise clear source attribution, actionability, consistency, impact-based wording, visual support and multi-channel dissemination.	Tippett et al. (2021); Greer et al. (2020a, 2020b, 2020c); Mehta (2022); Sutton & Kuligowski (2019); Dallo et al. (2022); Weyrich (2020); Ortiz et al. (2024); Tupper et al. (2023); Takenouchi (2020)
Post-disaster, recovery and learning	Support explanation, accountability, continued engagement, recovery choices, relocation decisions, evaluation and institutional learning. Post-disaster communication is less developed in the corpus than preparedness and warning communication.	Cubeddu (2025); Parida et al. (2021); Xue et al. (2022); Khan et al. (2022); Dehghani et al. (2022); Onal et al. (2021); Yudarwati et al. (2022); Fathollahzadeh (2023)
Cross-cutting theoretical foundations	Risk perception, social amplification, heuristics and biases, self-efficacy, social norms, CERC, PADM, co-production, participation and socio-technical systems explain why information alone rarely produces action.	Agyepong & Liang (2022); Slovic/Fischhoff tradition as reviewed in Raue et al. (2018) and Bostrom et al. (2018); Palma-Oliveira et al. (2017); Palma-Oliveira et al. (n.d.); Sundh (2024); Dallo (2022); Knoblauch et al. (2018)

2.2.1. Preparedness phase: building risk culture, preparedness, capability and trust

Preparedness as ordinary-time risk communication

Preparedness communication is not simply an early version of a warning message. It is the long-term work of helping people, communities, institutions and professionals **understand risks before there is any indication that a specific event is about to occur**. Its purpose is to **build the knowledge, trust, confidence, relationships, habits and practical capacities that make later action possible**. This distinction is especially important for HILP events, because their rarity weakens direct experience, reduces availability in memory and makes preparedness easy to postpone. In this phase, the communication challenge is not how to warn people of imminent danger, but how to make a rare, abstract and uncertain risk meaningful enough for people to prepare before there is urgency (Agyepong & Liang, 2022; Dallo, 2022; Sundh, 2024; Domestic Preparedness, 2025).

Preparedness communication should therefore be treated as a **continuing process** rather than a campaign delivered only when attention is already high. It should not be episodic or limited to occasional awareness-raising campaigns. Instead, it should **be sustained through education, community engagement, local partnerships, professional training, public deliberation, media relationships, and recurring risk-culture activities adapted to different socio-ecological systems, places, and geographies**. For HILP events, this work is especially important because the first moments of crisis may not allow time to explain basic concepts, build trust, establish communication channels, or introduce unfamiliar protective actions.

Recent survey evidence from Portugal reinforces the gap between **risk awareness, preparedness, trust and participation**. A national questionnaire on public participation and risk culture found that respondents expressed high concern about major risks such as wildfires, extreme weather, earthquakes, floods and pandemics, but this did not translate into equivalent levels of preparedness. This research also reports low individual preparedness, perceived societal vulnerability, and structural gaps in prevention and capacity-building. At the same time, respondents perceived risk information as dispersed and unequal in quality, and official entities were consulted less frequently in Portugal than the EU average. Trust appeared stronger in operational and proximity-based actors, such as fire brigades, emergency services, armed forces and local authorities, than in central political institutions (Abreu dos Santos et al., 2025). For HILP risk communication, these findings support three practical conclusions:

- Awareness is not enough to produce preparedness;
- Trusted local and operational actors are essential messengers and
- Citizens need communication that helps them know how to act, not only information that tells them that a risk exists.

The reported willingness to participate in prevention, awareness, training, simulations, drills and local initiatives further suggests that preparedness communication should be designed as a participatory process that mobilises existing civic capital rather than treating the public only as passive recipients of information.

This is consistent with OECD guidance, which distinguishes risk communication from crisis communication and notes that many countries have historically invested more in crisis communication than in pre-event risk communication (OECD, 2016). This imbalance is a major weakness. If people first encounter a low-probability catastrophic risk only when a crisis is unfolding, communication must simultaneously explain the hazard, build trust, introduce protective actions and motivate behaviour under uncertainty and time pressure.

Preparedness communication should therefore be embedded in ordinary-time risk governance, education, community engagement and exercises, rather than treated only as an emergency response function. In this broader sense, preparedness communication is part of risk

communication because it helps build the knowledge, relationships, trust and practical capacity that make later crisis communication more effective. It should not be reduced to crisis messaging in advance but understood as the long-term communication work that enables people, communities and institutions to recognise risks, understand their roles and act when an event begins to unfold.

Moving beyond one-way information transfer

A first theme in the literature is the need to **move beyond the deficit model of risk communication** (also known as the knowledge model). Preparedness is often treated as a problem of missing knowledge: experts know the risk; the public does not and the solution is to transmit more information. The reviewed literature suggests that this is insufficient.

Stewart (2024) distinguishes between dissemination, dialogue and participation, arguing that science communication – and consequently disaster risk communication – has moved progressively toward more participatory models. One-way dissemination remains necessary for some types of information, but preparedness also requires **social learning, local interpretation and opportunities for communities to shape risk knowledge.**

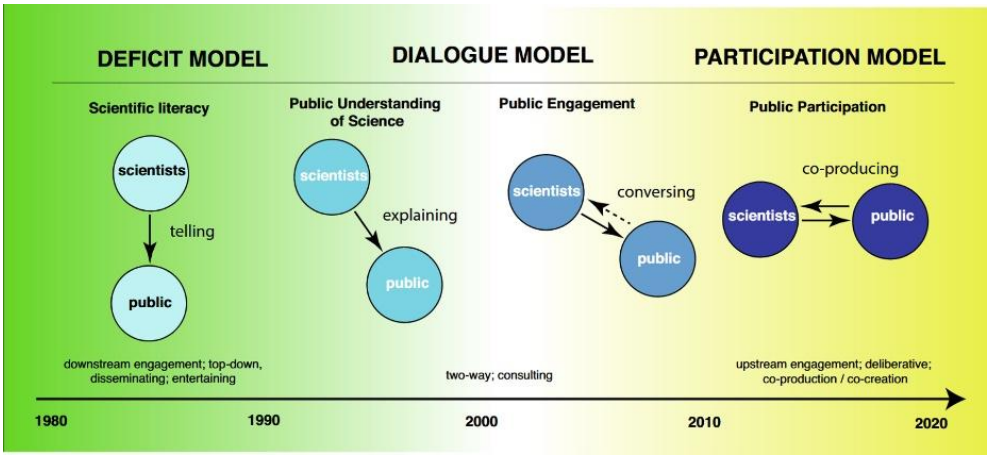


Figure 2. Schematic summary of the evolving history of science communication (Stewart, 2024).

Model	Deficit/ Dissemination	Dialogue	Participation
Strategic intent	Deficit / Dissemination	Persuasion	Partnership
Aspects of science	**Findings**: finished knowledge	**Issues**: applications and implications of knowledge	**Processes**: interpreting and (de)constructing knowledge
Social perspectives	***Science literacy, public understanding of science (PUS)***	***Science and society,*** Mode 2 science, post-normal science	***Society in science***: civic science, citizen science, participatory democracy
Public uses	**Information**: awareness, learning	***Questioning***: opinion, discussion	**Sharing**: creating, enjoyment, critique
Expert View of the public	*"They are hostile"* *"They are ignorant"* *"They can be persuaded"*	*"We see their diverse needs"* *"We find out their views"* *"They talk back"* *"They take on the issue"*	*"They and we shape the issue"* *"They and we set the agenda"* *"They and we negotiate meanings"*
Sci-comm applications	Deficit Defence Promotion Popularisation Outreach	Consultation Persuasion Nudge Deliberation	Partner Co-design Co-creation Empower
Orientation	Hierarchial Formal Closed	⟷	Participatory Informal Open

Figure 3. Simplified schema of science communication perspectives, uses and applications (Stewart, 2024).

Lejano, Haque and Berkes (2021) make a similar argument through the **co-production of risk knowledge**. Communities should not be treated only as recipients of expert information. They hold knowledge about place, social networks, mobility constraints, livelihood dependencies, local

memory, informal care structures, trusted intermediaries and barriers to action. This is directly relevant for HILP events, where technical advice may be correct in general but difficult to act upon in a specific community. Fonseca et al. (2025) show that top-down flood risk communication can limit preparedness when risk communication is treated mainly as an emergency function. Yudarwati, Putranto and Delmo (2022) similarly show that institutional use of social media often remains largely one-way, even though digital platforms could support dialogue, listening and engagement.

At the same time, **participatory and co-production models** should not be interpreted as implying that scientists or technical experts can, by themselves, sustain direct engagement with communities. In practice, such engagement usually **depends on institutional and political arrangements that make participation possible, legitimate and continuous**. Scientists, forecasters and technical specialists may contribute essential expertise, but community engagement is typically initiated, structured and maintained through local authorities, civil protection systems, public agencies, community organisations, intermediaries and policy frameworks operating at local, national or international levels. A limitation of some participatory communication models is therefore that they understate the governance work needed to connect expert knowledge, public institutions and community experience. For HILP risk communication, co-production should be understood not simply as direct scientist–community interaction, but as an organised process in which scientific, institutional and local knowledge are brought together through clearly supported structures.

Learning preparedness through practice

Participatory approaches are useful because they allow preparedness to be practised rather than only explained. Lee and Yamori (2020) show that **disaster games** can create a safe setting for communities to discuss difficult choices before a crisis, including trade-offs involving family, neighbours, property, evacuation, scarce resources and collective action. Iwahori (2020) adds that people often become prepared gradually through participation in real practices, not only through instruction. They may begin by observing preparedness activities, joining local discussions, helping with small tasks, participating in drills or learning from more experienced community members.

Iwahori (2020) adds a complementary perspective through the idea of **legitimate peripheral participation**. This approach suggests that people do not become prepared only by receiving expert instructions. They become involved gradually through participation in real practices, initially from the margins and then with increasing confidence and responsibility. In disaster risk reduction, this may include observing community preparedness activities, joining local discussions, helping with small tasks, participating in drills, contributing local knowledge, or learning from more experienced community members. The value of this approach is that preparedness becomes embedded in everyday social practice rather than treated as a one-off educational intervention. For HILP communication, this is particularly relevant because rare hazards are difficult to keep salient. Gradual participation can help sustain attention to disaster preparedness and build practical familiarity over time. The case-study analysis further below in this deliverable also shows that preparedness is strongest when protective behaviours are culturally embedded, regularly practised, and socially reinforced before an event occurs, rather than introduced for the first time during a crisis.

Shiroshita (2020) develops the idea of **reverse learning**, which challenges the assumption that disaster knowledge should flow only from experts, authorities, or highly prepared countries to less prepared communities. Instead, local and community experience can also generate knowledge that is useful for wider disaster risk reduction practice. Communities may have practical strategies for coping with uncertainty, improvising with limited resources, maintaining social support, or interpreting environmental cues that are not captured in formal expert models. Reverse learning is important for HILP preparedness because cascading and low-probability events often expose gaps in standard plans. Local experience can reveal vulnerabilities and capacities that centralised

communication may overlook. This supports a more reciprocal model of risk communication, where communities are not only the audience of preparedness messages but contributors to preparedness knowledge.

Takenouchi (2020) similarly shows the value of **producing risk information with communities**, rather than only delivering it to them. The example of **community weather information** is useful because weather data only becomes actionable when people can connect it to their own place: which roads flood first, which households are isolated, which slopes are unstable, which local signs people recognise, and which actions are realistic for different groups. In this sense, the communication task is not simply to translate technical information into simpler language, but to connect expert knowledge with local experience. For HILP preparedness, the same principle applies beyond weather hazards. Information about earthquakes, tsunamis, volcanic hazards, heat, technological accidents, or cascading infrastructure failures needs to be interpreted in relation to local vulnerabilities, routines, resources, and decision points. Preparedness communication is therefore more effective when it helps communities ask: what does this risk mean here, for us, before anything happens?

Together, these studies suggest that **preparedness communication is relational and practical**. It builds **shared language, social memory, mutual trust and familiarity** with action before time pressure exists. In the context of the AGILE project, this is directly relevant to stress test exercises and workshops in the case-study implementations – these activities should not be treated only as validation tools; they are also communication and learning processes through which communities, stakeholders, responders and institutions can rehearse uncertainty, test roles, identify barriers and refine messages before a real event.

Building self-efficacy, social norms and feasible action

A second theme is that preparedness depends not only on awareness, but also on coping appraisal, social norms, available resources, and perceived responsibility. Lim's (2022) integrated model of risk communication is useful here because it shows that disaster risk reduction and adaptation behaviours are shaped by several interacting drivers, not by risk perception alone. Four drivers are particularly relevant for HILP communication:

- **Risk perception**, as we have seen before, includes the perceived likelihood, perceived impact, risk knowledge and negative emotions associated to a certain risk – i.e., how likely, severe, familiar, or emotionally concerning a risk appears to be.
- **Coping appraisal** refers to whether people believe that protective action is possible, effective, and within their capacity; this includes self-efficacy, perceived controllability, response efficacy, response knowledge, and resource constraints.
- **Social norms** are the informal, unwritten rules and shared expectations that guide acceptable behaviour within a group or society. In other words, they refer to what people believe others are doing (descriptive norms) and what they believe others expect them to do (injunctive norms).
- **Perceived protection responsibility** concerns whether preparedness and protection are understood as individual responsibilities, institutional responsibilities, or shared responsibilities across individuals, communities, and authorities.

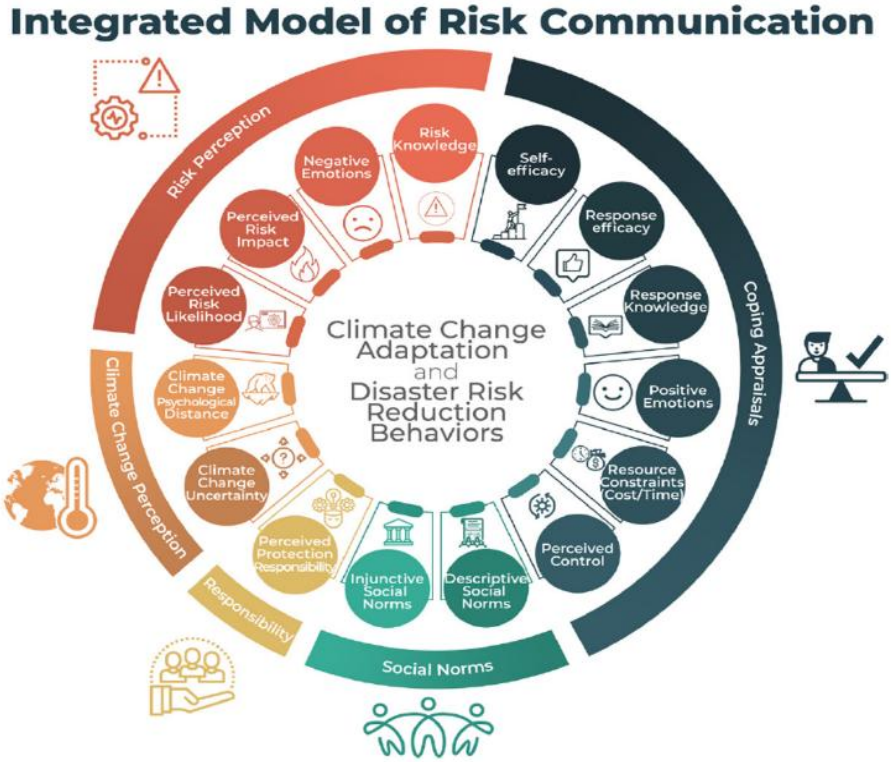


Figure 4. Integrated model of risk communication for climate change adaptation and DRR behaviours (Lim, 2022).

This shifts the purpose of disaster preparedness messages. Messages should not only state that a catastrophic event is possible. They should **make action feel feasible, effective and socially supported**. This means answering practical questions such as what can be done before anything happens, why the action helps, how difficult it is, who else is preparing, what support is available, and which responsibilities belong to individuals, communities, responders, and institutions.

In the absence of recent direct experience, visible social norms can partly substitute for personal memory. Families discussing preparedness plans, schools practising drills, workplaces reviewing continuity arrangements, community groups mapping vulnerabilities, local leaders endorsing action and neighbours sharing practical steps can all help make preparedness visible. Preparedness communication should also **reduce perceived barriers by presenting action as a sequence of manageable steps** rather than a single demanding or abstract task. This may include identifying one trusted information source, discussing one household plan, preparing one essential item, learning one protective option or joining one community activity (Lim, 2022; Bostrom et al., 2018; Meyer & Kunreuther, 2017).

The GCS Behavioural Science Team (2022) makes a related point by distinguishing between awareness, attitudes and actual behaviour. Beliefs and knowledge can influence behaviour, but they are not behaviours themselves. For HILP preparedness, **communication objectives should therefore be defined behaviourally** wherever possible: preparing supplies, identifying trusted sources, learning local risks, discussing household or workplace plans, participating in exercises, registering for alerts, or supporting institutional preparedness. This helps avoid the common problem of campaigns that increase concern but do not make preparedness easier or more likely.

Making rare and abstract risks meaningful

A third theme is the **need to translate abstract risk into personally and locally meaningful knowledge**. HILP events are often difficult to communicate because they are rare, technical, uncertain and outside everyday experience. Low probability creates a specific communication problem: a technically accurate probability may still fail to motivate preparedness if people interpret it as “not relevant to me”. Communication should therefore not rely only on precise probability figures. It should combine probability with scenarios, consequences, uncertainty

explanations and action thresholds (Knoblauch, Stauffacher, & Trutnevyte, 2018; Herovic et al., 2020; Tolerating Uncertainty About the Communication of Risk, 2025).

Dallo et al. (2020) show that rare hazards may remain cognitively unavailable even when they are scientifically recognised, while Dallo and Marti (2021) suggest that multi-hazard platforms may help because people are unlikely to use separate tools for hazards they may never experience. However, multi-hazard communication must be carefully designed. If earthquake, volcanic, radiological or other HILP information is displayed alongside weather-related information, people may wrongly assume that all hazards are forecastable in the same way. Preparedness communication should therefore distinguish between long-term risk information, forecast-based information, real-time event information and post-event information.

Maps, scenarios, simulations, visualisations and games can help make rare risks concrete, but they must be designed to support action rather than fatalism. Hatayama and Nakai (2020) show that tsunami simulations can support communication when they help people understand evacuation dynamics and local consequences. Sun (2020) warns that extreme tsunami scenarios may also produce fatalism or overdependence on authorities if people conclude that survival is impossible. The lesson is that visualisation should not merely dramatize catastrophe. It should show choices, feasible actions and the difference preparedness can make.

Kuligowski et al. (2024) similarly show that people use bushfire maps not only to observe where a hazard is located, but also to locate themselves in relation to the threat, assess personal relevance, decide what action to take, warn others and interpret changing conditions. For HILP preparedness, this means that people should become f**amiliar with risk maps, evacuation zones, local landmarks and spatial risk information** before crisis conditions arise.

During an event, **dynamic spatial information should then be made available** and actively promoted to support **situational awareness**. Maps and location-based tools can help people understand whether they are within or near an affected area, how the situation is evolving, which routes or places may be unsafe, and what actions are recommended. This type of information is especially useful when it connects hazard location with local consequences and practical decision points, allowing people directly exposed to the event to make more informed and timely choices.

Trust, ethics and cultural adaptation before crisis

A fourth theme is that **trust must be built before there is an event**.

Trust operates **simultaneously as a precondition and a consequence** of risk communication. Without pre-existing trust, messages may be received but not believed, and warnings acted upon too late or not at all. At the same time, every act of communication either strengthens or erodes the trust that future communication will depend on, including the trust needed in the next crisis. This means trust cannot be treated only as a communication variable to be managed during emergencies: it is infrastructure that must be built continuously between events and protected in every interaction.

Agyepong and Liang (2022) identify trust as a central theme in public risk communication research. Herovic et al. (2020) show, in relation to earthquake science communication, that scientific credibility during uncertainty depends partly on proactive pre-crisis communication. Institutions that only appear when a crisis occurs may struggle to be trusted, especially when they must communicate low probabilities, uncertainty or disruptive preparedness measures.

Additionally, trust is **not based only on competence**. Palma-Oliveira, Gaspar and Mendes (2017) argue that publics also **evaluate messengers through warmth, empathy, fairness, identity and perceived group belonging**. A scientist or institution may be seen as competent but distant, or technically correct but socially misaligned. If the source is perceived as indifferent to local realities, communication may fail even when information is accurate. COVID-19 communication provides similar lessons. Palma-Oliveira, Trump and Linkov (2020) argue that communication failures partly reflected **insufficient attention to the concerns, incentives, sacrifices and social dilemmas**

experienced by different publics. Khan et al. (2022) similarly show that COVID-19 risk communication required community engagement, not only information dissemination.

Preparedness communication should also **establish trusted communication channels** before they are needed. The literature on social media use shows that official online communication can support public engagement, but that it often remains underused as a dialogic tool (Fathollahzadeh, 2023; Malik, 2021; Onal et al., 2021; Yudarwati et al., 2022; Khan et al., 2022). For HILP preparedness, agencies should build audiences, trust, tone, formats, and monitoring capacity before a crisis. Otherwise, official accounts may struggle to compete with rumours, unofficial sources, or misinformation when uncertainty increases.

Anthony et al. (2023) add that risk communication is also an ethical practice. Communication failures may arise when institutions prioritise reputation, liability, political convenience or reassurance over public safety and informed decision-making. For preparedness communication, this means that **authorities should avoid overpromising certainty, minimising risk to prevent concern, or withholding inconvenient information**. Ethical communication helps people make informed choices even when evidence is uncertain or uncomfortable.

Preparedness messages must also be **culturally and socially adapted**. Risk information is interpreted through local values, family roles, community expectations, religious beliefs, political histories and trust relationships (Bostrom et al., 2018; Raue et al., 2018; Lejano et al., 2021; Fonseca et al., 2025; Yudarwati et al., 2022; Xue et al., 2022). In more individualist cultural contexts, preparedness may be framed more effectively around personal responsibility, household readiness, autonomy, and protecting one's immediate family. However, in more collectivist contexts, communication may resonate more when it emphasises mutual aid, obligations to vulnerable community members, neighbourhood preparedness, duties to elders and children, and collective resilience. The distinction should not be treated rigidly, since every community contains internal diversity, but it does underline the need for cultural adaptation. A message that feels empowering in one context may feel inappropriate, insufficient, or socially disconnected in another. For HILP preparedness, technical information about rare risks should therefore be connected not only to local hazards and practical actions, but also to the **values, identities, and social responsibilities through which people understand what it means to prepare** (Bostrom et al., 2018; Raue et al., 2018; Lejano et al., 2021; Fonseca et al., 2025; Yudarwati et al., 2022; Xue et al., 2022).

Addressing barriers, vulnerability and ordinary-time memory

Preparedness communication must also **account for unequal resources and vulnerability**. A recurring finding in the literature is that people may understand a risk but still be **unable to act if the recommended action is too costly, socially disruptive, inaccessible, or disconnected from their everyday constraints**. Xue et al. (2022), for example, show that relocation decisions are not shaped by risk perception alone. They also depend on whether people can afford to move, whether relocation threatens livelihoods, whether social ties would be disrupted, and whether government support is trusted. Dehghani et al. (2022) make a similar point in relation to health-system risk communication: messages are only useful if they are designed around the conditions in which vulnerable groups receive, understand, and use information, including coordination between institutions and services. Fonseca et al. (2025) further show that flood risk communication is weakened when it ignores local culture, participation, and structural constraints.

Taken together, these studies show that preparedness cannot be communicated as a purely individual responsibility. People may know what the risk is and still be unable or unwilling to prepare if doing so threatens housing, income, family responsibilities, social ties, or economic survival. HILP communication should therefore **link preparedness advice to realistic support, accessible options, and shared responsibilities** between individuals, communities, and institutions.

Additionally, preparedness communication must **address the psychological barriers that make ordinary-time action difficult**. Rare risks are easy to postpone because they do not feel urgent in everyday life. **Optimism bias** can lead people to assume that severe events are more likely to affect others than themselves. **Normalcy bias** can reinforce the expectation that the future will resemble the past, especially where communities have not recently experienced a major disaster. **Present bias** can make the immediate costs of preparedness feel more important than uncertain future benefits. **Denial** and **cognitive dissonance** can lead people to avoid information that is frightening, inconvenient, or inconsistent with previous decisions. **Simplification** can reduce complex cascading risks to narrower and more familiar hazards. **Herding** can reinforce inaction when others do not appear to be preparing, while **disaster amnesia** means that concern often fades with time after an event or near miss (PreventionWeb, 2025; Meyer & Kunreuther, 2017; Bryghtpath, 2025). For HILP communication, this means that preparedness messages should not assume that information alone will overcome inertia. They should make rare risks feel personally and locally relevant, reduce the perceived burden of action, show that preparedness is socially supported, and offer practical steps before there is any immediate sign of danger.

Yamori (2020a, 2020b) describes a **double-bind problem** in disaster preparedness communication. This occurs when **people receive two partly contradictory messages**: on one hand, authorities often present disaster management as something handled by experts, warning systems, emergency services and public institutions. This can create the expectation that people will be informed, protected or instructed when action is needed. On the other hand, the same authorities also tell individuals and communities that they must take responsibility for their own preparedness and be ready to act independently.

The problem is not that either message is wrong. Institutions do have responsibility for protection, and individuals and communities also need to prepare. The difficulty is that, **if this shared responsibility is not clearly explained, people may become uncertain about what is expected of them**. They may wait for official instructions when they should already be preparing or assume that preparedness is mainly a private responsibility when institutional support is actually needed. For HILP communication, this means that messages should make the division of responsibility explicit: what authorities will do, what communities can organise collectively, and what individuals or households should do before, during and after an event. Wood and Miller (2021) add that people may resist risk information when accepting it would challenge their identity, previous choices, or sense of competence. Preparedness communication should therefore **avoid blame, clarify shared responsibility, and help people take protective action without feeling powerless, guilty, or dependent on authorities alone**.

Multi-hazard early warning guidance reinforces this point through the concept of **the "last mile"**. UNDRR and WMO (2023) show that early warning effectiveness depends not only on monitoring and forecasting capacity, but also on whether warnings reach people at risk, are understood by them and can be acted upon. This is especially relevant for HILP events because the people least able to receive, interpret or act on warnings may also be those most exposed to harm. Preparedness communication should therefore include **disaggregated knowledge of vulnerable groups, locally trusted channels, accessible formats and practical support for people who cannot act on warnings without assistance**.

Preparedness as a socio-technical and institutional process

Finally, preparedness communication is not only public facing, but also an institutional process. It **requires institutions to build the relationships, channels and capacities that will later make communication credible and useful**. UNDRR and WMO (2023) frame effective multi-hazard early warning around risk knowledge, monitoring and forecasting, dissemination and communication, and preparedness and response capacity. Tupper, Fearnley and Kelman (2023) similarly stress that risk information becomes meaningful only when embedded in preparedness and response capability. For HILP events, this means that **communication must be connected**

to governance, institutional roles, warning systems, community capacity and practical action.

Digital tools can support this process, but only as part of a broader communication ecosystem. Dallo and Marti (2021) show the promise of multi-hazard platforms for rare hazards, while Jan et al. (2025a, 2025b) show that disaster apps can become more useful when they move beyond static information and include two-way functions, reporting, needs assessment and links to authorities. At the same time, preparedness communication must not over-rely on digital systems. UNDRR and WMO (2023), Tupper et al. (2023), Fonseca et al. (2025), Yudarwati et al. (2022) and Dehghani et al. (2022) all point to the need for **accessibility, inclusion and redundancy**. HILP communication must reach people with limited internet access, low literacy, disabilities, language barriers, distrust of authorities or weak connection to formal institutions.

Preparedness communication should also include **communication among response organisations**. Davidson et al. (2025) show that interoperability depends partly on whether responders from different services develop a **shared identity as one emergency response team**. Joint training, co-location, shared exercises, common language, multi-agency debriefs and informal contact can build trust and role understanding before an incident occurs. For HILP preparedness, **institutional communication** should therefore build not only plans and protocols, but also the **relationships, shared identity and mutual understanding that allow different agencies to act together under uncertainty and time pressure**.

Overall, risk communication before HILP events should be understood as the **long-term construction of meaning, trust, capability, and social readiness in the absence of immediate danger**. It should combine scientific information with local knowledge; probability with scenarios and consequences; digital tools with interpersonal and community channels; and threat information with efficacy, fairness, and practical support.

2.2.2. Response phase: warnings, crisis communication and protective action

From preparedness to urgent protective action

Crisis communication during an event differs from preparedness communication because the communicative task changes. Before an event, communication builds meaning, trust, risk literacy and preparedness capacity. During an event, **communication must support rapid interpretation and protective action under uncertainty, time pressure and emotional stress** (Reynolds & Seeger, 2005; Sutton & Kuligowski, 2019; Cubeddu, 2025). The central questions become: what is happening, who is affected, what should people do, when should they act and whom should they trust (Lindell & Perry, 2012; Sutton & Kuligowski, 2019).

This is especially important for HILP events. Once a rare or cascading event begins to unfold, the lack of familiarity that weakened preparedness can become a source of fear, confusion and urgent information-seeking (Agyepong & Liang, 2022; Dallo, 2022; Sundh, 2024). HILP events may involve hazards that are invisible, technically complex, fast-changing, geographically dispersed or difficult to interpret from local cues alone, such as radiological releases, major earthquakes, volcanic eruptions, pandemics, cascading infrastructure failures or compound events (Sutton & Kuligowski, 2019; Casagli et al., 2021; Parida et al., 2021). Communication must therefore **support sense-making and action at the same time**.

Protection Motivation Theory is useful for framing this response-phase challenge because it distinguishes between **threat appraisal and coping appraisal**. These concepts were already introduced in relation to preparedness, but they are especially important during response. As illustrated, people first assess whether a threat is serious and relevant enough to process further. If threat appraisal is low, they may not engage with the message. If threat appraisal is high, they then assess whether the recommended action is clear, feasible and effective. When coping appraisal is also high, people are more likely to take protective action and “control the danger”. When coping appraisal is low, people may instead try to “control their fear” through disengagement, denial or avoidance (Rogers, 1975, 1983; GCS Behavioural Science Team, 2022).

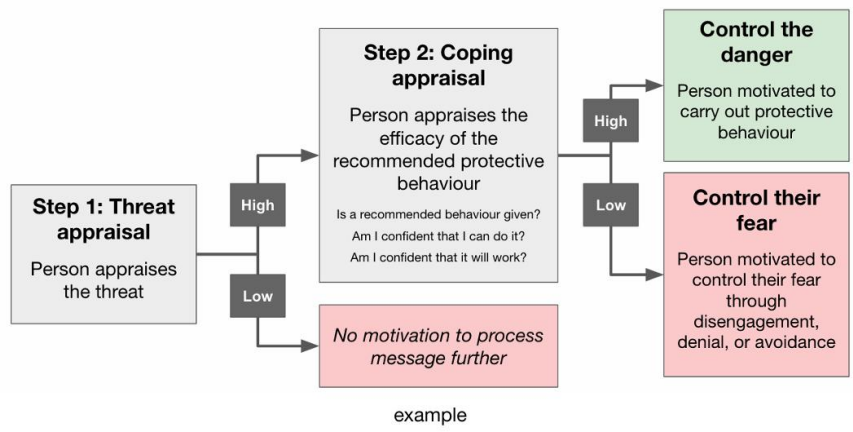


Figure 5. Threat appraisal, coping appraisal and protective behaviour in Protection Motivation Theory (GCS Behavioural Science Team, 2022).

For HILP crisis communication, this means that messages should not only make the seriousness of the situation clear. They must also explain what action is recommended, why that action helps, whether it is urgent, how people can carry it out and what support exists for people who face barriers. Otherwise, communication may successfully increase concern without increasing protective behaviour.

This gap between concern and action is not only a matter of message design. For many people, low coping appraisal reflects not a failure to understand the recommended action but a genuine

lack of capacity to carry it out. An instruction to evacuate, for example, may be clearly understood and accepted as necessary, yet still go unheeded because the person has no transport, no knowledge of safe routes, no accessible temporary shelter, no means of caring for dependants during displacement, or no financial resources to sustain relocation. In HILP events — where cascading impacts may simultaneously disrupt transport networks, overwhelm public services and cut off informal support systems — these barriers are likely to be acute and unevenly distributed. Communication that does not account for the material and institutional conditions required to act on it risks transferring responsibility to individuals who lack the means to respond. Effective protective action communication must therefore be coordinated with the **practical infrastructure that makes protective action possible**: identified evacuation routes, accessible transport, support for people with disabilities, older adults and families with young children, and clear information about where people can go and what assistance is available.

Public behaviour: beyond the panic assumption

A behavioural approach to crisis communication requires avoiding common but misleading assumptions about public panic. Crisis communication is often shaped by the idea that publics are prone to irrational, selfish, or disorderly behaviour and therefore need to be calmed or controlled. However, behavioural and disaster research suggests that **"true panic" is rare**. Behaviours that appear chaotic from the outside are often better understood as **attempts to secure safety, find information, reconnect with others, or meet essential needs under constrained conditions** (GCS Behavioural Science Team, 2022; Clarke, 2002; Heide, 2004; Mawson, 2005; Drury et al., 2013).

This distinction matters because **intense fear and panic are often confused**. For example, running away is the recommended and sensible response to a potential firearms attack. Yet, to an observer watching news footage of crowds leaving a train station at speed, this behaviour may look like "mass panic". The people involved may be seriously afraid, but their action — moving quickly away from danger — is rational and consistent with the emergency advice. Similarly, when people report observing or experiencing "panic" during a crisis, they are often describing understandable fear, urgency, confusion, or information-seeking rather than uncontrolled behaviour that puts others at risk.

Classic disaster research supports this distinction. Quarantelli (1954) defined panic as an **acute fear reaction involving loss of self-control** but also showed that **it is not the normal response to disaster**. It tends to occur only under specific conditions, such as immediate threat, perceived entrapment, limited escape options, or perceived competition for survival. Dynes (1970) and later Tierney, Lindell and Perry (2001) showed that **disaster behaviour is often socially organised, adaptive, and guided by emergent norms** rather than by social breakdown. Clarke (2002) similarly argues that "panic" is often a misleading label applied to urgent but meaningful behaviour under uncertainty.

Figure 6. On 9/11, people in the World Trade Centre took twice as long to descend than safety engineers had predicted. In the image, firefighter Mike Kehoe helps evacuate people from the stairwell of Tower 1 during the attacks. Kehoe escaped before the towers collapsed; 343 firefighters did not survive. | John Labriola, AP (Ripley, 2008).

Evidence from major emergencies also challenges the panic assumption. Studies of evacuation during the 1993 World Trade Centre bombing found that **behaviour was shaped by social relationships, group processes, information exchange, and emergent norms** rather than by uncontrolled panic (Aguirre, Wenger, & Vigo, 1998). Research following the 9/11 attacks similarly showed that evacuation from the World Trade Centre involved delay (referred to as "the reckoning stage"), information-seeking, helping behaviour, group

coordination, and assistance to injured or less mobile people, rather than a simple pattern of selfish flight (National Institute of Standards and Technology [NIST], 2005; Gershon et al., 2007).

These findings are important because they show that even under extreme and life-threatening conditions, **people often try to understand what is happening, coordinate with others, and help those around them**. At the same time, behavioural paralysis and delayed response are also documented — particularly when the situation is unfamiliar, when cues are ambiguous, or when the scale of the threat exceeds prior experience. Both patterns have direct implications for communication: messages should support active sense-making and collective efficacy, not assume either immediate orderly compliance or irrational panic.

The **persistence of the panic myth matters because it can shape communication in counterproductive ways**. If authorities assume that the public is likely to panic, they may delay warnings, soften the severity of messages, withhold uncertainty, avoid worst-case information, or rely on vague reassurance rather than clear instructions. These strategies may be intended to prevent disorder, but they can undermine trust and protective action. When people sense that information is incomplete, delayed, or overly reassuring, they may seek confirmation elsewhere, rely on unofficial sources, or interpret institutional silence as evidence that something is being hidden.

The Chernobyl disaster on 26 April 1986 remains one of the most documented historical examples of this dynamic. Soviet authorities delayed public warnings, minimised the scale of the danger and suppressed information for days after the accident. The international community learned of the accident not through official Soviet disclosure but after elevated radiation was detected at the Forsmark nuclear plant in Sweden on 28 April 1986. The evacuation of Pripyat began only on the third day. The long-term consequence was a collapse of institutional credibility that extended well beyond the accident itself — a reminder that communication designed to prevent alarm can produce far greater distrust than transparency would have done.

In this sense, **communication designed around fear of panic can contribute to the confusion, mistrust, and uncoordinated behaviour it aims to avoid** (Mileti & Sorensen, 1990; Clarke, 2002; GCS Behavioural Science Team, 2022).

The panic myth can also distort how authorities understand **crowd dynamics**. Crowds are often treated as inherently volatile or irrational, but **crowd behaviour is usually shaped by information, social norms, shared identity, environmental constraints, and the availability of safe options**. Apparent disorder may reflect unclear routes, bottlenecks, perceived entrapment, poor communication, lack of visible assistance, or conflicting instructions rather than irrationality. Crowd movement research shows that dangerous outcomes can emerge when density, urgency, limited exits, and poor coordination combine, even when individuals are behaving reasonably from their own perspective (Helbing, Farkas, & Vicsek, 2000; Moussaïd et al., 2016). The task is therefore not simply to “control” crowds, but to **create the conditions for coordinated behaviour**: clear information, visible routes, trusted messengers, feasible instructions, and support for mutual aid.

Crowd conflict should also be understood as an **intergroup communication problem**, not simply as evidence of crowd irrationality. The elaborated social identity model shows that conflict is more likely when authorities treat a diverse crowd as a single threat and act in ways perceived as illegitimate, indiscriminate, or disproportionate. Such responses can create a stronger shared identity among previously diverse crowd members and intensify opposition to authorities (Reicher, 1996; Stott & Reicher, 1998; Drury & Reicher, 2000; Drury, 2026). In HILP events, this matters for evacuation, aid distribution, quarantine enforcement, protest around emergency measures, crowd control, and restrictions on access to affected areas. Communication and operational practice should therefore differentiate between groups and behaviours, explain the rationale for restrictions, support legitimate aims where possible, and respond proportionately to actual risks.

For HILP communication, the implication is important. Strategies based on calming or controlling the public may misdiagnose the problem. The more useful questions are **what people need, what barriers they face, what behaviours they may adopt to overcome those barriers and how communication can make those behaviours safer and more coordinated**. People may seek shelter, water, food, warmth, medical help, money, information, contact with loved ones or ways to assist others. If these needs are blocked, they may rely on unofficial sources or take unsafe actions. Communication should therefore **anticipate need-seeking behaviour, explain where essential support can be accessed and reduce practical barriers to safe action** (GCS Behavioural Science Team, 2022; Michie et al., 2011).

This does not mean ignoring fear. HILP events may generate intense concern because they are uncertain, unfamiliar and potentially catastrophic. But **fear is not the same as panic**. Communication should make fear manageable by connecting it to **clear protective action, credible information and collective efficacy**. Generic instructions such as "do not panic" or "stay calm" are less useful than messages that state the seriousness of the situation, legitimise concern and explain what people can do now. This approach treats the public not as a problem to be managed, but as an active part of the response system.

Collective resilience and the public as active responders

The social identity approach further challenges the panic assumption. Instead of assuming that emergencies turn crowds into irrational or selfish masses, this approach examines how shared threat can create a sense of common fate and, through this, a **shared social identity**. As illustrated, shared identity can support helping, routine civility, expectations of support, collective efficacy and coordinated action. This helps explain why affected publics often organise, assist others and share information during emergencies rather than simply acting as isolated individuals.

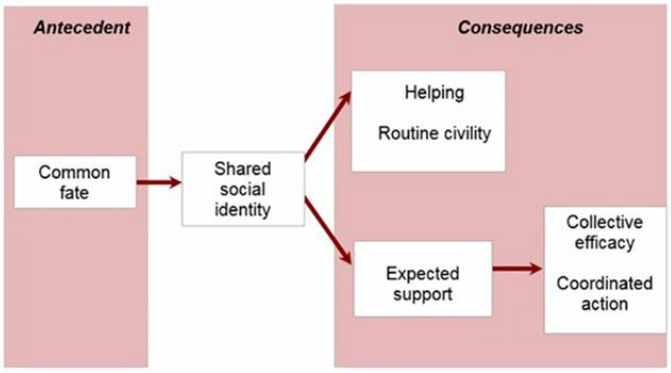


Figure 7. Social identity model of collective psychosocial resilience in emergent groups (Drury et al. 2019).

Drury, Cocking and Reicher (2009) found evidence of **solidarity and mutual support** among emergency survivors, while Drury (2018) argues that **shared social identity helps explain supportive collective behaviour** in mass emergencies. Drury et al. (2019) describe affected publics as **"zero responders" or a "fourth emergency service"**, because survivors and bystanders often provide first aid, emotional support, information, evacuation assistance and practical help before professional responders arrive.

This is highly relevant for HILP events, where cascading impacts often delay or overwhelm centralised response capacity. Collective psychosocial resilience emerges when people experience a shared threat or common fate and begin to **see themselves as part of a shared "we"**. This shared identity can increase solidarity, expected support, collective efficacy, trust and coordinated action (Drury et al., 2019; Drury, 2018). More recent work also distinguishes between a physical crowd and a psychological crowd: a physical crowd is simply a collection of people in the same place, while a psychological crowd exists when people experience themselves as part of a shared group (Drury, 2026; Reicher, 1984, 1987; Turner et al., 1987; Neville & Reicher, 2011; Hopkins et al., 2019; Ntontis et al., 2021).

Crisis communication should therefore **activate and support collective resilience** rather than suppress it. Messages should frame authorities, responders, communities and publics as working together against a shared threat. They should explain **what people can do for themselves, what they can do for others and how they can support responders safely**.

Table 3. Collection of images depicting collective resilience and the public as an active participant in the response.






Drury et al. (2019) provide practical recommendations that are directly relevant here, such as:

- provide informative and actionable communication;
- build shared identity between the public and responders;
- avoid language that positions the public as a problem;
- accommodate the public urge to help;
- and **work with trusted group representatives**: Messages are more likely to be accepted when they are delivered or reinforced by people perceived as part of the audience's own group. This matters because trust is not only institutional; it is relational and identity-based. In HILP events affecting diverse communities, official communication should therefore be coordinated with local authorities, community organisations, faith leaders, transport staff,

venue staff, health workers, schools, employers, and other trusted intermediaries. These intermediaries can help translate official instructions into locally meaningful terms, identify barriers that authorities may not see, reinforce guidance through trusted relationships, and relay community needs, rumours, misunderstandings, and practical constraints back to authorities (Drury et al., 2019).

For HILP communication, this means designing messages not only for individual compliance, but also for safe mutual aid and coordinated community action.

Warning content: what people need immediately

The warning literature is consistent on the core content of effective emergency messages. Sutton and Kuligowski (2019) identify **five elements that warnings should include**:

1. The threat,
2. The affected population or geographical area,
3. The time to act,
4. The recommended protective action, and
5. The source of the message.

These elements are especially important for HILP events because recipients may not already have a clear mental model of the hazard. A warning about a familiar flood or storm may connect to prior experience; a warning about radiological exposure, cascading infrastructure failure, or an unfamiliar biological threat may not (Sutton & Kuligowski, 2019; Herovic et al., 2020; Dallo et al., 2022).

For HILP events, each message element may be difficult to communicate. The threat may be uncertain or evolving, the affected area may change as cascading effects unfold, the time available for action may be unclear, protective actions may be unfamiliar, and several institutions or jurisdictions may be involved (Parida et al., 2021; Casagli et al., 2021; Fathollahzadeh et al., 2024). Warnings should therefore **avoid vague statements and unnecessary technical language** where possible.

They should **answer practical questions directly** (Sutton & Kuligowski, 2019; Greer et al., 2020; Ortiz et al., 2024):

- What is happening,
- Where it is happening,
- Who is affected,
- What could happen next,
- What people should do,
- When they should do it,
- Where they can obtain reliable updates.

Ortiz, Aznar-Crespo and Aledo (2024) distinguish between the technical existence of an alert system and the communicative work of a warning system. Alert systems may be protocolised, but **warning messages still require contextualised content adapted to the emergency and affected populations**. **Pre-written message catalogues and templates** can reduce improvisation, inconsistency and lack of actionability, provided they are tested in advance and remain adaptable to the specific event (Ortiz et al., 2024; Sutton & Kuligowski, 2019).

Spatial information is also central to warning comprehension. Kuligowski (2024) shows that community members use bushfire maps not only to locate the hazard, but also to understand whether they are personally affected, assess the level of threat, decide what action to take, warn others, and monitor changing conditions. Figure 8 illustrates how incident maps can combine warning levels, hazard location, affected areas, and local landmarks. For HILP events, this kind of map can support rapid sense-making, but only if users can clearly understand whether they are inside the affected area, what warning level applies, and what action is expected.

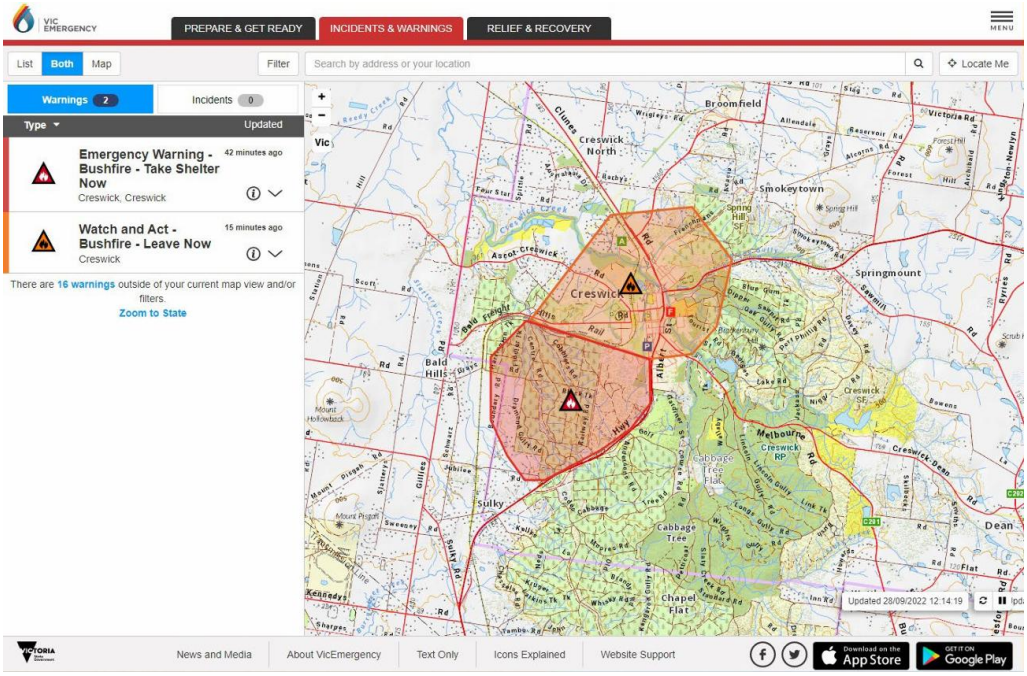


Figure 8. Example of a map used to communicate warning zones and local hazard information (Kuligowski, 2024).

Multi-hazard warning interfaces raise an additional challenge: they must help users interpret several possible hazards, warning levels and action categories at once. Dallo, Stauffacher and Marti (2022) found that **warning overviews were more easily interpreted when they were tailored to users' locations** or pre-selected regions, and **when users could switch between map and list formats**. They also recommend **keeping hazard categories and action categories simple**, since too many levels or ambiguous terms can reduce comprehension. Figure 9 illustrates overview formats that helped users interpret active notifications and identify whether they should inform themselves, prepare, or act.

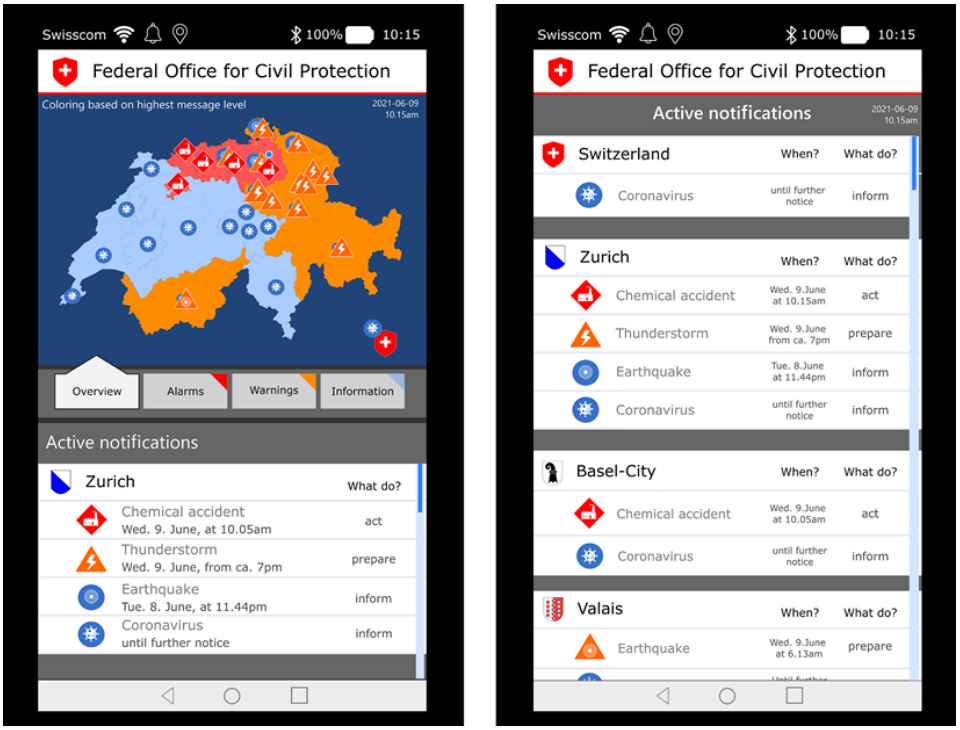


Figure 9. Multi-hazard warning overview formats tested by Dallo, Stauffacher and Marti (2022). These were the two hazard overviews that were correctly interpreted and triggered people the most to act. The authors recommend that the list below the map be tailored to the users' locations or to pre-selected regions. Users should be able to switch between the formats, as they each have their advantages and in combination best meet people's needs.

Dallo et al. (2022) also show the importance of **structuring individual warning messages around action**. In the examples in Figure 10, each notification identifies the hazard, affected area, timing, recommended action, further information, responsible authority and publication time. The **use of action categories such as "Act now", "Prepare yourself" and "Inform yourself" helps translate hazard information into a behavioural prompt**. For HILP communication, this is particularly important because people may face unfamiliar hazards or simultaneous warnings and need to understand quickly what the message means for them.

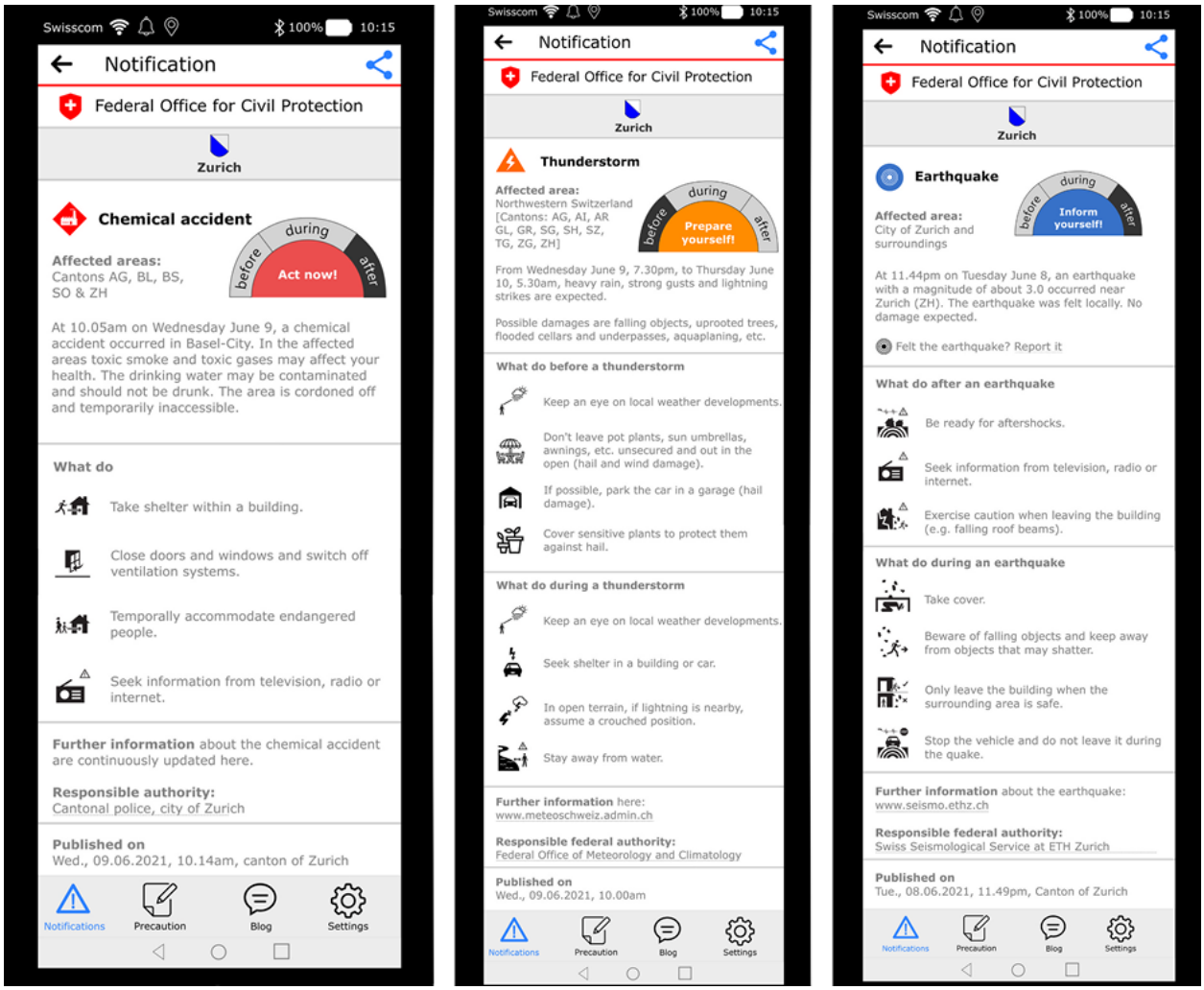


Figure 10. Examples of actionable multi-hazard warning messages structured around hazard, area, timing, action guidance and responsible authority. The hazard messages with the most effective time- and action-related icon (the half-circle icon) for three different hazards. Including an icon is thus important not only for forecasts but also for ongoing hazards or post-event information (Dallo, Stauffacher and Marti, 2022).

Clarity, consistency and actionability

A recurring finding in warning research is that **clarity and internal consistency are essential**. Messages with **clear calls to action produce stronger threat and coping appraisal**, especially when people perceive the recommended action as effective and feasible (Mehta, 2022; Greer et al., 2020; Sutton & Kuligowski, 2019). Warnings should contain **one main instruction** wherever possible; combining messages such as "Evacuate Now" with advice for people who decide to stay can create uncertainty about the expected behaviour. Alternative instructions may sometimes be necessary, but they should be clearly separated, targeted to specific groups, or placed in linked supporting resources (Tippett et al., 2021; Greer et al., 2020).

Language also matters. Mehta (2022) and related warning research identify **words and phrases that communicate high threat and urgency**, such as "Evacuate Now", "Act Now" and "Prepare

to Evacuate". These terms can increase urgency and protective intentions, but they must be calibrated and used consistently across hazards and jurisdictions (Mehta, 2022; Tippett et al., 2021). A **harmonised lexicon of warning terms** can help ensure that the same words carry the same meaning across agencies and communities.

Guidance on public warning systems and social media messages also stresses consistency across channels. The **Common Alerting Protocol** can support this by providing a **standard structure** for communicating **hazard type, severity, urgency, affected area and recommended action** across different systems and platforms (Rossi et al., 2018; CEN, 2023). Consistent terminology and message structure reduce the risk that different audiences receive different interpretations of the same event.

Clarity also means **translating technical information into meaningful consequences**. Emergency messages should assume that recipients may lack detailed hazard knowledge, geographic knowledge, or prior preparedness. Past events can sometimes be used as reference points to help people understand possible impacts, while **direct links to authoritative information** can reduce barriers to information seeking. **Bolding, headings, colours, icons and text boxes** can help **highlight key information** such as location, warning level and protective action, but they should support rather than replace clear wording.

Visual features can support warning interpretation, but they should not be treated as a substitute for clear text. Greer et al. (2020) found that adding colours or icons to "Evacuate Now" bushfire messages produced small positive effects on **perceived comprehension, message effectiveness, perceived risk and self-efficacy**. Red headers were especially effective, likely because red is strongly associated with danger. However, orange headers on "Prepare to Evacuate" messages showed no significant effect, and icons generally had limited impact. This suggests that **visual cues are most useful when they reinforce urgency and action, while the warning itself still needs clear, specific and actionable wording**.

Figure 11. Examples of colour and icon variations in "Prepare to Evacuate" warning messages tested (Greer, Dootson, Miller, and Tippett, 2020).

This is where the threat-and-coping logic becomes operational. Threat-based messages should be strengthened with efficacy. A weaker message says only that flooding can be deadly and that people should stay vigilant. A stronger message identifies the local risk, points to a simple action and explains why it helps: for example, preparing an emergency flood kit can be easy and can save lives. Similarly, a COVID-19 message that simply stresses danger is less useful than one explaining that specific behaviours, such as ventilation or face coverings, reduce transmission. For HILP events, the broader rule is to pair seriousness with feasible action: messages should communicate urgency but also show people what they can do and why it matters.

Table 4. Example: How to enhance threat-based messages with insights from Protection Motivation Theory (GCS Behavioural Science Team, 2022).

Weaker message	Stronger message
Flooding can be deadly. Stay vigilant and keep up to date with the latest advice.	*There is a high risk of flooding in your area. Using this checklist makes preparing an emergency flood kit easy, and it can save your life.*

COVID-19 is a deadly disease, and the only way to completely avoid it is to stay at home.	*Catching COVID-19 can have long-term health consequences. Wearing a face covering and letting fresh air in reduces the spread of the virus.*

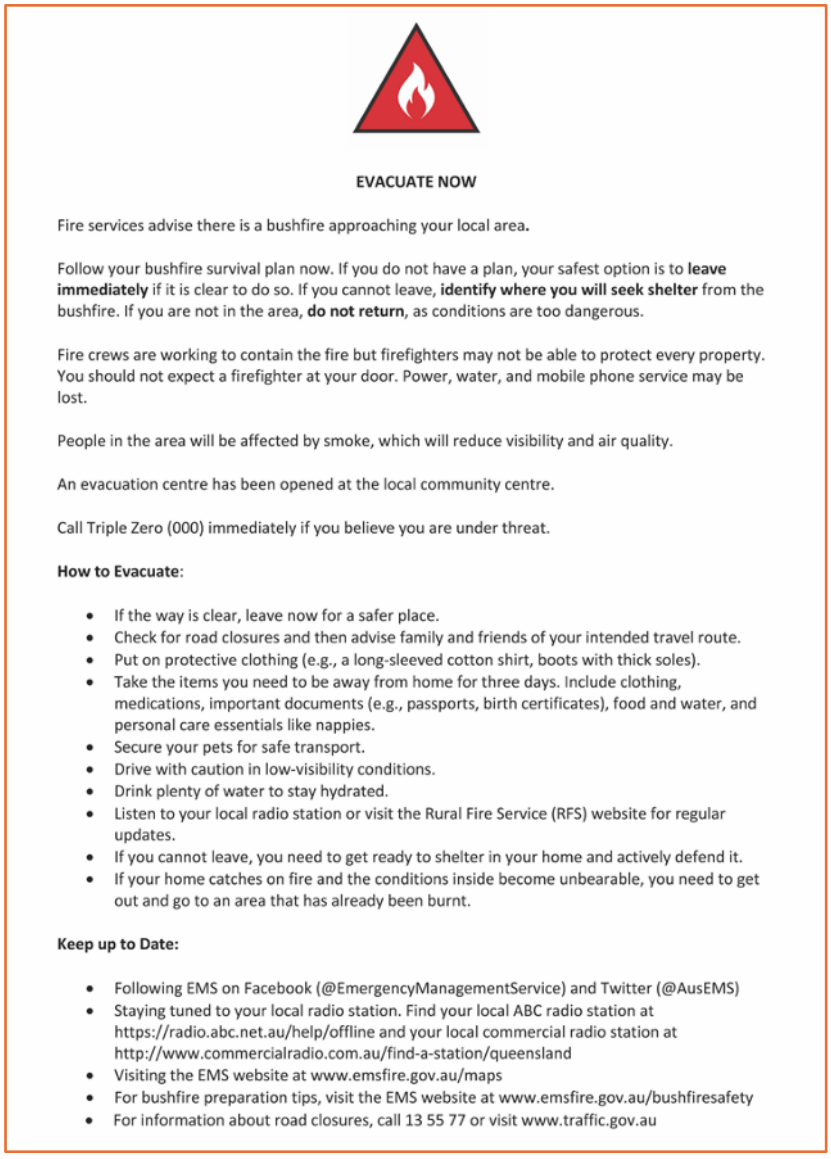
A practical disaster warning template should therefore include:

- **source,**
- **hazard,**
- **affected area,**
- **expected impacts,**
- **time window,**
- **one main protective action,**
- **explanation of why that action matters,**
- **support for people who cannot act alone,**
- **and a reliable update point.**

Communication authorities and civil protection agencies should test this template in advance with diverse audiences — including vulnerable groups, tourists, cross-border audiences and people with low prior knowledge of the hazard — working with local organisations, disability groups, and migrant and tourist-facing services to reach groups that standard testing processes tend to miss.

Public warning guidance makes this operational. Rossi et al. (2018) identify core alert elements that are directly relevant to HILP warnings: the hazard, affected location, time validity, behavioural instructions, source of the message and sufficient anticipation where possible. CEN (2023) provides similar guidance for social media warnings, recommending that messages identify the alerting authority, target audience, threat type, severity and likelihood, recommended action, expected impacts, time of issue and where to obtain more information.

In sum, effective warnings need more than a hazard label or alert level. They should translate the threat into clear, feasible protective action. Figure 12 illustrates an action oriented "Evacuate Now" bushfire message tested by Greer et al. (2020). The message **combines urgency with practical guidance**: it identifies the hazard, gives a clear evacuation instruction, explains expected impacts, warns about possible service disruption, identifies an evacuation centre, provides step-by-step evacuation advice and lists trusted update channels. This type of structure is especially relevant for HILP events, where people may need to act quickly under uncertainty and may not already know what protective action is required.



EVACUATE NOW

Fire services advise there is a bushfire approaching your local area.

Follow your bushfire survival plan now. If you do not have a plan, your safest option is to **leave immediately** if it is clear to do so. If you cannot leave, **identify where you will seek shelter** from the bushfire. If you are not in the area, **do not return**, as conditions are too dangerous.

Fire crews are working to contain the fire but firefighters may not be able to protect every property. You should not expect a firefighter at your door. Power, water, and mobile phone service may be lost.

People in the area will be affected by smoke, which will reduce visibility and air quality.

An evacuation centre has been opened at the local community centre.

Call Triple Zero (000) immediately if you believe you are under threat.

How to Evacuate:

- If the way is clear, leave now for a safer place.
- Check for road closures and then advise family and friends of your intended travel route.
- Put on protective clothing (e.g., a long-sleeved cotton shirt, boots with thick soles).
- Take the items you need to be away from home for three days. Include clothing, medications, important documents (e.g., passports, birth certificates), food and water, and personal care essentials like nappies.
- Secure your pets for safe transport.
- Drive with caution in low-visibility conditions.
- Drink plenty of water to stay hydrated.
- Listen to your local radio station or visit the Rural Fire Service (RFS) website for regular updates.
- If you cannot leave, you need to get ready to shelter in your home and actively defend it.
- If your home catches on fire and the conditions inside become unbearable, you need to get out and go to an area that has already been burnt.

Keep up to Date:

- Following EMS on Facebook (@EmergencyManagementService) and Twitter (@AusEMS)
- Staying tuned to your local radio station. Find your local ABC radio station at https://radio.abc.net.au/help/offline and your local commercial radio station at http://www.commercialradio.com.au/find-a-station/queensland
- Visiting the EMS website at www.emsfire.gov.au/maps
- For bushfire preparation tips, visit the EMS website at www.emsfire.gov.au/bushfiresafety
- For information about road closures, call 13 55 77 or visit www.traffic.gov.au

Figure 12. Example of an action oriented "Evacuate Now" bushfire warning message (Greer, Dootson, Miller, and Tippett, 2020).

Hazard sensitivity and message testing

Warning messages should also be **adapted to hazard type**. Evidence comparing warning compliance across severe weather, violent acts and COVID-19 suggests that predictors of compliance differ by risk context. For severe weather, intention to comply was associated with perceived severity; for violent acts, compliance was more strongly associated with anticipated negative emotions; for COVID-19, risk appraisal did not significantly predict compliance, with age acting as a stronger predictor (Rahn et al., 2021). This suggests that **different hazards activate different combinations of cognitive appraisal, emotional appraisal, routine behaviour, trust, vulnerability and social norms**.

This reinforces the **need to test warning messages** across HILP scenarios rather than assuming that one format will work for all hazards. Severe weather-type events may require emphasis on expected impacts, timing and severity. Sudden violent or hostile-threat events may require shorter and more urgent messages. Pandemic-type or prolonged events may require sustained communication that supports habits, trust, social norms, self-efficacy and perceived effectiveness over time. Message testing should therefore **examine not only whether messages are understandable, but also whether they increase perceived relevance, response efficacy, self-efficacy, trust, urgency and willingness to act.**

Trust, legitimacy and respectful communication

Compliance with crisis guidance depends not only on whether people understand the instruction, but also on **whether they see the message, the messenger and the measure itself as legitimate, fair and respectful**. Most people are more likely to follow guidance when they understand what is required, why it matters, how it helps, and how practical barriers can be overcome.

Communication that appears coercive, blaming or dismissive can trigger **psychological reactance** – an unpleasant feeling of tension that drives individuals to reject rules, advice, or demands, often resulting in them doing the exact opposite of what is requested –, especially **when people feel that their autonomy, identity or control is being threatened** (GCS Behavioural Science Team, 2022; Webster et al., 2020; Neville et al., 2021). This is particularly relevant for HILP events where protective measures may be disruptive, prolonged, unevenly burdensome, or difficult to maintain over time.

Trust is not a single attribute of authorities. Drawing on organisational trust research, the GCS guide highlights **three core components of trustworthiness** (GCS Behavioural Science Team, 2022; Mayer, Davis, & Schoorman, 1995):

1. **Competence:** refers to whether authorities appear capable and effective;
2. **Integrity:** refers to whether they are truthful, consistent, and principled;
3. **Benevolence:** refers to whether they are perceived as caring about public wellbeing

These distinctions are useful for HILP communication because different failures damage different aspects of trust. Delayed, inaccurate, or poorly coordinated messages may undermine competence; unexplained changes, contradictions, or withheld information may undermine integrity; and messages that ignore public hardship may undermine benevolence.

Crisis communication should therefore demonstrate all three qualities:

1. To show competence, authorities should **explain the plan, the evidence base, and the actions being taken**.
2. To show integrity, they should **be open about uncertainty, changes, and mistakes**.
3. To show benevolence, they should **acknowledge public needs, communicate with empathy, and explain how decisions protect people fairly**.

Honest communication is not the opposite of reassurance; it is one of the conditions for credible reassurance.

The GCS Behavioural Science Team (2022) illustrates the importance of tone through examples of messages that are more or less likely to cause reactance. Messages that threaten important freedoms or tie behaviour to moral worth may provoke resistance, while messages that enable informed choice and use neutral language are less likely to do so.

Table 5. Example: Messages that are more/less likely to cause psychological reactance (GCS Behavioural Science Team, 2022).

More likely to cause reactance	Less likely to cause reactance
Strong threat to important freedoms: *If you don't get vaccinated, you will be banned from some events.*	Enable informed choice: *It's not too late to get vaccinated. Chat to GPs this weekend by ringing 191.*
Tying behaviour to moral or personal values: *If you care about others, wear your mask.*	Use neutral language: *Please wear a face covering in the building.*

The crowd behaviour literature referenced above also cautions against withholding information to prevent panic, as referred above. If authorities assume that the public will panic, they may restrict information, delay warnings, or rely on vague reassurance. Drury's review shows that this can be

counterproductive: people may fail to prepare or evacuate in time, and **trust may be damaged** if the public later believes that information was withheld (Drury, 2026; Proulx & Sime, 1991; Drury et al., 2013). For HILP events, the relevant principle is to tell people the truth early, while also giving clear protective actions and explaining uncertainty.

Communication also shapes whether responders are seen as legitimate helpers. Evidence from mass casualty and CBRN decontamination studies shows that procedures based on panic assumptions — such as limited information, shouting, threats, or command-only communication — can increase anxiety, anger, and resistance. By contrast, communication that is informative, empathic, supportive, and open can increase perceived responder legitimacy, reduce anxiety, and improve cooperation with emergency procedures (Carter et al., 2013b, 2014a, 2015; Drury et al., 2019; Drury, 2026). This is directly relevant to HILP events involving unfamiliar, intrusive, or disruptive measures, such as evacuation, sheltering, decontamination, quarantine, triage, movement restrictions, or controlled access to affected areas. People are more likely to cooperate when they understand what is happening, why a procedure is necessary, what will happen next, and how responders are acting in their interests.

In prolonged crises, communication must therefore do more than issue repeated instructions. It needs to **sustain motivation, reinforce collective efficacy** and show that individual behaviour contributes to a **wider shared effort**. The COVID-19 message in Figure 13 illustrates this approach. By stating that "every day at home is making a difference", the message frames staying at home not as passive obedience, but as an active contribution to reducing harm. It also uses inclusive language — "let's keep going" — to reinforce shared responsibility and collective persistence.

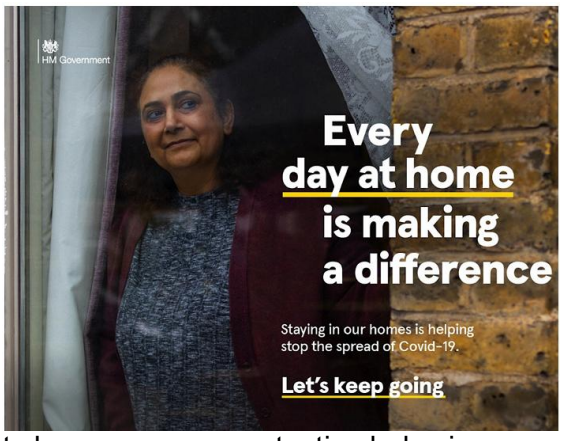


Figure 13. Example of collective-efficacy messaging during COVID-19 (GCS Behavioural Science Team, 2022).

This type of communication is relevant for HILP events because many protective behaviours are not one-off actions. Evacuation warnings may require immediate compliance, but pandemics, prolonged infrastructure disruption, environmental contamination, heatwaves, or extended recovery periods may require people to sustain protective behaviours over days, weeks or months. In these situations, messages should acknowledge effort, explain why continued action still matters, and show that people's actions are part of a collective response.

Institutional crisis communication guidance also emphasises **people-centred language**. UNDP (2024) recommends that crisis messages describe the situation and the actions being taken but also remain emotionally appropriate and focused on people rather than organisations. Affected publics need to understand what the situation means for households, communities, services, livelihoods and daily life. Bureaucratic language, acronyms or organisational self-protection can weaken trust, while human-centred communication can support empathy, legitimacy and cooperation.

Crisis messages should therefore **explain the rationale for protective measures, emphasise shared goals, use trusted messengers** where possible, and **avoid over-publicising non-compliance** if it is not widespread. If authorities repeatedly highlight rule-breaking, they may unintentionally create the impression that non-compliance is normal. A **staged approach of engaging, explaining, encouraging and only then enforcing** is more consistent with evidence that people are more likely to comply when they feel listened to, treated fairly and given clear reasons (GCS Behavioural Science Team, 2022). For HILP communication, the tone should

therefore be firm but respectful: guidance should be clear about what is expected, while also recognising constraints, supporting collective efficacy and avoiding blame.

Communicating uncertainty, conflicting cues and misinformation

HILP response communication must communicate uncertainty without creating confusion or false certainty. In fast-moving or cascading events, authorities may not know the full scale, pathway or duration of the risk. The evidence suggests that communication should distinguish between:

- **what is known,**
- **what is unknown,**
- **what is being done to find out,**
- **what people should do now,**
- **and when further information will be provided.**

This is preferable to silence, vague reassurance or overconfident statements that later prove wrong (Reynolds & Seeger, 2005; Anthony et al., 2023; GCS Behavioural Science Team, 2022).

This is especially important for HILP events because uncertainty is not only a technical problem; it is also a trust and sense-making problem. Public health and crisis communication guidance increasingly emphasises the need to "speak in uncertainty": to explain what is currently known, what remains uncertain, how evidence is being gathered, why recommendations may change, and how decisions are being made (WHO Regional Office for Europe, 2024). During prolonged or evolving crises, such as pandemics, scientific evidence and public guidance may change over time. If this is not explained, changing recommendations may be interpreted as inconsistency, incompetence, or concealment rather than as a normal feature of decision-making under uncertainty (Khan et al., 2022; Palma-Oliveira, Trump, & Linkov, 2021).

This approach is also reflected in institutional crisis communication guidance. WHO guidance on public health emergencies emphasises the need to "speak in uncertainty", including explaining what is known, what remains unknown, what is being done and why recommendations may change (WHO Regional Office for Europe, 2024). The UK Government Communication Service similarly recommends setting expectations that information may change quickly and communicating consistently about what is known, what is not yet known, what authorities are doing, what the public should do and when further information can be expected (GCS Behavioural Science Team, 2022). A practical uncertainty formula can therefore be used across response communication: state what is confirmed, what is still uncertain, what authorities are doing, what people should do now, and when the next update will come. This approach helps avoid two common failure modes: official silence, which leaves an information vacuum, and overconfident reassurance, which may damage credibility if the situation later changes.

Uncertainty is made harder when **official messages conflict with what people see, hear, or receive** from other sources. Warning response is shaped not only by the warning itself, but also by environmental cues, media cues, unofficial organisations, and social cues from neighbours, family, friends, and the wider community. When these cues contradict official advice, people may delay action, seek confirmation, reinterpret the warning, or follow the cue that feels more immediate or credible. Figure 14 summarises the main types of socio-environmental cues that can conflict with agency warnings.

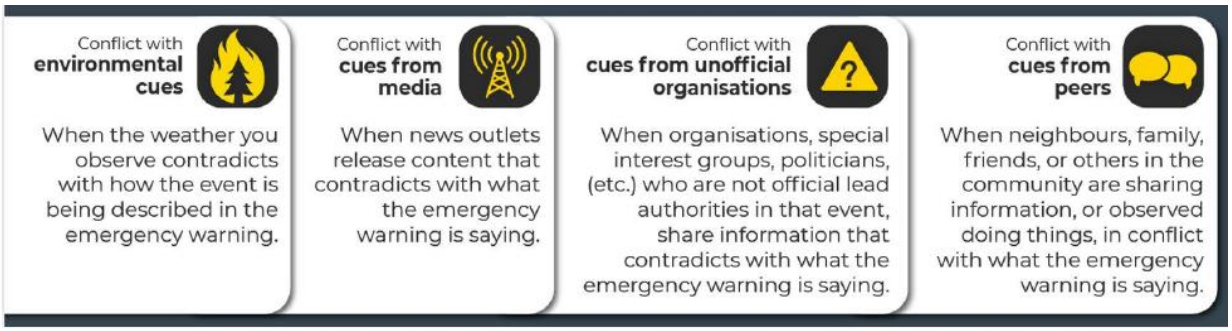


Figure 14. Socio-environmental cues that may conflict with official warning messages (Tippett et al., 2021).

Visual media can be especially powerful because images may appear to provide direct evidence of what is happening. However, **visuals can also undermine official guidance when they show behaviour that contradicts emergency instructions**. For example, media images of people playing in floodwater can conflict with official "do not play in floodwater" or "stay indoors" advice, even when the news story itself is about danger. Such images may normalise unsafe behaviour or create ambiguity about how seriously the instruction should be taken.

Figure 15. Examples of media visuals during natural hazard emergencies that conflict with official emergency instructions. The left image conflicts with instruction to "stay indoors" and the right image conflicts with the instruction "do not play in floodwater" (Tippett et al., 2021).

Information vacuums are especially risky in HILP events because uncertainty, high stakes, fragmented channels, and public anxiety can create space for rumours, speculation, and misinformation. WHO's approach to risk communication, community engagement and infodemic management highlights the importance of **systematic listening, including social listening, focus groups, sentiment analysis, message testing, and the identification of information voids** (WHO Regional Office for Europe, 2024).

Social media should therefore **not be treated only as a broadcast channel**. It is also a source of public concerns, rumours, misunderstandings, unmet needs, local observations, and misleading or manipulated content (Agyepong & Liang, 2022; Khan et al., 2022; Fathollahzadeh et al., 2024). Misleading content should not go unaddressed: leaving misinformation unchallenged allows it to fill the information void. Responses should be factual, timely and non-confrontational — correcting the record without amplifying the false message (Palma-Oliveira et al., 2017).

The Australian bushfire example in Figure 16 illustrates how problematic visuals can circulate widely during disasters. A composite image shared during the 2019–2020 fires digitally combined separate images to create a powerful but misleading visual. Such content can intensify fear, distort public understanding of impacts, and make it harder for official communicators to maintain an accurate information environment. The point is not that emotional images should be avoided altogether, but that **crisis communicators must monitor how visuals are being used, correct misleading content quickly, and provide credible alternative information**.

Figure 16. Example of manipulated problematic visual circulated during the 2019-2020 Australian bushfires. The photo on the left, which was shared widely on social media during the bushfire crisis, is a composite of at least three other images that have been digitally combined in Photoshop, including photos on the right (Dootson et al., 2021).

Linking social media posts to a persistent source, such as a Common Alerting Protocol message or official webpage, can help **maintain consistency across platforms** (CEN, 2023). For HILP events, this is important because inconsistent terminology, conflicting updates, or fragmented messages across agencies can undermine trust and increase the space for misinformation.

Misinformation management should not rely only on correction after rumours have spread. Agencies should **anticipate likely misunderstandings, monitor emerging narratives, and respond quickly to information voids**. Corrections should be specific, timely, and linked to actionable guidance. In HILP events, misinformation may concern the cause of the event, the severity of the threat, the safety of protective actions, the availability of aid, the trustworthiness of institutions, or the needs of affected groups.

WHO's risk communication, community engagement and infodemic management guidance strengthens this point by treating listening as part of emergency communication, not an optional add-on. Tools such as social listening, focus groups, sentiment analysis, message testing and the identification of information voids can help authorities understand what different groups are hearing, misunderstanding, fearing or unable to act upon (WHO Regional Office for Europe, 2024). For HILP events, this is important because rumours and misleading claims often spread where official information is delayed, unclear or incomplete. Social media should therefore be used not only to broadcast official messages, but also to detect emerging concerns, misinformation, unmet needs and barriers to protective action.

Communication should therefore **combine official updates with two-way listening, trusted intermediaries, community-level feedback, and rapid correction of misleading claims or visuals**.

Finally, uncertainty and misinformation communication must be **coordinated across institutions**. If different agencies, jurisdictions, experts, or political leaders communicate different interpretations of the same evolving event, the public may struggle to identify which source is authoritative. This is particularly relevant for cross-border, multi-agency, technological, public health, or infrastructure-disruption events. For HILP response communication, managing misinformation therefore means more than correcting false claims. It requires maintaining a credible information environment through transparency, consistency, monitoring, rapid response, and alignment between official messages, visuals, media partners, and community intermediaries.

Inclusion, access and coordination during response

HILP crisis communication must be **inclusive, accessible, and resilient**. It should not assume that all audiences can receive, understand, trust, or act on the same message in the same way.

Vulnerable groups may face barriers linked to disability, age, language, mobility, literacy, housing conditions, socioeconomic status, digital access, institutional distrust, or weak informal networks (UNDRR & WMO, 2023; Dehghani et al., 2022; Xue et al., 2022). These barriers are especially important during HILP events because cascading impacts may disrupt the systems through which information, mobility, care, and support normally reach people.

Inclusion is therefore not only a matter of translating messages or adding accessible formats, although both are essential. It also requires **designing communication around the real conditions in which people receive and use information**. Dehghani et al. (2022), for example, emphasise that disaster risk communication in health systems must account for vulnerable groups, institutional coordination, and the practical conditions under which information is received and acted upon. Xue et al. (2022) similarly show that decisions such as relocation are shaped not only by risk perception, but also by livelihood, affordability, social ties, and trust in government support. For response communication, this means that instructions must be connected to realistic support: evacuation advice is not sufficient if people lack transport, accessible shelters, childcare, medication, money, or trusted assistance.

Communication channels also need redundancy. Public warning system guidance stresses that no single technology can meet all warning requirements; communication should combine channels such as SMS, cell broadcast, sirens, television, radio, apps, websites, social media, community organisations, local leaders, and door-to-door or face-to-face contact where needed (Rossi et al., 2018; UNDRR & WMO, 2023). This is especially important for HILP events because power, mobile networks, internet access, transport, or institutional communication systems may fail. Digital tools are valuable, but they must be complemented by low-tech and no-tech options.

Two-way communication is equally important. Many public warning systems remain predominantly one-directional, even though local observations, community reports, and public feedback may be essential during fast-moving, cascading, or uncertain events (Rossi et al., 2018). Jan et al. (2025a, 2025b) show that disaster apps can become more useful when they move beyond static information and include **reporting, needs assessment, two-way functions, and links to authorities**. For HILP response communication, affected people should not be treated only as recipients of warnings. They can also provide information about blocked roads, infrastructure failures, unmet needs, misinformation, vulnerable neighbours, or changing local conditions.

Coordination across agencies is also a communication requirement, not just an operational one. HILP events often involve several institutions, sectors, jurisdictions, and sometimes countries. If responsibilities are unclear or agencies issue inconsistent messages, the public may receive contradictory guidance. Standards such as the Common Alerting Protocol can support interoperability by helping different systems and channels **communicate consistent information** about hazard type, severity, location, timing, and recommended action (Rossi et al., 2018; CEN, 2023). However, technical standardisation is not enough. Agencies also need **shared terminology, agreed spokespersons, escalation procedures, and pre-established coordination mechanisms**.

Institutional guidance also stresses the need to **"speak with one voice"** during crises, while avoiding excessive or poorly prioritised messaging (ESM, 2024). Speaking with one voice does not mean suppressing uncertainty or disagreement. It means that agencies should align terminology, source attribution, recommended actions, update cycles and explanations of uncertainty so that the public receives coherent guidance. Frequent communication is useful only if each update reduces confusion.

Multi-agency coordination failures are not only technical or procedural; they can also be psychological and identity-based. Davidson et al. (2025) apply the Social Identity Approach to interoperability and show that responders from police, fire, and ambulance services may operate through strong organisational identities that can make joint working harder. **Interoperability**

improves when responders develop a shared identity as one emergency response team, because this supports trust, communication, confidence, respect, information-sharing, and coordinated action. This is directly relevant to HILP events, where cascading impacts often require multiple agencies and sectors to work together under uncertainty. Communication should therefore **build a shared operational "we" across agencies** by clarifying common goals, explaining roles, using shared language, creating opportunities for joint interaction, and addressing structural or cultural barriers that keep services working in silos (Davidson, Carter, Drury, Amlôt, & Haslam, 2025).

This is particularly relevant to AGILE's focus on interagency alignment, critical infrastructure, public inclusion in information gathering, and cross-border coordination. In fact, AGILE's stress test exercises consistently surface interagency alignment as a primary need: participants — often for the first time in a structured multi-actor setting — recognise that their separate communication plans are not compatible under shared event conditions. HILP response communication should therefore be planned as a **multi-actor process** that identifies who communicates what, through which channels, to which audiences, and how information from communities, responders, infrastructure operators, media organisations and neighbouring jurisdictions will be integrated. Where multiple organisations are involved, messages should still **appear coherent to the public**: consistent in terminology, compatible in recommended action, clear about source and authority, and aligned with what people are likely to see in media and local environments.

Overall, inclusion and coordination are conditions for actionable communication. A message is not effective simply because it is accurate or timely. It must reach the people at risk, be understandable and trusted by them, connect to feasible action, and remain coherent across the institutions and channels involved. For HILP events, this requires **accessible formats, multilingual communication, trusted intermediaries, channel redundancy, two-way feedback, coordinated institutional messaging, and active monitoring of conflicting cues and misinformation**.

2.2.3. Recovery phase: explanation, accountability, learning and future preparedness

From crisis response to recovery communication

Communication after a disaster is often treated as less urgent than preparedness or crisis response, but it is a critical phase of risk communication. Once the immediate threat has passed or stabilised, **affected publics still need information** about safety, services, health risks, damaged infrastructure, compensation, recovery timelines, and future risk (Cubeddu, 2025; Anthony et al., 2023; Xue et al., 2022). Post-event communication also **shapes whether the disaster becomes a moment of learning and preparedness**, or whether it is treated as an isolated interruption after which institutions and communities return to previous assumptions (Parida, Moses, & Rahaman, 2021; Agyepong & Liang, 2022).

Cubeddu (2025) frames this as the ex-post phase of risk and emergency communication, where the communicative task is to explain impacts, support regeneration, and encourage participation in safeguarding actions for the future. This is particularly important for HILP events because their consequences may continue long after the acute phase. Infrastructure disruption, displacement, health effects, economic loss, environmental contamination, social conflict, institutional distrust, and cascading impacts may persist for weeks, months, or years (Parida et al., 2021; Casagli et al., 2021; UNDRR & WMO, 2023). Communication after HILP events therefore cannot be limited to saying that "the event is over". It must **help people understand what remains unsafe, what support is available, what is still uncertain, what is being done, and how lessons will be used to reduce future risk** (Cubeddu, 2025; Anthony et al., 2023; Fathollahzadeh et al., 2024).

This phase also completes the risk communication cycle. Recovery communication should not only describe damage or provide administrative updates; it should **support explanation, accountability, continued engagement, recovery choices, evaluation, institutional learning, and renewed preparedness**. Post-event evaluation and learning are part of a continuous communication process rather than an optional add-on.

Recovery information and continuing uncertainty

The first post-event communication task is practical: **people need clear, accessible, and regularly updated information about recovery conditions**. This may include information on safe return, damaged buildings, drinking water, health risks, environmental hazards, transport disruption, school and workplace closures, financial assistance, psychological support, compensation schemes, relocation options, and rebuilding processes (Cubeddu, 2025; Xue et al., 2022; Dehghani et al., 2022).

In cascading HILP events, this communication may be especially complex because the end of the initial hazard does not necessarily mean the end of risk. A flood may be followed by contamination, infrastructure disruption, housing loss, disease risk, and economic hardship; a technological accident may be followed by environmental monitoring, compensation disputes, and long-term health concerns; a pandemic may leave continuing effects on health systems, livelihoods, education, trust, and social cohesion.

Post-event uncertainty should therefore be communicated honestly. After major events, authorities may still be investigating causes, damage, contamination, structural safety, casualty numbers, long-term health effects, or future hazard likelihood (Reynolds & Seeger, 2005; Anthony et al., 2023; Fathollahzadeh et al., 2024). Communicating uncertainty remains important because public trust can be damaged if authorities appear to hide information, minimise harm, or issue premature assurances that later prove incomplete (Anthony et al., 2023; Palma-Oliveira, Gaspar, & Mendes, 2017). The same crisis communication principles of transparency, credibility, and empathy continue into the recovery phase: authorities should explain what is known, what remains uncertain, what is being investigated, when further information will be available, and how affected people can access support (Reynolds & Seeger, 2005; Cubeddu, 2025; Anthony et al., 2023).

This is especially relevant for technological, environmental, or public health HILP events, where consequences may not be immediately visible. Radiological, chemical, biological, or contamination events may require long-term communication about exposure, monitoring, health surveillance, and uncertainty (Sutton & Kuligowski, 2019; Khan et al., 2022). Pandemic communication similarly shows that scientific evidence, policy measures, and public guidance may evolve over time, making it essential to explain why recommendations change rather than presenting change as inconsistency or institutional failure (Khan et al., 2022; Palma-Oliveira, Trump, & Linkov, 2020). In the post-event phase, transparency is therefore not only a matter of accountability; it is also a condition for continued cooperation.

Trust repair and institutional accountability

Post-event communication is also **a moment when trust can be repaired, strengthened, or further damaged**. Trust is a central theme in public risk communication research, and it depends not only on technical competence but also on honesty, empathy, fairness, consistency, and perceived care for affected populations (Agyepong & Liang, 2022; Palma-Oliveira, Gaspar, & Mendes, 2017; Herovic et al., 2020). After a disaster, publics often evaluate not only whether authorities communicated correctly during the event, but whether they acknowledge harm, explain decisions, accept responsibility where appropriate, and include affected people in recovery processes (Anthony et al., 2023; Xue et al., 2022).

Anthony et al.'s work (2023) is especially relevant because they frame risk and safety communication as an ethical practice. Communication failures may occur when institutions prioritise reputation, liability, political convenience, or reassurance over public safety and informed decision-making. This matters strongly after HILP events, where questions may arise about whether warnings were delayed, whether information was withheld, whether vulnerable groups were neglected, whether uncertainty was misrepresented, or whether authorities failed to act on available evidence. **Defensive, legalistic, or overly technical communication can deepen distrust.** By contrast, **transparent communication about decisions, uncertainties, mistakes, and corrective actions can support institutional credibility**.

Trust repair also requires **attention to competence, integrity, and benevolence**, as discussed earlier in relation to crisis communication (Mayer, Davis, & Schoorman, 1995; GCS Behavioural Science Team, 2022). To demonstrate competence, authorities should explain the recovery plan, timelines, responsibilities, available support, and how decisions are being made. To demonstrate integrity, they should acknowledge uncertainty, correct errors, explain changes, and be open about investigations and lessons learned. To demonstrate benevolence, they should recognise loss, hardship, unequal impacts, and public concerns, while explaining how recovery decisions are intended to protect people fairly.

For HILP events, accountability communication should avoid two extremes. On one side, institutions **should not simplify complex events into individual blame** before investigations are complete. On the other, they should **not hide behind complexity in ways that obscure responsibility, delay explanation, or prevent learning**. Once again, the task is to explain what is known, what is still being investigated, who is responsible for which aspects of recovery, and how affected people will be kept informed.

Participation, feedback, and community knowledge

Participation is important after events as well as before them, but it has a distinct function in the recovery phase. In preparedness, participation helps build risk literacy and readiness; during response, it can support immediate sense-making and protective action. In recovery, **participation is central to accountability, legitimacy, rebuilding, and learning**. Post-event communication should therefore not only inform affected communities; it should also listen to them. Communities can identify communication failures, unmet needs, inaccessible services, misunderstood instructions, local rumours, barriers to recovery, and groups that were missed.

This is particularly important for HILP events because official systems may not have full situational awareness of cascading and localised impacts.

Recovery guidance emphasises that communication channels should be timely, accessible, culturally appropriate, and trusted, and that **affected communities should have opportunities to provide feedback and receive responses**. The GFDRR Guidelines for Community Participation in Disaster Recovery stress that **feedback should be documented and reported** because it supports accountability, and that recovery communication should use multiple outlets to reach different socioeconomic and marginalised groups (GFDRR, 2017). This complements Agyepong and Liang's (2022) observation that public risk communication research often focuses on communication during and after disasters, especially through social media, but that post-event communication should move beyond updates and damage reporting toward more structured engagement.

Participation also needs to be **meaningful rather than symbolic**. Recovery processes can reproduce inequalities if they rely mainly on the most visible, connected, or organised groups. For HILP recovery communication, listening processes should therefore **actively include people who may be displaced, digitally excluded, disabled, elderly, economically vulnerable, linguistically marginalised, or distrustful of institutions**. This is especially important when recovery decisions concern relocation, compensation, rebuilding, land use, infrastructure access, health monitoring, or long-term restrictions, because these decisions may affect livelihoods, family responsibilities, housing, social ties, and economic survival (Xue et al., 2022; Dehghani et al., 2022).

Post-event communication should therefore create **structured feedback loops** through community meetings, local organisations, surveys, social listening, participatory evaluations, trusted intermediaries, and multi-agency debriefs. UNDRR and WMO (2023) similarly emphasise that early warning systems should be evaluated not only by whether messages were issued, but by whether they were received, understood, trusted, and acted upon. This feedback function is especially valuable because direct experience is rare with HILP events. When an event occurs, it provides an important **opportunity to create institutional memory and social learning** before the risk again becomes psychologically distant (Meyer & Kunreuther, 2017; Yamori, 2020). Lessons from post-event engagement should therefore feed directly into preparedness planning, message design, warning templates, exercises, and future communication strategies.

Psychosocial recovery, social capital, and collective meaning-making

Recovery communication also has a psychosocial function. Disasters create not only material damage, but also grief, uncertainty, anger, blame, fear, loss of control, and disruption to identity and place. Affected people may need communication about services and infrastructure, but they may also need acknowledgement of loss, validation of experience, and reassurance that their concerns are being taken seriously. Communication that **recognises suffering, treats affected communities respectfully, and explains how public input will shape recovery can help rebuild trust**. Communication that is vague, defensive, overly bureaucratic, or disconnected from lived experience can deepen distrust and reinforce feelings of abandonment or disempowerment.

For HILP events, this is particularly important because recovery may be prolonged and uneven. Some groups may recover quickly, while others face displacement, health risks, financial hardship, loss of social networks, disruption to identity and place, or long-term uncertainty. Recovery communication should therefore avoid implying that recovery is complete simply because the acute emergency phase has ended. It should recognise that different groups may be at different stages of recovery at the same time, and that some consequences may remain invisible to those not directly affected.

The social identity and collective resilience literature remains relevant here. Disaster-affected publics often mobilise mutual aid, share information, and provide practical and emotional support during and after crises (Drury, 2018; Drury et al., 2019). Recovery-specific resilience research

strengthens this point. Norris et al. (2008) describe **community resilience** as a process linking adaptive capacities to recovery and adaptation after disturbance, including social capital, information and communication, economic resources, and community competence. Aldrich and Meyer (2015) similarly show that social ties and networks are critical for disaster survival and recovery.

Recovery communication should therefore **recognise and support community agency, but without shifting responsibility away from institutions**. Strong social networks can help circulate information, organise support, and sustain recovery, but this capacity is not evenly distributed. Some groups have strong community organisations and trusted networks, while others may be isolated, displaced, disabled, elderly, socioeconomically vulnerable, or institutionally disconnected. Authorities should support local initiatives, connect people to assistance, and create channels through which community knowledge can inform recovery decisions. This helps communities make sense of what happened, understand what support is available, and see how their experience will shape future preparedness and risk reduction.

Misinformation, rumours, and post-event information gaps

Misinformation does not end when the immediate crisis stabilises. In some events, the post-event phase may be especially vulnerable to **speculation, blame narratives, conspiracy theories, and contested interpretations of responsibility**. This is particularly likely where the event involves unfamiliar science, invisible exposure, delayed impacts, unclear institutional responsibility, or unpopular protective measures (Palma-Oliveira, Trump, & Linkov, 2020; Anthony et al., 2023). If authorities do not continue to communicate consistently after the event, **information gaps may be filled by rumours or unofficial explanations** (Agyepong & Liang, 2022; Khan et al., 2022).

Post-event misinformation may concern the cause of the event, the severity of harm, the safety of return, contamination, health effects, compensation, aid distribution, or whether authorities are hiding information. These narratives can damage trust, stigmatise affected places or groups, reduce uptake of support, or undermine future preparedness. Post-event communication should therefore **remain active, responsive, and transparent even after media attention declines**. This includes monitoring public concerns, correcting false or misleading claims, linking corrections to practical guidance, and working with trusted intermediaries who can help address rumours in locally meaningful ways.

Social media can support this process, but it should not be treated only as a broadcasting tool. It can also provide insight into public concerns, misinformation, unmet needs, and barriers to recovery (Agyepong & Liang, 2022; Khan et al., 2022; Fathollahzadeh, 2023; Yudarwati et al., 2022). However, online listening should be combined with offline engagement, since the groups most affected by a disaster may not be the most visible online. This is particularly important for elderly people, displaced populations, people with disabilities, low-income households, non-native language speakers, and people with limited access to digital infrastructure.

Media framing, memory, and public learning

Post-event communication also **shapes public memory**. How a disaster is explained affects whether it is remembered as unavoidable, exceptional, and temporary, or as evidence of vulnerability, preparedness gaps, and systemic risk (Parida et al., 2021; Agyepong & Liang, 2022). This matters because public memory influences future preparedness. HILP events are rare, and once the immediate shock fades, societies may return to normalcy bias, disaster amnesia, and short-term priorities (Meyer & Kunreuther, 2017; PreventionWeb, 2025).

Parida, Moses and Rahaman (2021) show this through their analysis of Cyclone Amphan during the COVID-19 pandemic. They argue that media framing often treated Amphan as a natural disaster, reinforcing a short-term response-and-recovery frame rather than a broader understanding of compound risk, preparedness, and systemic vulnerability. In HILP events, compound and cascading disasters are rarely “natural” in their consequences; the initiating

hazard may be natural, technological, biological, or financial, but the scale of impact is shaped by exposure, vulnerability, infrastructure, governance, inequality, preparedness, and institutional coordination (Parida et al., 2021; UNDRR & WMO, 2023; Casagli et al., 2021).

Post-event communication should therefore **support public learning without simplifying the event into either blame or inevitability**. It should explain contributing factors, including what was known before the event, what uncertainties remained, what systems worked, what failed, and what needs to change (Anthony et al., 2023; UNDRR & WMO, 2023). This can help counter the tendency toward disaster amnesia identified in preparedness research, where lessons from previous events fade as immediate concern declines (Meyer & Kunreuther, 2017; PreventionWeb, 2025). Communication should **convert event experience into risk literacy, institutional learning, and future preparedness**.

This learning function should also include **stories of effective action**. The literature on preparedness shows that self-efficacy, response efficacy, and social norms influence protective behaviour (Lim, 2022; Bostrom et al., 2018). After an event, communication can strengthen future preparedness by **showing which actions reduced harm, which community networks worked, which preparations mattered, and how feasible actions can be adopted more widely** (Lim, 2022; Lejano et al., 2021). This should be done carefully, without implying that all losses were preventable or blaming those who were unable to act due to structural constraints (Xue et al., 2022; Anthony et al., 2023).

Feeding lessons back into future preparedness

The post-event phase should **close the loop between crisis response and ordinary-time preparedness**. Communication should not end with damage reporting, recovery updates, or publication of an evaluation report. It should explain what has been learned, what will change, who is responsible for implementing changes, and how affected communities will be involved in future preparedness.

This is especially important because rare events may be difficult to learn from unless lessons are actively documented, communicated, and institutionalised. Lessons from recovery communication should feed into revised warning messages, updated risk maps, improved public guidance, better training, multi-agency exercises, community engagement, and message testing.

Practice-oriented guidance consistently treats evaluation as part of the communication cycle. Rossi et al. (2018) include resolution and evaluation within public warning practice, while OECD (2016) notes that although many countries evaluate communication impact, evaluation results do not always translate into policy change. For HILP events, post-event evaluation should therefore be more than a formal review.

Recovery communication should also **communicate back to the public what has changed because of lessons learned**. Without this feedback, evaluations may remain internal and affected communities may see little evidence that their experience has informed future practice. This can deepen cynicism and reduce trust in future warnings. Conversely, when authorities show that public experience has led to concrete improvements, recovery communication can strengthen preparedness, legitimacy, and long-term resilience.

Overall, communication after HILP events should be understood as **a bridge between the event that has occurred and the next event that may occur**. It is a moment for practical support, continued uncertainty communication, accountability, trust repair, participation, psychosocial recovery, public learning, and renewed preparedness. It should be transparent, empathetic, inclusive, participatory, and future-oriented. Its purpose is not only to help people recover from what happened, but also **to strengthen the capacity of communities, institutions, and communication systems to understand and respond to future HILPs.**

2.3. Summary: Implications for HILP Risk Communication

The table below synthesises the recurring implications from the theory, evidence and guidance documents reviewed in Sections 2.1 and 2.2.

Table 6. Synthesis of implications for HILP risk communication.

Repeated theme	Consolidated result	Guidelines in Section 6
Trust, credibility and source legitimacy	Trust appears repeatedly as a precondition for warning acceptance, preparedness and continued cooperation. Credibility depends on expertise, empathy/warmth, recognisable sources, consistency, transparency, prior relationships and perceived institutional trustworthiness.	Build and protect trust as communication infrastructure; Pre-position trusted messengers; Speak with one voice; Combine official authority with trusted local adaptation
Actionability and efficacy	Messages work better when they specify what to do, when to do it, where it applies, why it matters and whether people can realistically perform the action. Threat information should be paired with response efficacy, self-efficacy and practical support.	Use impact-based warnings; Pair threat information with feasible action; Define messages by behavioural purpose; Make every message relevant, findable, understandable
Uncertainty communication	HILP communication must distinguish what is known, what remains uncertain, what is being done, what people should do now and when the next update will come. Honest uncertainty communication can support trust, while silence or overconfident reassurance can damage credibility.	Communicate early, even when uncertainty remains; Speak with one voice, but do not hide uncertainty
Participation and co-production	One-way education is insufficient. Community participation, local knowledge, gaming, co-production and legitimate peripheral participation can build ownership, practical relevance and locally grounded preparedness. Participation is also needed after events to identify failures, unmet needs and lessons for future preparedness.	Build preparedness through participation; Include affected communities in recovery and learning
Low-probability / high-impact cognition	Rare hazards are difficult to imagine and easy to postpone. Narratives, analogies, simulations, drills, scenarios, comparisons and past-event references may make abstract probabilities and cascading consequences more meaningful.	Make HILP risks meaningful before they become urgent; Preserve memory and convert experience into preparedness
Visualisation, maps and digital platforms	Maps, icons, colours, infographics, apps and social media can improve reach and comprehension, but only when tested for user interpretation, accessibility and actionability. Visual and digital tools should support, not replace, clear instructions.	Use impact-based warnings; Make every message relevant, findable, understandable and usable

Multi-hazard, cascading and compound risk	HILP communication must anticipate secondary hazards, concurrent crises, cross-border impacts, infrastructure disruption and potentially conflicting protective actions. Communication should be embedded in multi-hazard and threat-agnostic preparedness, while still adapting to specific scenarios.	Design for cascading and compound impacts; Coordinate across agencies, sectors and borders
Misinformation, rumours and social amplification	Digital platforms accelerate both official reach and misinformation. Communication should monitor information voids, respond quickly to misleading claims, pre-bunk or debunk where appropriate, and work through trusted community channels.	Create real-time feedback loops; Monitor and respond to misinformation and conflicting cues
Inclusion, access and vulnerability	Communication must account for unequal capacity to receive, understand, trust and act on messages. Vulnerable groups may face barriers linked to disability, age, language, mobility, housing, income, digital access, institutional distrust or weak support networks.	Identify vulnerable groups and barriers before the event; Pair threat information with feasible action
Channel redundancy and communication resilience	No single channel is sufficient. HILP events may disrupt electricity, mobile networks, internet access or transport, so communication strategies need redundancy across digital, broadcast, local, interpersonal, low-tech and no-tech channels.	Use multiple channels and plan for communication failure
Multi-agency and cross-border coordination	HILP events often involve multiple agencies, sectors, jurisdictions and countries. Communication requires shared terminology, agreed responsibilities, coordinated spokespersons, interoperable systems and mechanisms for translating expert judgement into coherent public messages.	Coordinate across agencies, sectors and borders; Combine official authority with trusted local adaptation
Public behaviour and collective resilience	Crisis communication should avoid the panic assumption. Affected publics often seek information, coordinate, help others and provide practical support. Communication should support collective efficacy and treat the public as part of the response system.	Avoid the panic assumption; Build preparedness through participation
Recovery, relocation and learning	After the event, communication should support recovery decisions, explain residual risk, address fairness, repair trust, recognise psychosocial impacts and feed lessons into future preparedness. Recovery communication should not end with damage reporting.	Continue communicating after the acute emergency; Communicate accountability without defensiveness; Include affected communities in recovery and learning; Preserve memory and convert experience into preparedness
Evaluation and message testing	Communication should be evaluated not only by whether messages were sent or received, but by whether they were understood, trusted and	Evaluate whether communication produced the desired effect

	acted upon. Testing with diverse audiences is essential before, during and after HILP events.	

Box 2: Key takeaways – Evidence Base for Risk Communication

The evidence shows a consistent pattern across preparedness, response and recovery: communication that focuses only on transmitting information is insufficient.

- Awareness does not produce action on its own. People also need to believe that the recommended action is effective, feasible for them specifically, socially supported, and connected to clear responsibilities. Without this, threat-based messages can increase fear or avoidance without increasing preparedness.
- Impact-based messages outperform hazard-based messages. Rainfall in millimetres, water levels, alert colours and fire danger indices do not tell people what will happen to them or what to do about it. Effective messages specify who is affected, where, when, how severe the consequences may be, and what action to take.
- Trust is a precondition. Credibility depends on expertise, consistency, empathy and prior relationships, and it takes years to build. Communication that prioritises reassurance over accuracy, or withholds uncertainty, damages trust in ways that persist beyond the immediate event.
- Channel choice determines who is reached. No single channel is sufficient. Digital and mobile systems exclude people who are elderly, disabled, digitally disconnected, or linguistically marginalised — often the same groups at greatest risk. Communication strategies must plan for infrastructure failure.
- Preparedness is a social process, not an information transfer. It is built through participation, local knowledge, drills, community engagement and trusted intermediaries; not through one-off campaigns.
- Recovery communication is as important as preparedness communication. How authorities explain decisions, acknowledge failure, support accountability and engage communities after an event shapes both trust and future preparedness.

3. Integrating models for HILP risk communication

3.1. Crisis and Emergency Communication Model (CERC)

The **Crisis and Emergency Risk Communication model**, commonly referred to as CERC, was developed by Reynolds and Seeger (2005) as an integrative model connecting two related but historically distinct communication traditions: risk communication and crisis communication.

- **Crisis communication** is concerned with the sending and receiving of messages intended "to prevent or lessen the negative outcomes of a crisis" and thereby protect organisations, stakeholders, or wider systems from damage (Coombs, 1999, in Reynolds & Seeger, 2005).
- **Risk communication**, by contrast, has often been associated with the identification of public health risks and communication efforts intended to persuade the public to adopt healthier or less risky behaviours (Freimuth et al., 2000, in Reynolds & Seeger, 2005).

CERC was proposed to bridge the gap between these traditions by offering a more comprehensive approach to emergency public health events, combining risk communication, crisis communication, and public health practice. The model is particularly relevant for AGILE because it understands communication as a process that extends across the full temporal arc of a crisis. This corresponds with the AGILE proposal's framing of **risk communication as a continuous cycle of evaluation, research, and engagement across preparedness, prevention, response, and the post-event phase**. CERC is therefore not limited to the issuing of warnings during an emergency, but also includes pre-event education and preparedness, communication during the crisis, and post-event evaluation and learning.

CERC is structured around **five crisis phases**:

I. In the **pre-crisis phase**, communication activities include risk messages, warnings, and preparedness communication. These activities aim to facilitate public and response-community understanding of emerging risks, support preparedness, encourage behaviours that reduce harm, develop alliances between agencies and organisations, and test messages for later phases.
II. In the **initial event phase**, communication focuses on reducing uncertainty, establishing official spokespersons and channels, providing reassurance and empathy, explaining what is known about the event and its consequences, and promoting self-efficacy through guidance on what people can do and where they can obtain more information.
III. In the **maintenance phase**, communication continues to reduce uncertainty, correct rumours and misunderstandings, explain background factors, support cooperation with response and recovery efforts, and maintain understanding of protective actions.
IV. In the **resolution phase**, communication provides updates on the resolution of the event, explains causes and new risks, and supports new understandings of the crisis.
V. Finally, in the **evaluation phase**, communication concerns the adequacy of the response, lessons learned, and the development of improved crisis communication and response capabilities, thereby linking back to pre-crisis activities (Reynolds & Seeger, 2005).

CERC is also associated with a **set of communication principles** that have become widely used in crisis and emergency communication practice: **be first, be right, be credible, express empathy, promote action, and show respect**. These principles are especially relevant for HILP events because they connect information provision with trust, emotional response, and behavioural guidance.

Table 7. CERC model's communication principles.

CERC principle	Meaning	Relevance for HILP risk communication
Be first	Communicate early, even when information is incomplete.	Delays can create an information vacuum where rumours, speculation, misinformation or unofficial interpretations spread. Early communication should acknowledge the situation, state what is known and unknown, and indicate when further updates can be expected.
Be right	Prioritise accuracy, clarity, and correction of errors.	In uncertain and cascading events, early information may change. Communicators should avoid false certainty and distinguish between confirmed facts, assumptions, uncertainties, and possible scenarios.
Be credible	Build and maintain trust through consistency, transparency, and reliability.	Credibility may be challenged by changing guidance, conflicting messages between organisations, or previous distrust of authorities. Communicators should explain why recommendations are made, why they may change, and how decisions are being taken.
Express empathy	Acknowledge fear, loss, disruption, uncertainty, and public concern.	HILP events are not only technical events; they affect people's lives, safety, and sense of control. Empathy is especially important when communicating with vulnerable groups facing unequal exposure or limited capacity to act.
Promote action	Provide concrete, feasible, and timely guidance.	Information alone may not lead to preparedness or protective behaviour. Messages should explain what people should do, why it matters, and how actions can be carried out.
Show respect	Communicate with audiences as capable partners, not passive recipients.	Respect supports trust, inclusion, and empowerment. It requires understandable language, honest acknowledgement of uncertainty, attention to different needs and capacities, and avoidance of blame or patronising messages.

These principles will be further explored, justified and exemplified throughout the present deliverable. Later sections will examine when such principles are insufficient on their own or incorrectly applied, how they can be transformed in practical actions, why risk communication does not always work as intended, and how they can be adapted to HILP contexts marked by cascading effects, prolonged uncertainty, multiple audiences, and unequal vulnerability.

A major strength of CERC is that it **explicitly recognises that communication needs change over time**. Before a crisis, communication should support awareness, preparedness, and risk-reducing behaviour. During the initial phase, communication should reduce uncertainty and emotional turmoil. During the maintenance phase, communication should sustain public understanding, correct misinformation, and reinforce protective action. After the crisis, communication should explain what happened, support learning, and strengthen future preparedness. This phase-based structure is useful for analysing communication across different moments of an event and for identifying what types of information and engagement are most relevant at each stage.

The CERC model has been used as a basis to analyse communication in previous HILP events. Studies on Hurricane Maria and COVID-19 show that **information needs change as a crisis evolves**. In the early stages, communication often needs to focus on immediate risks, urgent needs, protective action, and reassurance. As the crisis develops, communication needs tend to

shift toward continuity of response, recovery, accountability, longer-term impacts, and lessons learned. These studies also show the practical value of monitoring social media, not only as a channel for disseminating official information, but also to understand public concerns, information needs, rumours, and emerging gaps in communication (Jin & Spence, 2020; Nagahawatta et al., 2022). At the same time, the use of CERC as a research framework also reveals some limitations. Miller et al. (2021) show that CERC has been widely used in case studies and retrospective analyses, but that its assumptions have been less frequently tested empirically. In other words, the model is useful for organising communication activities and reviewing what happened during a crisis, but it **should not be treated as a fully validated predictive model of how audiences will respond**. For AGILE, this distinction is important. CERC can help structure planning, message design, and evaluation, but it cannot by itself explain why communication sometimes fails, why people do not always follow guidance, or how communication should be adapted to different audiences, vulnerabilities, and risk contexts.

Another limitation concerns the phase-based structure of the model. Although CERC is intended to support communication in uncertain and chaotic situations, **real crises do not always unfold neatly through the five phases described by the model**. Reynolds and Seeger (2005) themselves acknowledge that crises may develop over long periods, recur, or contain elements of different phases at the same time. This is especially relevant for HILP events, which may involve **cascading effects, multiple sectors, cross-border impacts, infrastructure dependencies, and prolonged uncertainty**. A single HILP event may therefore generate **different communication needs simultaneously**: some audiences may still need preparedness information, others may need urgent protective instructions, while others may already be seeking recovery support or explanations of institutional performance. For this reason, CERC is best understood as a flexible heuristic rather than a rigid sequence. Its phases can help structure communication planning, analysis, and evaluation, but they should not be applied mechanically. In HILP contexts, **communicators may need to move back and forth between phases**, repeat earlier forms of communication as new risks emerge, and adapt messages as cascading consequences become clearer. This is consistent with AGILE's aim to adapt existing risk communication approaches, which are often based on single-risk scenarios, to the specific challenges of cascading effects and HILP events.

For AGILE, CERC is valuable because it offers a phase-based structure for communication before, during, and after crises; highlights key outcomes such as trust, self-efficacy, uncertainty reduction, and learning; and provides practical principles such as timeliness, credibility, empathy, and action-oriented messaging. At the same time, its limitations show where adaptation is needed for HILP events, particularly in relation to cascading effects, non-linear crises, prolonged uncertainty, diverse audiences, vulnerable groups, and evidence on message effectiveness.

Therefore, in the AGILE context, CERC is a flexible framework to support HILP risk communication rather than a fixed script. It helps identify communication tasks across crisis phases, anticipate changing information needs, and assess whether messages support trust, understanding and protective action. However, it must be complemented by evidence from past HILP events, public response analysis, communication standards, psychosocial theories of risk perception and behaviour, and the case-study findings reviewed in this deliverable. These combined sources inform the gaps, barriers and practical guidelines developed in Chapters 5 and 6.

3.2. Total Warning System (TWS)

Before introducing the Total Warning System, it is useful to situate it within the broader concept of an **Early Warning System** (EWS). An EWS can be understood as an **integrated system through which individuals, communities, organisations, and authorities are enabled to anticipate hazardous events and take timely action to reduce harm**.

Contemporary EWS frameworks commonly include four interrelated components (Chavula et al., 2025):

1. risk knowledge,
2. monitoring and forecasting,
3. dissemination and communication,
4. preparedness and response capacity

In this sense, early warning is not only a technical process of detecting and forecasting hazards, but also a communication and preparedness process that depends on whether warnings are understood, trusted, and acted upon.

The **Total Warning System** (TWS) builds on this broader understanding by defining warning not as a single message or alert, but as an integrated, end-to-end process through which technical information is transformed into public understanding, decision-making, and protective action. Originally developed in the context of flood warning in Australia, the model is directly relevant to AGILE's approach to risk communication, which treats communication as a continuous cycle across preparedness, prevention, response, and the post-event phase. Dufty (2021) describes the Total Flood Warning System as comprising six interdependent components: prediction, interpretation, message construction, communication, response, and review.

- **Prediction** refers to the technical identification and forecasting of the hazard.
- **Interpretation** concerns the assessment of what the forecast means for exposed people, places, infrastructure, and systems.
- **Message construction** involves translating this interpretation into warnings that are understandable and actionable.
- **Communication** refers to the dissemination of these messages through appropriate channels.
- **Response** concerns the actions taken by individuals, communities, institutions, and responders.
- **Review** refers to learning before and after events to improve future warning practice.

The core principle is that **the warning system is only as strong as its weakest component**; failure in any part of the chain can undermine the effectiveness of the whole system (Dufty, 2021).

The Total Warning System differs from broader EWS models mainly in emphasis. While EWS frameworks describe the core components needed for warning, the **Total Warning System focuses on how these components work together in practice and whether they result in appropriate action**. From this perspective, technical capacity is not enough: even when forecasts are accurate and alerts are issued, the system may still fail if messages are unclear, lack trust, do not support action, or are disconnected from institutional and community response capacities.

This distinction is especially relevant for HILP events, where uncertainty, cascading effects, cross-sector impacts, and evolving information can complicate response. In these contexts, warning effectiveness depends not only on issuing alerts, but on whether messages are understood, trusted, actionable, and useful for decision-making under uncertainty. The Total Warning System is therefore valuable for AGILE because it treats communication as a core part of warning, not merely as the final step after forecasting.

A key contribution of the Total Warning System is its emphasis on **message construction**. Warnings must translate technical information into guidance that supports decision-making. Evidence from flood warning research shows that behaviour-oriented warnings are more useful than purely operational warnings because they help people understand the risk, believe that action is possible, and know what to do. This means that warnings should not only describe the hazard, but clearly explain **what action people should take, when they should take it, and why it matters** (Mehta et al., 2021). This is particularly important for HILP events, where technical descriptions alone may not motivate preparedness before an event, and may increase confusion

once an event begins to unfold. Behaviour-oriented warnings can help bridge this gap by linking risk information to concrete protective actions. Similarly, simplified warning categories, such as risk levels connected to action plans, can help translate complex forecasts into usable knowledge for communities and responders (Haque et al., 2024).

The Total Warning System also shows that **warning failures are rarely only technical**. Studies on early warning and response systems highlight that failures often arise from institutional and social conditions, such as unclear governance, weak leadership, insufficient funding, lack of standard operating procedures, limited trust, or poor coordination (Samansiri et al., 2023). This is highly relevant for HILP events, which often require communication across agencies, sectors, jurisdictions, and borders. Even when the technical assessment of a hazard is accurate, warnings may fail if responsibilities are unclear, protocols are not agreed in advance, or institutions issue inconsistent messages.

Another important feature of the Total Warning System is the **review** component. Dufty (2021) notes that **review embeds learning into the warning process**. Warning systems should therefore be evaluated not only after major events, but also through exercises, education, community engagement, and preparedness activities before events occur. This aligns with CERC's emphasis on post-event learning.

At the same time, the reviewed literature points to several limitations. Much of the Total Warning System literature is rooted in flood risk, especially Australian flood warning practice, and its transferability to all-hazards or multi-hazard HILP events remains only partly tested. The model may also be too narrow if it focuses mainly on the technical warning chain and does not sufficiently include community education, emergency planning, public participation, and integration between components. This matters for AGILE because **HILP preparedness depends not only on warning messages, but also on prior engagement, public understanding, trust, and response capacity**.

Contemporary early warning research also shows that the "last mile" remains a persistent weakness. New technologies can improve detection and forecasting, but they do not automatically produce effective warning. Communication can still fail when messages are unclear, channels are inaccessible, uncertainty is poorly explained, or audiences lack the capacity to act. This is especially relevant for vulnerable groups, who may face barriers linked to language, disability, digital access, mobility, housing, socioeconomic status, or institutional trust (Chavula et al., 2025).

For AGILE, the Total Warning System is useful because it frames communication as an integral part of warning, not merely as final dissemination. It shows that effective warnings must be technically informed, clearly communicated, trusted, actionable, and continuously improved. For HILP events, this means adapting warning practice to multi-hazard, cascading, and cross-sector risks; addressing uncertainty and changing conditions; linking messages to realistic response capacities; and using review, testing, exercises, and engagement to strengthen future communication.

Other international guides and standards, including UNDRR/WMO early warning guidance, JRC public warning guidance, WHO RCCE-IM guidance, CEN social media guidance, ISO plain-language standards and OECD risk governance guidance, are treated in this deliverable as operational extensions of the same principles and are integrated into the thematic evidence-base sections rather than reviewed as a separate model.

3.3. What CERC and TWS add to HILP risk communication

The CERC model and the Total Warning System provide complementary lenses for HILP risk communication. **CERC frames communication as a phased process** — before a crisis, the challenge is building relevance, trust and response capacity; during an event, it is supporting rapid sense-making and protective action under uncertainty; after an event, it is explaining continuing

risk, repairing trust and preserving lessons. The **TWS adds a more operational view**: effective warning depends not only on detection or forecasting, but on converting risk information into messages that reach the right people, are understood and trusted, and can be acted upon — and failure can occur at any point in that chain.

Together, the two models support three implications for the rest of this deliverable:

1. HILP risk communication should be understood as a **continuous cycle** rather than as a warning message issued during the crisis.
2. Communication must be **evaluated by whether it supports action**, not only by whether information was produced or disseminated.
3. Both models **need to be adapted for HILP conditions**, where risks may be cascading, cross-border, infrastructure-disruptive, unfamiliar, politically contested and unevenly actionable across different groups.

These implications provide the conceptual bridge to the case-study analysis in Chapter 4. The case studies examine where this communication cycle and information-to-action chain worked, where they broke down, and which practical barriers need to be addressed in the final guidelines.

Box 3: Key takeaways – Integrating Models

The CERC model and the TWS offer complementary frameworks for thinking about HILP risk communication. Both challenge the assumption that communication is equivalent to issuing a warning.

- Communication is a cycle, not an event. CERC shows that communication needs change across five phases — pre-crisis, initial event, maintenance, resolution and evaluation — and that effective communication must begin before the crisis arrives. Warnings issued for the first time during a crisis cannot compensate for absent preparedness communication.
- Information must convert into action. The Total Warning System shows that warning effectiveness depends on every link in the chain: detection, interpretation, message construction, dissemination, public response and institutional review. Failure at any stage can undermine the entire system, even when forecasting is technically accurate.
- Both models need adaptation for HILP conditions. Real HILP events are non-linear, cascading and multi-sector. They do not unfold in neat phases, and different audiences may simultaneously require preparedness, response and recovery communication. Both frameworks should be treated as flexible heuristics, not rigid scripts.
- Warning cannot be evaluated solely by whether a message was issued. Effectiveness must be measured by whether messages were received, understood, trusted and acted upon — and by whether lessons are translated into improved future practice.

4. Case study evidence

4.1. Case study review approach

The case studies presented below were selected from the list of historical High-Impact, Low-Probability (HILP) events that meet the HILP criteria in D4.1 *Case Study Scenarios*, whereby events combine low probability arising from complex or historically infrequent hazard dynamics with high impact that produces severe consequences and strains critical systems (Mulder et al., 2025). The temporal scope was restricted to **16 case studies occurring between 2002 and 2023**, selected based on HILP criteria such as complexity, high uncertainty, and catastrophic cascading effects.

The methodology utilized a systematic literature search strategy. This academic evidence was synthesized with grey literature, including authoritative government inquiry reports, institutional evaluations, and contemporaneous media accounts. While the research was predominantly conducted in English, specific cases integrated primary sources in regional languages to ensure a granular understanding of regional operational environments.

An Information-to-Action Chain framework was designed to examine how technical warning signals are converted into protective public behaviour. Each case was evaluated across six dimensions: detection and lead time, channel reach and equity, trust and messengers, uncertainty and transparency, institutional coordination, and community agency.

This multidimensional lens enabled the identification of recurring failure modes such as the gap between technical lead time and public action, as well as enabling conditions across disparate hazard types and jurisdictions. Limitations included content gaps, such as the consistent lack of direct evidence regarding the impact of communication on disabled, non-native speaking, or otherwise marginalized populations. Furthermore, potential source biases have been identified, noting that institutional self-assessments may understate internal failures and that early post-disaster surveys may have suffered from sampling biases.

Finally, it should be noted that analytical depth was not uniform across the sixteen cases. Evidentiary density varied considerably according to source availability, with events such as the 2021 German Floods, Northern Rock, the Suez Canal Blockage, and Hurricane Katrina supported by parliamentary inquiries, official audits, or detailed empirical studies, while others, including the Prague Floods, the Central Portugal Forest Fires, and the Venice Floods relied on thinner or predominantly physical-science literature. As a result, the more richly documented cases inevitably shaped the cross-case findings more strongly, and certain failure modes (notably forecast underestimation) surfaced only where quantitative data permitted. This unevenness reflects the state of the available evidence rather than analytical bias; because the synthesis is pattern-based rather than frequency-based, identifying recurring mechanisms rather than counting their incidence, the findings remain valid while not being statistically weighted.

4.2. HILP Case studies

This section details the findings of the analysis of 16 high-impact, low-probability (HILP) case studies which took place between 2002 and 2023, focusing the risk and crisis communication processes that occurred in each of them. They comprise 11 natural hazards, including wildfire (n=2), flood (n=4), earthquake (n=1), tsunami (n=2), volcanic eruption (n=1), and hurricane (n=1); one biological hazard of pandemic (n=1); five technological hazards, specifically transport failure (n=1), structural fire (n=1), cyberattack (n=1), nuclear accident (n=1), and industrial accident/ incident (n=1); as well as one financial/ economic hazard of bank run (n=1). There were two global events (n=2), three cross-border events in Europe (n=2), and Asia and Africa (n=1); and 11

national events, in the Czech Republic (n=1), Egypt (n=1), Italy (n=1), Japan (n=1), Portugal (n=2), United Kingdom (UK) (n=2), and United States of America (USA) (n=3).

Table 8. HILP events analysed.

#	Events	Dates	Countries	Hazards	References
1	Wildfires in Hawaii	8-9 August 2023	USA	Natural: Wildfire	Chen et al. (2025), CRED (2024), Kerber and Alkonis, D. (2024a and b), Liu et al. (2024), Maui Emergency Management Agency. (2024), Sowby and Porter (2024), Stimpson et al. (2025)
2	Floods in Germany (Ahrtal case)	14-15 July 2021	Germany, Belgium, Luxembourg and the Netherlands.	Natural: Flood	Fekete (2021), Fekete and Sandholz (2021), Koks et al. (2022), Mohr et al. (2023), Nick et al. (2023), Rhein and Kreibich (2025), and Thieken et al. (2023)
3	Suez Canal Blockage	23-29 March 2021	Egypt	Technological: Failure in transport	Lee and Wong (2021), Panama Maritime Authority. (2023), Pratson (2023), Qu et al. (2024) Verschuur et al. (2022)
4	COVID-19 Pandemic and Loss of Critical Services	31 December 2019 - May 2022	Global	Biological: Pandemic	Bol (2021), Dryhurst et al. (2020), Gisondi et al. (2022), Independent Panel for Pandemic Preparedness and Response (2021), Loss et al. (2021), Sauer et al. (2021), UK COVID-19 Inquiry. (2025), WHO (2021)
5	Venice Floods	12 November 2019	Italy	Natural: Flood	Cavaleri (2020), Copernicus Marine Environment Monitoring Service (2019), ISPRA. CPSM. CNR-ISMAR. (2020), Lionello et al. (2021a and b), Schlumberger et al. (2022), Umgiesser et al. (2021), We Are Here Venice. (2020)
6	Forest Fires in Central Portugal	17-21 June 2017	Portugal	Natural: Wildfire	Guerreiro et al. (2022), Leone et al. (2023), OECD. (2023), Ribeiro et al. (2020), San-Miguel-Ayanz et al. (2020)
7	Grenfell Tower Fire	14 June 2017	UK	Technological: Major structural fire	Grenfell Tower Inquiry (2019 and 2024), Long et al. (2023)
8	WannaCry Cyberattack	12-19 May 2017	Global	Technological: Cyberattack	Bada and Nurse (2019), Ehrenfeld (2017), ENISA (2017), Ghafur et al. (2019a and b), House of Commons Committee of Public Accounts (2018), National Audit Office (2017), Smart (2018)

9	Tōhoku Triple Disaster	11 March 2011	Japan	Natural: Earthquake and tsunami; Technological: nuclear accident	De Saille and Matanle (2016), Sato (2016), Sekiya (2020)
10	Eyjafjallajökull Eruption	20 March - May 2010	Iceland; Europe	Natural: volcanic eruption	Alexander (2013), Bird and Gísladóttir (2012, 2018 and 2020), Bird et al. (2011), Budd et al. (2011), Donovan and Oppenheimer (2011 and 2012)
11	Deepwater Horizon Oil Spill	20 April - 15 July 2010	USA	Technological: industrial accident/ incident	Austin and Laferriere (2011), Beedasy et al. (2020), de Wolf and Mejri (2013), Jackson et al. (2019), Simon-Friedt et al. (2016), Ulmer and Pyle (2021)
12	Alluvial Flooding in Madeira	20 February 2010	Portugal	Natural: Flood	Baioni (2011), Camara Municipal do Funchal (2011), de Queiroz (2010), Fragoso et al. (2012), Governo Regional da Madeira (2010), Lopes et al. (2020), Nguyen et al. (2012), Zezere et al. (2014 and 2020)
13	Northern Rock Crisis	9 August - 17 September 2007	UK	Financial/ Economic: Bank run	Bruni and Llewellyn (2009), FSA (2008), House of Commons Treasury Committee (2008), Mayes and Wood (2008 and 2009), National Audit Office (2009), Shin (2009)
14	Hurricane Katrina	24 August - 4 September 2005	USA	Natural: Hurricane	Brodie et al. (2006), Cole and Fellows (2008), Eisenman et al. (2007), Kapucu (2006), Laska and Morrow (2006), National Weather Service (2006), Tierney et al. (2006), U.S. House of Representatives Select Bipartisan Committee (2006)
15	Indian Ocean Tsunami	26 December 2004	Indonesia, Sri Lanka, Thailand, Malaysia, Maldives, Somalia, Kenya, Tanzania, India	Natural: Tsunami	Doocy et al. (2007), Fritz Institute (2005), Gregg et al. (2006), Lauterjung et al (2010), MacDonald (2005), McAdoo et al. (2006), Spahn (2010), Telford et al. (2006)
16	Floods in Prague	6-19 August 2002	Czech Republic	Natural: Flood	Duží et al. (2017), Kreibich and Thieken (2009), Kreibich et al. (2005), Ministry of Environment of the Czech Republic (2004), Thieken

					et al. (2005 and 2007), Vávra et al. (2017), Weichselgartner (2005)

4.2.1. Cross-case findings

Drawing on documented operational responses, inquiries, evaluations and scientific assessments, the analysis examined how warning systems performed in practice, why communication succeeded or failed, and which structural, institutional and behavioural factors shaped outcomes. The findings are organised around **six core dimensions of the information-to-action chain**:

1. Detection, lead time, and the conversion of warning into action
2. Channels, reach, and equitable access to warnings
3. Trust, messengers, and the credibility of the institutional voice
4. Uncertainty, transparency, and the management of contested narratives
5. Coordination across agencies, sectors, and jurisdictions
6. Community agency, informal networks, and feedback loops

Together, these dimensions provide a structured analytical framework for examining the recurring patterns, failure modes, and enabling conditions that shape the effectiveness of risk communication. They help identify when communication supports preparedness, protective action, trust, and learning, and when it leaves populations exposed. The following section presents each domain in turn. The six domain sections are labelled with the prefix "S" and the corresponding number, while the findings within each domain are labelled with the prefix "F" and the corresponding number. These cross-case findings organised by domain sections are later summarized in a table format.

Section 1 (S-1). Detection, lead time, and the conversion of warning into action

Scope: This section examines the chain that runs from hazard detection through forecasting, public warning, message content, and timing of action. The thread holding the analysis together is the information-to-action chain and where it breaks. Subsequent sections address channels and reach (Section 2), trust and messengers (Section 3), uncertainty and contested narratives (Section 4), inter-agency coordination (Section 5), and community agency (Section 6).

What worked

Finding 1 (F-1): Detection capacity is rarely the binding constraint

In 12 of the 16 cases[2], some form of technical or institutional **detection signal was generated meaningfully in advance of the most damaging consequences**.

National Hurricane Center (NHC) track forecasts for Katrina exceeded historical accuracy with watch and warning lead times eight hours above average; the central Gulf Coast was identified as the likely landfall zone approximately 56 hours in advance. Deutscher Wetterdienst (DWD) operational forecasts captured high precipitation totals more than two days before the Ahrtal flood, and the European Centre for Medium-Range Weather Forecasts (ECMWF) Extreme Forecast Index (EFI) was above 0.8 from 12 July. UK National Health Service (NHS) Digital's CareCERT had issued a critical patch advisory 17 days before WannaCry, and the Microsoft patch had been available for 59 days. **The recurring weakness is not absent warning information but its failure to convert into timely public action.**

[2] 1. Wildfires in Hawaii, 2. Floods in Germany, 4. COVID-19 Pandemic and Loss of Critical Services, 5. Venice Floods, 6. Forest Fires in Central Portugal, 8. WannaCry Cyberattack, 9. Tohoku Triple Disaster, 10. Eyjafjallajökull Eruption, 12. Alluvial Flooding in Madeira 13. Northern Rock Crisis, 14. Hurricane Katrina, 16. Floods in Prague.

F-2: Successful warnings shared three clear features

Three cases[3] offer positive examples of how to successfully move people from warning to action. In each case, the system relied on three features:

1) a **short communication line** between forecasters and the community,
2) clear instructions on exactly **what to do**,
3) and **multiple backup channels** to spread the word.

Plaquemines Parish during Katrina issued an evacuation order almost two days before landfall, combined with house-to-house contact by law enforcement officers, achieving a 97–98% evacuation rate with only three deaths. The contrast with neighbouring New Orleans, which issued mandatory evacuation less than 24 hours before landfall and lost over 1,400 lives in the metropolitan region, isolates the **role of timing and direct contact** rather than weather forecasting alone, since both jurisdictions received the same NHC warnings.

On Simeulue Island, during the 2004 Indian Ocean Tsunami, the *smong* oral tradition produced near-total spontaneous evacuation within 8 to 20 minutes of shaking. *Smong*, meaning "the ocean coming onto the land", had been transmitted across generations through song, poetry, and storytelling describing a devastating tsunami in 1907. The tradition encoded both causal knowledge – prolonged ground shaking can be followed by ocean inundation – and the action prompt – run to the hills immediately. When the earthquake occurred, this internalised knowledge was activated simultaneously across the island's population, with word-of-mouth reinforcement between neighbours; the village of Langi (population approximately 800) suffered no deaths despite waves of 10 to 15 metres.

In Iceland, during the 2010 Eyjafjallajökull eruption, an automated telephone alert system rang households directly. This was complemented by a "sweeper" volunteer network of residents who went door to door verifying that neighbours had received warnings and were evacuating. Departing households displayed standardised gate signs visible from the air, allowing a Civil Protection helicopter to verify compliance without needing to land. The system layered automated dissemination with human verification and visual confirmation, reflecting decades of community familiarity with volcanic hazard procedures rebuilt for each generation through community meetings and full-scale exercises.

What Did Not Work

F-3: The dominant failure is the gap between technical lead time and public action lead time

This was identified in at least 11 of the 16 cases[4]. The Ahrtal case (floods in Germany) is the most extensively documented: the gap between DWD's (German National Weather Service) identification of an extreme event risk on 10–12 July and the declaration of a district-level state of emergency at 23:09 on 14 July, by which time floodwaters were already destroying buildings, represents a fundamental **information-to-action breakdown**. Approximately 35% of North Rhine-Westphalia (NRW) respondents and 29% of Rhineland-Palatinate respondents received no warning at all. In New Orleans, the mandatory evacuation order was not issued until 10:00 on 28 August, less than 24 hours before landfall, far too late for the approximately 100,000 car-less residents. The UK COVID-19 Inquiry's central finding is that the response "repeatedly amounted to a case of too little, too late".

F-4: Where forecasts underestimated severity, warnings inherited the error

[3] 10. Eyjafjallajökull Eruption, 14. Hurricane Katrina, 15. Indian Ocean Tsunami.

[4] 1. Wildfires in Hawaii, 2. Floods in Germany, 4. COVID-19 Pandemic and Loss of Critical Services, 5. Venice Floods, 6. Forest Fires in Central Portugal, 7. Grenfell Tower Fire, 8. WannaCry Cyberattack, 9. Tōhoku Triple Disaster, 12. Alluvial Flooding in Madeira, 14. Hurricane Katrina, 16. Floods in Prague.

This was identified in 5 of the 16 cases[5]. The harm was that **everything built on top of the incorrect forecasts inherited the error**.

In the Floods in Germany case, in the Ahrtal, the maximum water level at the Altenahr gauge was forecast at approximately 5.74–6.5 metres while the actual level exceeded 10 metres. This underestimate then propagated: the KATWARN (Catastrophe Warning) warning system message warned of levels exceeding 5 metres, framed within the cognitive scale of "high flood" rather than building destruction; the action recommendation that accompanied it – avoid cellars, clear drains – was appropriate for a 5-metre flood and dangerously inadequate for a 10-metre one; district-level decisions about whether to declare a state of emergency were made within the mental model of the forecast magnitude.

Venice's CPSM (Center for Tide Prediction and Warning) forecast a peak of approximately 140–150 cm for the evening of 12 November 2019; the actual peak was 189 cm, with a rise of 33 cm in under one hour. Venetian residents and businesses had decades of experience preparing for acqua alta in the 140–150 cm range and had calibrated their flood barriers (*paratie*) accordingly. Individual protective measures were overwhelmed not because residents failed to prepare but because **they prepared for the event they had been told to expect.**

Where ensemble or **probabilistic information was available, it was not converted into public-facing warnings**. In Venice, ECMWF 50+1 (European Centre for Medium-Range Weather Forecasts) ensemble members had indicated the possibility of the secondary depression traversing the lagoon, but CPSM treated this output qualitatively.

In Portugal forest fires, a **"yellow" fire danger** alert was issued on 16 June despite conditions the Independent Technical Commission **later assessed as warranting immediate escalation**; the entire pre-positioning of resources was scaled to a yellow-level event.

F-5: Message content failed in two ways: it was not impact-based and not action-specific

This was identified in at least 10 of the 16 cases[6]. Warnings **used hazard language** (e.g., rainfall in mm, water levels in cm, fire danger indices) **rather than impact language**. The Ahrtal KATWARN message issued at 19h35m in Ahrweiler warned of water levels exceeding 5 metres but recommended actions such as avoiding cellars and clearing drains, advice wholly inadequate for a flood that was destroying entire buildings less than two hours later. Survey data show that 85% of warned Ahrtal respondents did not expect very severe flooding, and 46% **did not know what protective action to take**. In Katrina, evacuation orders **did not specify destinations or transportation**; qualitative interviews recorded participants recalling messages to "go somewhere" without knowing where or how. In Portugal's forest fires, **no public warning of any kind was issued** to affected populations about affected villages and roads before the fatal downburst at approximately 20h00 on 17 June 2017.

F-6: The failure was located further upstream in detection itself

This was identified in 4 cases[7]. For the 2004 tsunami, **no Indian Ocean warning system existed**; the Pacific Tsunami Warning Center (PTWC) could not have generated warnings for near-field communities such as Simeulue (8–20 minutes lead time) in less than the approximately 15–20 minutes required. For Madeira 2010, **no weather radar existed** on the island, limiting forecasting of the rainfall event that produced 114 litres per square metre in five hours and at least 42 deaths.

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[5] 2. Floods in Germany, 3. Suez Canal Blockage, 5. Venice Floods, 6. Forest Fires in Central Portugal, 12. Alluvial Flooding in Madeira.

[6] 1. Wildfires in Hawaii, 2. Floods in Germany, 5. Venice Floods, 6. Forest Fires in Central Portugal, 7. Grenfell Tower Fire, 8. WannaCry Cyberattack, 12. Alluvial Flooding in Madeira, 13. Northern Rock Crisis, 14. Hurricane Katrina, 16. Floods in Prague.

[7] 5. Venice Floods, 6. Forest Fires in Central Portugal, 12. Alluvial Flooding in Madeira, 15. Indian Ocean Tsunami.

For Venice 2019, the secondary mesoscale depression that produced the catastrophic surge was **not resolved by any operational forecast model**.

Tensions

Three tensions in the case study evidence resist clean resolution.

1. **Lead time and forecast certainty trade off against each other**: the longer the lead time, the higher the uncertainty, and warnings issued at maximum lead time are most likely to attract "cry wolf" effects – a psychological phenomenon where repeated false alarms or warnings cause people to disregard, or take less protective action in response to, future warnings (e.g., Ahrtal, where heavy-rain warnings the previous week without serious flooding may have reduced attentiveness to subsequent warnings).
2. **Message simplicity and regulatory nuance pull in opposite directions**: the UK Inquiry found that "Stay Home, Protect the NHS" achieved high first-lockdown compliance precisely because of its simplicity, but this same simplicity became a source of confusion as tiered restrictions evolved.
3. **Urgency and reassurance can be in tension**: in the Northern Rock case, accurate official reassurances about the bank's solvency did not stop the run, whereas the unconditional government guarantee issued on 17 September had an immediate stabilising effect. This suggests that reassurance may fail when people no longer trust institutional assessments or when they perceive urgent protective action as necessary. At the same time, the case study evidence does not resolve how urgency and reassurance should be balanced in general. Rather, it points to this balance as context-dependent, shaped by factors such as trust, timing, message credibility, and the perceived consequences of inaction.

Section 2. Channels, reach, and equitable access to warnings

Scope: This section examines how warnings reached people: through which media, with what coverage, and with what systematic gaps. It moves the focus from whether information existed and was accurate (Section 1) to whether it physically reached the populations who needed it. The analysis covers channel architecture, reach, and equity. Section 3 then covers whether the source of communication was trusted while Section 4 covers what was communicated under uncertainty.

What worked

F-1: Where channel architectures achieved high warning reach, they shared identifiable design features.

Three cases[8] achieved high warning reach and protective behaviour, and they share four features:

- **Information pushed directly to people, not hidden behind a search:** They actively sent warnings out to residents (like automated phone calls or sirens) instead of waiting for people to hunt for updates themselves (like checking a website or tuning on the news).
- **Multiple backup channels to spread the word:** They did not rely on just one way to send a warning. By using different tools at the same time – like phones, word-of-mouth, and emergency systems – they made sure the message reached everyone, even if one system failed.
- **Human contact and face-to-face verification:** They included real people in the loop. Whether it was police officers doing door-to-door sweeps, local volunteers checking on neighbours, or people looking out for one another, human interaction made sure the message was actually received and acted upon.
- **Deeply rooted in local culture and habits:** The warnings were woven into the community's everyday history and traditions. Because the safety steps were built on

[8] 10. Eyjafjallajökull Eruption, 14. Hurricane Katrina, 15. Indian Ocean Tsunami.

generation-spanning stories, shared memories, or regular community drills, people instantly understood the danger and knew exactly how to react without hesitating.

Plaquemines Parish issued an evacuation order almost two days before Katrina's landfall and combined automated warnings with house-to-house contacts by law enforcement officers, achieving a 97–98% evacuation rate with only three deaths. Iceland's Eyjafjallajökull response combined automated telephone alerts with a door-to-door volunteer sweeper network and standardised household gate signs verifiable by Civil Protection helicopter. On Simeulue Island, the *smong* oral tradition required no technology and produced near-total spontaneous evacuation within 8 to 20 minutes of shaking.

F-2: Social media operated as a parallel and often faster informal channel, partially compensating for failures in official systems

This was identified in at least 7 of the 16 cases[9]. In the Ahrtal case in Germany, **Facebook groups** functioned as an unofficial early warning network, with community members observing rising water levels **warning each other in real time**, in some areas before official channels reached residents. In Maui, **survivor-led TikTok content** was more effective at capturing public attention and facilitating peer-led relief than traditional media; 93% of residents reported that their first alert came from neighbours or friends rather than official channels. During WannaCry, NHS staff **used Twitter to describe operational disruptions in real time**, functioning as a rapid informal communication channel that preceded and sometimes shaped official messaging. In the Deepwater Horizon response, local volunteers **used Twitter to match boat owners with organisations needing cleanup assistance**. The pattern is that **social media filled the vacuum left by failed or absent official channels**, though with consequences for information quality that are taken up in Section 4.

What Did Not Work

F-3: Opt-in subscription-based warning systems failed to reach most at-risk populations

The pattern operates as a structural design failure rather than an implementation problem, with coverage figures in the two best-documented cases[10] showing systematic under-reach.

Two architectures for delivering warnings to mobile phones recur across the cases. **Opt-in systems require users to take a deliberate action in advance**: they must download an app, register their location, and accept notifications. KATWARN and NINA (Emergency Information and News App) in Germany are the clearest examples. **Push-to-all systems**, of which Cell Broadcast is the most prominent, use the cellular network itself to send messages to every phone within range of designated towers, **requiring no prior action from the user**.

The coverage figures from the Ahrtal are precise. KATWARN reached approximately 18% of Ahrweiler residents prior to the flood; NINA was used by approximately 4% of the German population nationwide. Even if the warnings issued through these channels had been perfect in content and timing – which Section 1 shows they were not – they could not have reached more than these proportions of the population. The downstream consequence appears in the survey data: 35% of NRW respondents and 29% of Rhineland-Palatinate respondents received **no warning at all**. In Maui, despite 18 press releases issued within 24 hours, 93% of residents reported that their **first alert came from neighbours or friends rather than official channels**. A natural response to the 18% figure in the Floods in Germany (Ahrtal) case would be to argue that the answer is more aggressive subscription drives. The case study evidence pushes against this. The post-Ahrtal institutional response was not a marketing campaign for KATWARN; it was the deployment of Cell Broadcast in February 2023, an **architectural change** explicitly framed as

[9] 1. Wildfires in Hawaii, 2. Floods in Germany, 4. COVID-19 Pandemic and Loss of Critical Services, 6. Forest Fires in Central Portugal, 7. Grenfell Tower Fire, 8. WannaCry Cyberattack, 11. Deepwater Horizon Oil Spill.

[10] 1. Wildfires in Hawaii, 2. Floods in Germany.

a lesson learned. Iceland post-2010 acquired equivalent **push-to-all capacity** after Eyjafjallajökull, similarly framed as a structural response. Both institutional responses treat the **opt-in architecture as the failure** rather than its uptake.

The reason this is **a structural rather than incidental finding** is taken up in Findings 5 and 6: the populations least likely to subscribe to opt-in systems are systematically those most vulnerable in disasters. Coverage figures of 18% are not a marketing problem to be solved at the margin; they reflect the demographic profile of who can and cannot be expected to opt in to a warning system in advance. This is consistent with behavioural-economics evidence on default effects: when participation is necessary for public protection, the default option should support the socially desirable and protective outcome, rather than requiring individuals to actively opt in.

F-4: Telecommunications infrastructure failed in the moment warnings were most needed

This was identified in at least 7 of the 16 cases[11]. In Maui, total failure of all 21 local cell towers left over 14,000 subscribers **unable to send or receive emergency alerts**. In the Ahrtal, **mobile networks collapsed in the most affected areas**; TETRA BOS (Emergency Services radio network) digital radio became overloaded and 38–40% of first responders cited radio failure as an operational impairment; one district crisis centre had its main IT server located in the basement, which flooded. In Portugal forest fires, five SIRESP (Integrated System of Emergency and Safety Networks of Portugal) **antennae in the affected zone were destroyed or disconnected** by fire, causing the network to revert to local-only operation and congesting the remaining nodes; SADO log entries confirm that information about rescue requests "did not reach the Operational Command Post (PCO) due to communication difficulties" across multiple entries from 22h45 on 17 June into 18 June. In Katrina, commercial telecommunications outages affected NWS (National Weather Service) field offices' ability to disseminate weather information, requiring activation of continuity-of-operations plans with backup support from offices across Texas to Florida.

The vulnerability is structural: **warning systems built on infrastructure that is itself destroyed** by the disasters they are meant to communicate about have a **built-in failure mode**. This is why warning strategies should include redundant and resilient channels, including global or wide-area information media such as radio, as well as community-based and amateur radio networks that may remain functional when local telecommunications infrastructure fails.

F-5: Vulnerable populations were systematically excluded by channel design choices

Across at least 9 of the 16 cases[12], the **same demographic groups were repeatedly disadvantaged**: elderly residents, persons with disabilities, low-income populations, residents of care homes, tourists, and non-native language speakers.

The Ahrtal **mortality concentration** is the most quantified example: 78–80% of victims in the Ahrtal were **aged 60 or over**, partly attributable to a **warning system reliant on smartphone apps, media consumption, and active information-seeking**, all of which systematically disadvantaged populations less likely to use these channels. The 12 deaths in the Sinzig care home for people with disabilities reflect the absence of targeted warning and evacuation plans for that specific population; 16% of all Ahrtal fatalities had a **recorded disability**. In New Orleans before Katrina, approximately one in five households lacked a car and 8% had no land telephone service; the entire **warning architecture assumed car ownership and active information-seeking**. Community leader Dyan French testified to the Select Bipartisan Committee:

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[11] 1. Wildfires in Hawaii, 2. Floods in Germany, 6. Forest Fires in Central Portugal, 7. Grenfell Tower Fire, 12. Alluvial Flooding in Madeira, 14. Hurricane Katrina, 15. Indian Ocean Tsunami, 16. Floods in Prague.

[12] 1. Wildfires in Hawaii, 2. Floods in Germany, 4. COVID-19 Pandemic and Loss of Critical Services, 5. Venice Floods, 6. Forest Fires in Central Portugal, 7. Grenfell Tower Fire, 10. Eyjafjallajökull Eruption, 14. Hurricane Katrina, 15. Indian Ocean Tsunami.

Why would you get in the public media and ask a city, where 80 percent of its citizens ride public transit, to evacuate? What [were] they supposed to do? Fly?

In Grenfell Tower, **no multilingual fire safety notices or accessible-format guidance** had been provided despite the building's diverse population. The UK COVID-19 Inquiry found that the UK government and Northern Ireland Executive "initially failed to provide British Sign Language interpretation for press conferences or to provide key guidance in alternative formats", **excluding deaf and hard-of-hearing communities** from primary communication channels during the most critical period of the pandemic.

F-6: Tourists and transient populations represent a systematic blind spot in warning architecture

This was identified across 5 of the 16 cases[13]. Warning systems are typically calibrated to permanent residents who subscribe to local channels, recognise local sirens, and understand local hazards; **transient populations are structurally disconnected** from this architecture. Venice in 2019 had tourist bedspaces (52,720) approaching its resident population (52,996), with tourist capacity exceeding residents that year for the first time, but **warning communication remained calibrated to a declining resident base**. The Venice siren coding system (110/140 cm thresholds) presupposes prior knowledge of code meaning and offers **no intuitive interpretation** for unfamiliar visitors. In Portugal forest fires, the event occurred on a Saturday in mid-June when **seasonal visitors and secondary-home owners** were present alongside the elderly permanent residents; approximately half of the 64 fatalities were residents while 12% were described as regular visitors. In Iceland, the 2009 tourist survey was constrained to English and Icelandic speakers, **limiting understanding of non-English-speaking tourists' communication needs**; two domestic tourists died during the Eyjafjallajökull fissure phase having lost their way on the glacier at night. In Maui, tourists unfamiliar with local roads were identified as among the populations at extreme risk during the wildfire evacuation.

Tensions

Three tensions emerge from the channel evidence.

1. Push-based universal systems such as Cell Broadcast **maximise reach but lose the granularity** of subscription-based systems that can be calibrated to specific risks for specific populations; the **trade-off** is between **near-universal coverage of a generic message** and **tailored coverage of a specific subscriber group**.
2. **Channel redundancy improves reach** but **multiplies the risk of inconsistent messages** across channels, a tension taken up in Section 4.
3. **Social media reaches populations that official channels miss** and often does so faster, but it **operates outside institutional quality control and amplifies misinformation** as readily as accurate warnings (e.g., Maui TikTok conspiracy theories, COVID-19 infodemic, Katrina post-landfall violence rumours).

The case study evidence does not resolve these tensions; it does, however, suggest that the cases with the best outcomes did not choose between push and pull, formal and informal, or institutional and community channels, but **layered them**.

Section 3. Trust, messengers, and the credibility of the institutional voice

Scope: This section examines who communicated warnings and risk information, and whether those sources were credible to the populations they addressed. It moves the focus from the channels through which information travelled (Section 2) to the question of whether recipients believed the source enough to act on the message. The section covers institutional trust, the role

[13] 1. Wildfires in Hawaii, 5. Venice Floods, 6. Forest Fires in Central Portugal, 10. Eyjafjallajökull Eruption, 12. Alluvial Flooding in Madeira.

of trusted messengers at community level, and the consequences when institutional credibility was absent or eroded.

What worked

F-1: Community-embedded messengers consistently outperformed institutional voices when institutional trust was low or absent

This was identified in at least 8 of the 16 cases[14]. The Simeulue *smong* tradition operated through **community storytelling** and the *bupati* (district governor) functioned as a **trusted local authority figure**; the cohesive Islamic community structure of *ijma* (**consensus**) reinforced **collective adherence** to evacuation norms. In Iceland during the Eyjafjallajökull eruption, scientists were rated 4.0–4.1 (on a 1–5 scale) by both rural and urban residents; local police chiefs in their **dual role as community leaders and emergency authorities** executed evacuations through the sweeper volunteer network. In Deepwater Horizon-affected communities, the Mary Queen of Vietnam Community Development Corporation and Bayou Interfaith Shared Community Organizing functioned as "boundary spanners" facilitating **reliable information flow between authorities and residents** who had low trust in petroleum industry officials. In post-event Indian Ocean Tsunami response, the governments of Tamil Nadu and Kerala posted **women fire officers, police officers, and doctors** to camps and affected villages, creating safer environments for women survivors and reducing violence.

F-2: Where political and scientific communication aligned, public compliance was higher

The COVID-19[15] cross-national comparison provides the clearest evidence. New Zealand under Prime Minister Ardern **combined scientific advice with empathetic communication delivered through accessible social media**, contributing to high compliance and the country declaring itself "Covid-free" in November 2020. Germany's BfR-Corona-Monitor data showed that by March 2021, 95% of respondents approved mandatory mask wearing and 91% supported distancing regulations, in a context where **federal communications were broadly aligned with scientific guidance** even when federal-state coordination produced inconsistencies. The Independent Panel for Pandemic Preparedness and Response identified countries that "took **whole-of-government and whole-of-society approaches**, sought **scientific guidance**, **engaged with community** health workers and community leaders, **involved vulnerable and marginalised populations**" as those that **managed COVID-19 substantially better** than countries characterised by "denial, delay, and distrust".

What Did Not Work

F-3: Pre-existing institutional distrust was a recurring constraint on warning effectiveness

This was identified in at least 7 of the 16 cases[16]. In New Orleans before Katrina, qualitative interview participants expressed beliefs that levees had been deliberately breached to flood poor Black neighbourhoods and protect wealthy areas and the French Quarter; these beliefs reflected **deep pre-existing distrust of authorities** shaped by historical experiences of racial discrimination and were not addressable through better communication during the event itself. Cole and Fellows note that women and African Americans had reduced confidence in government authorities, making exclusive reliance on official spokespersons particularly unsuited to the New Orleans context. After Fukushima, trust in Tokyo Electric Power Company (TEPCO) and the Japanese government was structurally compromised by the "nuclear village" of collusive ties

[14] 1. Wildfires in Hawaii, 4. COVID-19 Pandemic and Loss of Critical Services, 6. Forest Fires in Central Portugal,10. Eyjafjallajökull Eruption, 11. Deepwater Horizon Oil Spill, 12. Alluvial Flooding in Madeira, 14. Hurricane Katrina, 15. Indian Ocean Tsunami.

[15] 4. COVID-19 Pandemic and Loss of Critical Services.

[16] 3. Suez Canal Blockage, 4. COVID-19 Pandemic and Loss of Critical Services, 7. Grenfell Tower Fire, 9. Tōhoku Triple Disaster, 11. Deepwater Horizon Oil Spill, 13. Northern Rock Crisis, 14. Hurricane Katrina.

between regulators, power companies, and politicians; many residents **interpreted vague official statements as evidence that information was being hidden**. In Grenfell Tower, residents had a **documented history of distrust and a negative relationship** with the building's manager Kensington and Chelsea Tenant Management Organisation (TMO), which shaped how official communications during and after the fire were received.

F-4: Institutional voices were repeatedly damaged by communication that prioritised reassurance over accuracy or that lagged behind known events

This was especially evident in 3 of the 16 cases[17]. In the United States during COVID-19, Sauer et al. document that "**withholding information from the public and communicating known falsehoods undermined the President's credibility and damaged public trust**"; the federal communication lag of more than two months after the first USA cases left an **information vacuum filled by unofficial and inaccurate sources**. After Hurricane Katrina, 70% of Houston shelter evacuees disapproved of President Bush's handling of the crisis, 58% disapproved of Governor Blanco's, and 53% disapproved of Mayor Nagin's. This deep dissatisfaction stemmed from a systemic failure to provide pre-planned evacuation support, which ultimately left tens of thousands of low-income and car-less residents stranded when the mandatory evacuation order was issued less than 24 hours before landfall. After Fukushima, the **delay** in releasing SPEEDI (System for Prediction of Environmental Emergency Dose Information) radiation simulation results, combined with **vague reassurances** about "no immediate health effects", produced **enduring credibility damage**. In the Northern Rock case, the leaked emergency support announcement was **meant to reassure, but instead signalled crisis**: the FSA (Financial Services Authority) Chairman described it as having made institutional intervention appear to be "a panic measure". The run only stopped after the government's unconditional deposit guarantee on 17 September provided depositors with a credible commitment.

F-5: Language and accessibility failures functioned as trust failures, signalling that certain populations were not the intended audience of official communication

This was identified in at least 4 of the 16 cases[18]. The Suez Canal case is the most direct illustration: the Suez Canal Authority (SCA) pilots conducted critical navigational discussions exclusively in Arabic, preventing the Master and bridge team from understanding the unfolding crisis; the PMA investigation explicitly recommended that the SCA impose English as the mandatory working language between pilots when non-Arabic-speaking Masters are present. In Grenfell Tower, the **systematic failure to provide multilingual fire safety notices** for the building's diverse population is identified by both Inquiry phases as a fundamental communication failure. The UK COVID-19 Inquiry found that the government "initially **failed to provide British Sign Language interpretation** for press conferences **or to provide key guidance in alternative formats**" and was explicit that these were "not secondary considerations". In the Indian Ocean Tsunami response, MacDonald documents that women in Sri Lanka were reluctant to speak in mixed groups, requiring **gender-sensitive communication formats** that Oxfam adopted but that mainstream relief operations often did not.

F-6: Trusted messengers were rarely deployed systematically; their effective role tended to be emergent rather than designed

Across case studies[19], the cases where **community leaders, religious figures, health workers, or non-governmental organisations** (NGOs) functioned as **effective intermediaries** did so largely through **ad hoc activation rather than pre-planned integration into warning architectures**. Governor Blanco's late-stage effort to enlist clergy in Katrina evacuation had

[17] 4. COVID-19 Pandemic and Loss of Critical Services, 13. Northern Rock Crisis, 14. Hurricane Katrina.

[18] 3. Suez Canal Blockage, 4. COVID-19 Pandemic and Loss of Critical Services, 7. Grenfell Tower Fire, 15. Indian Ocean Tsunami.

[19] 6. Forest Fires in Central Portugal, 12. Alluvial Flooding in Madeira, 14. Hurricane Katrina

limited participation as the storm came ashore. The role of community leaders in the Madeira 2010 event is essentially undocumented in the official sources. The Portugal forest fires Independent Technical Commission recommended that municipal authorities should be proactive in mobilising communities for protective measures, implying this role was not fulfilled during the event.

Loss et al. recommend, as a general principle, involving "those affected, community representatives and multipliers" in the design of risk communication strategies; the evidence across cases suggests this principle is **widely endorsed in retrospect and rarely operationalised in advance**. This is also consistent with the social identity and collective resilience literature, which shows that people affected by disasters may develop a shared sense of identity and are often more willing to help, share information and act altruistically toward others facing the same threat. Involving affected communities and trusted multipliers in advance can therefore support not only message design, but also the social conditions through which warnings and protective behaviours are circulated and reinforced.

Tensions

Three tensions structure the trust evidence.

1. **Institutional voices and community messengers carry different forms of authority** that do not substitute cleanly for each other: institutional voices command resources and formal legitimacy; community messengers command relational trust. The cases with the best outcomes used both.
2. Transparent acknowledgement of uncertainty (detailed below in Section 4) can either build or erode trust **depending on the prior relationship between communicator and audience**: New Zealand's transparent communication built trust because Ardern's prior credibility was high; Fukushima's belated transparency about radiation data eroded trust because the prior credibility of TEPCO and the government was already damaged.
3. **Trust takes years to build and erodes in days**: the Katrina, Fukushima, and Deepwater Horizon cases all show that pre-existing distrust shapes communication outcomes during the event itself, with limited scope for in-event recovery. This implies that **trust is more usefully understood as infrastructure to be maintained** between disasters than as a resource to be deployed during them.

Section 4. Uncertainty, transparency, and the management of contested narratives

Scope: This section examines how uncertainty was communicated, where transparency succeeded or failed, and how contested narratives developed when information vacuums or institutional ambiguity left space for alternative accounts. It connects directly to Section 1 (where forecast underestimation was a recurring failure) and Section 3 (where institutional credibility shaped what audiences were prepared to accept) but focuses specifically on the management of incomplete or contested information.

What worked

F-1: A small number of cases operationalised explicit uncertainty communication, and these are repeatedly cited as best practice[20]

During the August 2002 Czech floods, the Czech Hydrometeorological Institute (CHMI) generated alternative precipitation scenarios on 11 August, distinguishing minimum, maximum, and most likely outcomes; the actual development tracked the maximum alternative, and **decision-makers had been given the range rather than a single deterministic estimate**. Germany's BfR-Corona-Monitor and the COSMO survey project provided **near-real-time longitudinal monitoring of**

[20] 4. COVID-19 Pandemic and Loss of Critical Services, 10. Eyjafjallajökull Eruption, 16. Floods in Prague.

public risk perception throughout the COVID-19 pandemic, enabling **adaptive communication management**. New Zealand under Ardern explicitly **combined transparency about scientific uncertainty with empathetic framing**, which BoI identifies as a core differentiator between national communication strategies during COVID-19. The International Maritime Organization (IMO) website during the Eyjafjallajökull eruption made **near-real-time GPS and seismic data publicly available**, empowering citizens to follow the eruption's progression directly and reducing pressure on telephone enquiries.

F-2: Where official institutions made probabilistic information accessible to the public, this supported rather than undermined protective behaviour[21]

The Eyjafjallajökull case illustrates the value of communicating uncertainty through factual and observable information. Icelandic scientists, particularly at the Icelandic Meteorological Office and the University of Iceland, prioritised **clear factual statements and real-time observational reports** of volcanic activity. This made the evolving situation easier for non-specialist audiences to follow. Icelandic media also played a constructive role by reproducing IMO monitoring plots responsibly and without sensationalism. Together, these practices helped the public understand the hazard as an actively monitored event. The COVID-19 cross-national survey by Dryhurst et al., across 6,991 respondents in ten countries, found that risk perception correlated significantly with adoption of preventative health behaviours in all ten countries. **Trust in government, science, and medical professionals** was a statistically significant predictor in most countries, and this trust was **supported by transparent communication of uncertainty**.

What Did Not Work

F-3: Forecast and ensemble uncertainty was systematically not communicated to the public

This was identified in at least 5 of the 16 cases[22]. In Venice, ECMWF 50+1 ensemble members had indicated the possibility of the secondary depression traversing the lagoon, but CPSM treated this output qualitatively and **the public received only the deterministic central forecast** of 140–150 cm against an actual 189 cm. In the Ahrtal, the probabilistic nature of extreme weather forecasts, including the ECMWF EFI (European Centre for Medium-Range Weather Forecasts Extreme Forecast Index) above 0.8 from 12 July, was **not translated into accessible public communication**. Mohr et al. recommend the EFI and similar metrics as tools for communicating the probability of an extreme event to users and the general public; this recommendation post-dates the Ahrtal failure.

F-4: The downplaying dynamic recurred across institutional contexts

This was identified in at least 9 of the 16 cases[23]. In each, **official communication minimised severity at moments when more accurate communication would have prompted protective action**. The Maui AM fire was prematurely declared extinguished. Governor Blanco's "hopefully" framing on 28 August softened the Katrina evacuation message. Japanese government communications mixed reassurance with the delayed release of SPEEDI radiation simulation data after Fukushima. BP underestimated the Deepwater Horizon spill's magnitude in early communications and was accused of censuring news releases from workers. In the United States during COVID-19, the federal government communicated that "the virus would disappear on its own" and downplayed transmission risk; Sauer et al. document this as a failure of the Crisis and Emergency Risk Communication (CERC) "Be Right" principle. In Madeira, official statements

[21] 4. COVID-19 Pandemic and Loss of Critical Services, 10. Eyjafjallajökull Eruption.

[22] 2. Floods in Germany, 5. Venice Floods, 6. Forest Fires in Central Portugal, 10. Eyjafjallajökull Eruption, 12. Alluvial Flooding in Madeira

[23] 1. Wildfires in Hawaii, 3. Suez Canal Blockage, 4. COVID-19 Pandemic and Loss of Critical Services, 9. Tōhoku Triple Disaster, 11. Deepwater Horizon Oil Spill, 12. Alluvial Flooding in Madeira, 13. Northern Rock Crisis, 14. Hurricane Katrina.

rejected criticism of urban planning failures while environmental organisations and civil protection experts contested this framing.

The recurrence of downplaying may partly reflect the persistent "panic assumption" described earlier: the belief that stronger warnings will provoke irrational or disorderly public behaviour. In practice, this can lead institutions to soften language, delay escalation, or prioritise reassurance over actionable warning. This is problematic because disaster research shows that panic is rare, and that clear, honest, specific guidance is more likely to support protective action than to produce disorder (Quarantelli, 1954; Clarke, 2002; Drury, 2018; GCS Behavioural Science Team, 2022). The panic assumption is not the only driver of downplaying; similar dynamics may also reflect reputational concerns, fear of economic disruption, uncertainty, liability, political pressure, or institutional overconfidence.

F-5: Conflicting messages between agencies, between levels of government, or across time eroded the credibility of any single source

This was identified in at least 9 of the 16 cases[24]. In the Ahrtal, different districts issued **warnings at different times and with different content**, with **no consistent national or state-level messaging framework**. In the United States during COVID-19, the Surgeon General and Dr. Fauci advised against public mask wearing on 29 February 2020; the Centres for Disease Control and Prevention (CDC) reversed this approximately one month later. South Dakota Governor Noem described protective actions as "optional", **contradicting** public health guidance. In Germany during COVID-19, Bol notes that **constant federal-state disagreements** produced "irregular and confusing" public communication. After the Suez Canal grounding, the SCA attributed fault to the vessel's Master while the UK Protection and Indemnity (P&I) Club asserted SCA pilot and Vessel Traffic Management Service (VTMS) responsibility for excessive speed; the absence of an SCA public investigation report left a significant evidentiary gap. After Fukushima, experts on television frequently gave diverging interpretations of risk, undermining public trust in science.

F-6: Information vacuums were predictably filled by rumour and misinformation

This was identified in at least 9 of the 16 cases[25]. Post-Katrina media coverage **amplified unverified rumours** of looting, gang violence, murder, and child rape at the Superdome and Convention Centre; these reports were later found to be without empirical basis but had direct operational consequences, including the shift from lifesaving to law-enforcement priorities by Governor Blanco and Mayor Nagin within three days of landfall. Fukushima **rumours about contamination caused severe economic damage** to the agriculture and fishery industries. After the Suez Canal grounding, ENISA (European Union Agency for Cybersecurity) and Sauer et al. respectively document how social media platforms **amplified low-credibility sources** during COVID-19; **bots were deployed as disinformation weapons**; 50.5% of identifiable misinformation in one content analysis was **disseminated by social media platforms**.In the Maui fires, **conspiracy theories about supply withholding** by national organisations circulated widely on TikTok. In the Ahrtal, anti-COVID protest groups (*Querdenker*) **actively spread misinformation** and physically interfered with relief operations. The UK SAGE (Scientific Advisory Group for Emergencies) **secrecy** during the Eyjafjallajökull aviation crisis, where minutes were not published until parliamentary scrutiny forced disclosure, contributed to a **prevalence of rumour in the media**.

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[24] 2. Floods in Germany, 3. Suez Canal Blockage, 4. COVID-19 Pandemic and Loss of Critical Services, 5. 7. Grenfell Tower Fire, 9. Tōhoku Triple Disaster, 10. Eyjafjallajökull Eruption, 12. Alluvial Flooding in Madeira, 13. Northern Rock Crisis, 14. Hurricane Katrina.

[25] 1. Wildfires in Hawaii, 2. Floods in Germany, 4. COVID-19 Pandemic and Loss of Critical Services, 9. Tōhoku Triple Disaster, 10. Eyjafjallajökull Eruption, 11. Deepwater Horizon Oil Spill, 13. Northern Rock Crisis, 14. Hurricane Katrina, 15. Indian Ocean Tsunami.

Information vacuums were predictably filled by rumour and misinformation. This supports the recommendation that authorities should respond quickly to incorrect or misleading messages, especially when they concern protective action, the scale of harm, available support, or institutional responsibility. Rapid correction should be paired with clear, authoritative information about what is known, what remains uncertain, what people should do, and where reliable updates can be found.

Tensions

Three tensions emerge from the uncertainty and transparency evidence.

1. **Transparency about uncertainty can paradoxically induce anxiety**: Loss et al. note that repeated emphasis on uncertainty can itself increase public concern, while simultaneously identifying transparency as essential for trust. The case studies do not resolve this; they suggest that the framing and the moment when uncertainty is communicated matters more than the volume of uncertainty information.
2. **Speed and accuracy trade off against each other**: communicating first risks being wrong; waiting for certainty risks being too late. The CERC principle requires "Be First" and "Be Right" simultaneously; the COVID-19 evidence shows these can conflict; thus, this risk communication needs to be dynamic and evolve with time.
3. **Official silence and official certainty both create vulnerability to misinformation**: silence leaves an information vacuum (e.g., Eyjafjallajökull SAGE secrecy, BP early communications), while overconfident certainty discredits the institutional voice when reality diverges from the assertion (e.g., Maui AM fire extinguished declaration, Fukushima reassurances). The case studies suggest that calibrated transparency, acknowledging what is known, what is unknown, and what is being done to find out, performs better than either extreme.

Section 5. Coordination across agencies, sectors, and jurisdictions

Scope: This section examines how agencies coordinated with each other to produce coherent communication, whether jurisdictional and sectoral fragmentation produced inconsistent messages, and how decision-making bottlenecks at the institutional level produced communication failures downstream. It moves the focus from individual messages and channels to the institutional architecture that produced them.

What Worked

F-1: A small number of cases demonstrated effective inter-agency coordination as a foundation for coherent communication[26]

In Iceland during Eyjafjallajökull, the IMO and IES operated as a closely integrated monitoring partnership, sharing equipment and data, with the Icelandic Department of Civil Protection and Emergency Management (DCPEM) acting as the lead operational body and local police chiefs executing communication through the automated alert system; **coordination between scientific, civil protection, and law enforcement agencies was well established before the eruption**. In the August 2002 Czech floods, the **legislative and organisational improvements** introduced after 1997 – including the merging of fire and civil protection into Fire Rescue Brigades and improved flood management plans – contributed to a "significant reduction of improvisation" compared to the 1997 response. **International coordination** through established agreements with neighbouring countries enabled successful transboundary information exchange. In the Indian Ocean Tsunami response, the international community's rapid establishment of the Tsunami Evaluation Coalition within weeks of the disaster, **bringing together over 40 humanitarian agencies in a collaborative evaluation process**, was described by the UN

[26] 10. Eyjafjallajökull Eruption, 15. Indian Ocean Tsunami, 16. Floods in Prague.

Secretary-General's Special Envoy as "an extraordinary effort at reflection, self-criticism and transparency".

F-2: Co-located, integrated coordination structures produced more coherent communication than distributed ones[27]

The Deepwater Horizon Joint Information Centre in Houma demonstrated **effective coordination through the integration of BP and USA Coast Guard personnel in a single facility**; this co-location is credited with fostering a unified front and professional working relationship, despite broader coordination failures with the Unified Area Command in New Orleans (described by participants as a "Black Hole"). During WannaCry, NHS Digital's CareCERT escalated the incident to the Department of Health and Social Care within approximately three hours of the first trust reports, and NHS England's prompt activation of the EPRR structure major incident protocol at 16h00 provided a **formal coordination structure**. The activation of the first-ever EU Standard Operating Procedures for cyber cooperation during WannaCry represents a positive precedent in international cyber incident coordination.

What Did Not Work

F-3: Jurisdictional fragmentation produced inconsistent warnings and decision-making bottlenecks

This was identified in at least 9 of the 16 cases[28]. Germany's federal disaster management structure assigns **primary responsibility to districts** (Kreise), with the result that the smallest administrative units, sometimes with very limited professional emergency management capacity, hold the authority to declare states of emergency. In Ahrweiler, this structural weakness was catastrophically exposed: the Landrat was identified by the parliamentary inquiry as having failed to act on available information during the flood night. There is **no mandatory disaster management training for district administrators, who are elected politicians**; the system relies on these individuals making **life-or-death operational decisions without professional preparation**. The UK's devolved four-nation COVID-19 governance produced **messaging inconsistencies** that the Inquiry found "difficult for members of the public to understand". In the United States during Katrina, jurisdictional tensions between the Mayor of New Orleans, the Governor of Louisiana, and federal authorities complicated pre-landfall decision-making. During the Eyjafjallajökull aviation crisis, the **absence of a coordinating intergovernmental scientific body** for European volcanic ash management meant **responses were improvised and nationally fragmented**.

F-4: Decision-making bottlenecks at the institutional level produced communication delays downstream

This was identified in at least 8 of the 16 cases[29]. The Ahrweiler state of emergency declaration at 23h09 on 14 July – by which time, many communities were already overwhelmed and homes were flooded – was the bottleneck that translated meteorological lead time into inadequate public warning. While early warnings were issued, the failure to declare a disaster or initiate timely evacuations at the local level meant many residents were **not adequately prepared for the severity** of the surge. In Portugal forest fires, the PCO (operations control centre) was not fully operational until 19h58 on 17 June, nearly five-and-a-half hours after the initial alert, and the specialist GRUATA force (Portuguese specialist rescue force) was not mobilised until 22h30 and

[27] 8. WannaCry Cyberattack, 11. Deepwater Horizon Oil Spill.

[28] 2. Floods in Germany, 4. COVID-19 Pandemic and Loss of Critical Services, 6. Forest Fires in Central Portugal, 7. Grenfell Tower Fire, 9. Tōhoku Triple Disaster, 10. Eyjafjallajökull Eruption, 12. Alluvial Flooding in Madeira, 13. Northern Rock Crisis, 14. Hurricane Katrina.

[29] 2. Floods in Germany, 4. COVID-19 Pandemic and Loss of Critical Services, 6. Forest Fires in Central Portugal, 7. Grenfell Tower Fire, 8. WannaCry Cyberattack, 9. Tōhoku Triple Disaster, 13. Northern Rock Crisis, 14. Hurricane Katrina.

arrived at 03h00 when all **fatalities had already occurred**. In WannaCry, the three-hour gap between CareCERT's first alert (just after 13h00) and NHS England's major incident declaration (at 16h00) left 46 trusts making independent system-shutdown decisions without central guidance. In the Northern Rock case, the Treasury Committee concluded that the Tripartite authorities "ought to have strained every sinew to finalise the support operation and announce it within hours rather than days"; once the run began, the deposit guarantee that halted it was not made until more than 75 hours after the BBC broadcast.

F-5: Practitioner coordination repeatedly failed at the interface between sectors

This was identified in at least 7 of the 16 cases[30]. In the Ahrtal, post-event interviews with hospital managers, water providers, and health authorities found that hospitals were largely unable to independently manage infrastructure failures and were critically dependent on external support from THW (Federal Agency for Technical Relief) and the fire department, whose capacity was simultaneously overwhelmed; **insufficient pre-established information exchange protocols between sectors** significantly hampered effective response. In Portugal forest fires, the National Republican Guard (GNR) confirmed it received **no contact** from District Command for Relief Operations (CDOS) during the event and **made road-closure decisions independently**; health centres received **no instructions** from the operations control centre and **acted independently**. In Iceland during Eyjafjallajökull, agricultural authorities were **not incorporated into emergency planning or the initial response**, creating a sector-specific gap that had direct consequences for livestock management and farmer welfare. In Grenfell, the failure to follow established JESIP (Joint Emergency Services Interoperability Principles) resulted in a **lack of shared understanding** of the fire's nature among the LFB (London Fire Brigade), police, and ambulance services.

F-6: Pre-existing personal relationships and informal networks consistently outperformed formal coordination protocols during crisis

This was identified in at least 5 of the 16 cases[31]. Nick et al. found that physical infrastructure failure, insufficient preparedness, unclear role definitions, and inadequate communication protocols all hindered effective coordination during the Ahrtal floods, and that personal relationships and informal networks were often more effective than formal coordination channels. The implication is consistent across the case studies: **where formal protocols failed, the system relied on whether the right individuals happened to know each other and could improvise around institutional gaps**. This is a structural fragility, not a strength.

Tensions

Four tensions emerge from the coordination evidence.

1. **Decentralisation and centralisation each carry costs**: decentralised systems (Germany, Iceland) preserve local knowledge and accountability but risk uneven capacity at the smallest administrative units; centralised systems (NHS during WannaCry, Federal Emergency Management Agency (FEMA) during Katrina) achieve scale but can lose responsiveness to local conditions.
2. **Formal coordination protocols and informal personal networks are not substitutes**: cases that worked well drew on both, while cases that failed often had formal protocols that nobody had practised and informal networks that had not been built.
3. **Command-and-control structures designed for a particular hazard type often perform poorly when the hazard is novel**: the UK's EPRR (Emergency, Preparedness, Resilience and Response) was not designed for a cyber incident; FEMA (Federal

[30] 2. Floods in Germany, 4. COVID-19 Pandemic and Loss of Critical Services, 6. Forest Fires in Central Portugal, 7. Grenfell Tower Fire, 10. Eyjafjallajökull Eruption, 12. Alluvial Flooding in Madeira, 14. Hurricane Katrina.

[31] 2. Floods in Germany, 6. Forest Fires in Central Portugal, 12. Alluvial Flooding in Madeira, 14. Hurricane Katrina, 15. Indian Ocean Tsunami.

Emergency Management Agency) was not designed for the post-9/11 organisational form it had been given. The cases suggest that **institutional adaptability**, and the capacity to recognise that an existing protocol does not fit, is itself a coordination capability.

4. **Political–expert articulation is a coordination problem on its own.** Political decision-making is present at every level, and legal frameworks usually define how political, expert and operational responsibilities should connect. However, the cases show that this connection can be distorted by assumptions about public panic, reputational concerns, economic pressures or misunderstanding of expert advice. The result can be inconsistent, delayed or softened communication.

Section 6. Community agency, informal networks, and feedback loops

Scope: This section examines the role of communities, civil society, and informal networks as communicators in their own right, the frequent absence of structured feedback loops from communities to authorities, and the consequences of treating risk communication as a one-way transmission rather than a relational process. It connects to Section 2 (community-led communication appeared frequently as a parallel channel) and Section 3 (community messengers were often the trusted ones) but focuses specifically on community agency.

What Worked

F-1: Communities consistently filled vacuums left by failed or absent official communication

This was identified in at least 10 of the 16 cases[32]. Approximately 70,000 **spontaneous volunteers** arrived in the Ahrtal in the weeks following the flood, providing clean-up, logistical, and emotional support that formal organisations could not have delivered alone; a private entrepreneur who lost his own premises organised a volunteer shuttle service that operated for weeks before public authorities established a comparable alternative, bringing approximately 40,000 private helpers into the area. After Hurricane Katrina, **informal community networks,** particularly extended family and church contacts, operated as a **parallel communication system**; emotional appeals from family members, social-service workers, and neighbours **prompted evacuation decisions** that media and official communications alone had not secured. In Grenfell Tower, civil society organisations including the British Red Cross, the Al Manaar Mosque, and the Rugby Portobello Trust **filled the humanitarian vacuum** left by a largely absent local authority, providing clothing, food, medical aid, and distributing millions in donated funds. In the Czech 2002 floods, "enormous efforts of intervention teams and a large number of volunteers" were specifically credited with preventing further damage to protective embankments.

F-2: Community-led adaptive innovation generated solutions that institutional actors would not have produced

This was evident across multiple cases. The pattern is consistent: where formal preparedness had not anticipated a specific operational need, **community actors generated functional solutions in real time**, sometimes with significant scale. Community-built bamboo **evacuation shelters** on Simeulue Island had been constructed and maintained without government support, providing pre-positioned physical infrastructure for the response that the *smong* tradition prescribed. The Eyjafjallajökull "hay bank", proposed by Álftaver farmers in the national agricultural press for **neighbouring farms to donate** surplus hay, addressed a livestock fodder shortage that emergency planning had not anticipated; the proposal was implemented nationally. In Grenfell, ground-floor lobby officers innovated by creating a **whiteboard grid system to manage fire survival guidance data** after paper-based systems failed under the volume of calls. After Fukushima, residents started **citizen science programmes** to independently monitor radiation

[32] 1. Wildfires in Hawaii, 2. Floods in Germany, 4. COVID-19 Pandemic and Loss of Critical Services, 7. Grenfell Tower Fire, 8. WannaCry Cyberattack, 10. Eyjafjallajökull Eruption, 11. Deepwater Horizon Oil Spill, 14. Hurricane Katrina, 15. Indian Ocean Tsunami, 16. Floods in Prague.

levels in their own neighbourhoods, addressing the gap between official reassurances and community demand for verifiable local information. In Deepwater Horizon-affected communities, local volunteers used Twitter to **match boat owners with organisations needing cleanup assistance**, building informal logistics infrastructure that formal coordination had not provided.

These innovations share a feature: they **emerged from people closest to the operational problem**, sharing the same social identity, working with available materials and existing community relationships, addressing gaps that institutional planning had missed. They are not a substitute for institutional capacity, but they consistently filled spaces that institutional capacity left empty.

F-3: Where pre-event community engagement had occurred, it shaped in-event response significantly

Iceland's pre-eruption community meetings in 2005/06 and again in early 2010, building on a full-scale evacuation exercise originally designed for a hypothetical Katla eruption, meant that **residents understood procedures** when Eyjafjallajökull occurred; officials' satisfaction with public compliance was attributed to "trust in local police and DCPEM, built through open, regular and transparent communication before and during the eruptions". Plaquemines Parish's house-to-house contact during Katrina relied on existing relationships between law enforcement officers and the rural population. The Independent Panel for Pandemic Preparedness and Response identified countries that "engaged with community health workers and community leaders, involved vulnerable and marginalised populations" as those that managed COVID-19 substantially better than centralised, top-down approaches.

What Did Not Work

F-4: Structured feedback loops from communities to authorities were absent in the large majority of cases

This was identified across at least 11 of the 16 cases[33]. The Czech 2002 floods documentation incorporated questionnaire-based public inquiry methods to collect data on damage and household experience after the event, but this was **retrospective research rather than real-time feedback**. The Indian Ocean Tsunami evidence is striking: in the post-event development of Indonesia's tsunami warning system, Spahn et al. note that local authorities were able to provide **feedback to warning providers on message comprehensibility and actionability** through cross-visits and dialogues, but this feedback loop had not existed during the event itself. The structural pattern across the case studies is that **risk communication operated as one-way transmission**: authorities communicated to communities, and communities had no formalised mechanism to communicate back, except through post-event inquiries, parliamentary testimony, or academic research.

The cases show a strong response bias: communication systems were usually more developed for issuing warnings and managing the acute emergency than for supporting recovery, resilience and post-event learning. Community feedback was rarely institutionalised after the event, even though affected populations can identify communication failures, unmet needs, inaccessible support, misinformation, and groups that were missed. This absence weakens recovery communication and prevents lived experience from being translated into preparedness, future warning design and institutional resilience.

F-5: Community agency was systematically under-recognised and under-resourced in formal preparedness architectures

[33] 1. Wildfires in Hawaii, 2. Floods in Germany, 3. Suez Canal Blockage, 5. Venice Floods, 6. Forest Fires in Central Portugal, 7. Grenfell Tower Fire, 8. WannaCry Cyberattack, 10. Eyjafjallajökull Eruption, 12. Alluvial Flooding in Madeira, 13. Northern Rock Crisis, 15. Indian Ocean Tsunami

This was identified in at least 7 of the 16 cases[34]. The Portugal forest fires Independent Technical Commission specifically recommended **the incorporation of "local and practical knowledge from communities, families and businesses" into territorial management**, implying this had not occurred. In the Indian Ocean Tsunami response, Telford et al. document the "proliferation of international organisations" as a major coordination failure, with international actors too often bypassing local structures and **"leaving communities on the sidelines".** In the Hawaii fires, the Hawaii Wildfire Management Organization had led pre-event planning and risk mapping, though their recommendations were not always institutionalised.

The pattern is consistent: **communities were treated as recipients of risk communication rather than as partners in its design and delivery**.

F-6: Spontaneous community response, while lifesaving, also created coordination problems for formal organisations

The **relationship between community mobilisation and institutional response** is not unambiguously positive, and the case study evidence shows several **distinct failure modes**.

The 70,000 spontaneous volunteers who arrived in the Ahrtal represented both a critical resource and a coordination challenge: **official organisations lacked mechanisms to integrate volunteer effort** at this scale, and overall satisfaction with cooperation among helpers was high (approximately 92% rated it as at least satisfactory) while satisfaction with information provision and overall crisis management was substantially lower than in the 2013 floods. In the Indian Ocean Tsunami response, large numbers of unaffiliated volunteers participated in search, rescue, and relief in the first 48 hours, but their **coordination with formal aid agencies was limited** and the Tsunami Evaluation Coalition documented international actors "leaving communities on the sidelines".In Grenfell, the rapid mobilisation of community organisations sometimes **outpaced the local authority's capacity to integrate or support them**. Most consequentially, anti-COVID protest groups (Querdenker) in the Ahrtal actively spread misinformation and physically interfered with relief operations. Community mobilisation can be antagonistic to formal response as well as supportive of it, and the institutional capacity to engage with both forms is rarely pre-positioned.

F-7: Vulnerable groups frequently lacked the informal networks that supported others

This was identified across at least 6 of the 16 cases[35]. The 12 deaths in the Sinzig care home for people with disabilities reflect the **absence of any community network around residents who could not self-evacuate**. In Fukushima, information disparities left elderly-only households and the unemployed **more vulnerable due to fewer social interactions**. In Grenfell, residents with mobility, sensory, or cognitive impairments who lacked Personal Emergency Evacuation Plans were **systematically disadvantaged by both formal warning and informal community response**.

The implication is that **community agency is not evenly distributed**: some communities can self-organise effectively, others cannot, and the most vulnerable individuals are often those with the weakest informal networks.

Tensions

Three tensions emerge from the community agency evidence.

1. **Community resilience and institutional accountability can pull against each other**: cases where communities self-organised effectively (e.g., Iceland sweepers, Simeulue

[34] 6. Forest Fires in Central Portugal, 7. Grenfell Tower Fire, 10. Eyjafjallajökull Eruption, 11. Deepwater Horizon Oil Spill, 12. Alluvial Flooding in Madeira, 14. Hurricane Katrina, 15. Indian Ocean Tsunami.

[35] 2. Floods in Germany, 4. COVID-19 Pandemic and Loss of Critical Services, 7. Grenfell Tower Fire, 9. Tōhoku Triple Disaster, 14. Hurricane Katrina, 15. Indian Ocean Tsunami.

smong) sometimes did so because formal institutions had not stepped in, but the absence of formal capacity is also a vulnerability for communities without strong informal networks.

2. **Community-led communication is faster and often more trusted than institutional channels but operates outside institutional quality control**: the Ahrtal Facebook groups warned residents earlier than KATWARN, but the same dynamic on TikTok produced Maui conspiracy theories.
3. **Integrating community agency into formal preparedness architectures risks instrumentalising it**: the cases that worked best (e.g., Iceland, Plaquemines, Simeulue) drew on **long-standing community structures rather than purpose-built community engagement** programmes, and the question of whether top-down "community engagement" can substitute for bottom-up community capacity is not resolved by the case study evidence.

Taken together, the case-study findings show that communication failures rarely result from a single missing message. They more often emerge from interacting barriers: delayed or uncertain warning, weak translation of technical information into public action, fragmented institutional responsibilities, unequal access to warnings, limited local adaptation, insufficient feedback loops and under-recognition of community agency.

Box 4: Key takeaways – HILP Case Study Evidence

Sixteen cases, spanning natural disasters, pandemics, infrastructure crises and financial shocks, show recurring patterns of both failure and success in HILP risk communication.

- Detection was rarely the binding constraint. In 12 of the 16 cases, early warning signals existed. The bottleneck was almost always the conversion of technical information into timely protective action.
- Successful warning systems shared three features: a short chain from forecasters to the public, clear instructions on what to do, and multiple redundant channels. Where these were absent, warnings that were technically accurate failed to protect people.
- Opt-in warning systems consistently under-reached the most vulnerable populations. The case evidence supports push-to-all architectures as an architectural necessity, not a matter of preference.
- Downplaying severity — often driven by the panic assumption — repeatedly caused harm. Clear, specific and honest guidance is more likely to support protective action than to produce disorder.
- Institutional trust determines what people do with warnings. Pre-existing distrust — rooted in historical experience, perceived discrimination or documented institutional failures — cannot be addressed during the crisis itself. Trust is infrastructure that must be maintained between events.
- Uncertainty should be communicated, not hidden. Cases where probabilistic information was shared openly showed higher trust and better compliance. Cases where institutions issued false certainty, downplayed severity or delayed updates suffered lasting credibility damage.
- Community agency was a consistent resource but was rarely planned for. Communities filled communication vacuums in at least 10 of the 16 cases. This capacity is not evenly distributed, and it should be supported by formal systems rather than treated as a substitute for institutional responsibility.

4.2.2. Case-Study Evidence Matrix

The **case-study evidence matrix** below summarises the main findings from the case-study analysis in a structured format. It organises the evidence by analytical domain and by specific findings within each domain, allowing recurring communication failures, enabling conditions and cross-case patterns to be compared across different types of HILP and HILP-like events. The matrix is intended as a synthesis tool. The following chapter synthesises these issues with the wider evidence base to identify the main gaps, practical barriers and needs that guidelines must address.

An overview of the findings across all the HILP cases is provided in Table 9: Overview of positive and negative findings from the HILP case studies; Table 10: Overview of what did not work in the risk communication of the HILP case studies; and Table 11: Overview of what worked in the risk communication of the HILP case studies.

Table 9. Overview of positive and negative findings from the HILP case studies.

Number of Findings	1. Wildfires in Hawaii	2. Floods in Germany	3. Suez Canal Blockage	4. COVID-19 Pandemic and Loss of Critical Services	5. Venice Floods	6. Forest Fires in Central Portugal	7. Grenfell Tower Fire	8. WannaCry Cyberattack	9. Tōhoku Triple Disaster	10. Eyjafjallajökull Eruption	11. Deepwater Horizon Oil Spill	12. Alluvial Flooding in Madeira	13. Northern Rock Crisis	14. Hurricane Katrina	15. Indian Ocean Tsunami	16. Floods in Prague
Positive findings	4	3	0	8	0	3	3	4	2	10	5	2	1	6	6	4
Negative findings	10	16	6	13	8	15	14	4	9	9	4	15	9	17	10	3

Table 10. Overview of what did not work in the risk communication of the HILP case studies.

What did not work	1. Wildfires in Hawaii	2. Floods in Germany	3. Suez Canal Blockage	4. COVID-19 Pandemic and Loss of Critical Services	5. Venice Floods	6. Forest Fires in Central	7. Grenfell Tower Fire	8. WannaCry Cyberattack	9. Tōhoku Triple Disaster	10. Eyjafjallajökull	11. Deepwater Horizon Oil Spill	12. Alluvial Flooding in Madeira	13. Northern Rock Crisis	14. Hurricane Katrina	15. Indian Ocean Tsunami	16. Floods in Prague
S-1. Detection, lead time, and the conversion of warning into action																
1. The dominant failure mode is the gap between technical lead time and public action lead time (S-1, F-3)	X	X		X	X	X	X	X	X			X		X		X
2. Forecast underestimation propagated downstream (S-1, F-4)		X	X		X	X						X				

What did not work	1. Wildfires in Hawaii	2. Floods in Germany	3. Suez Canal Blockage	4. COVID-19 Pandemic and Loss of Critical Services	5. Venice Floods	6. Forest Fires in Central	7. Grenfell Tower Fire	8. WannaCry Cyberattack	9. Tōhoku Triple Disaster	10. Eyjafjallajökull	11. Deepwater Horizon Oil Spill	12. Alluvial Flooding in Madeira	13. Northern Rock Crisis	14. Hurricane Katrina	15. Indian Ocean Tsunami	16. Floods in Prague
3. Message content failed in two consistent ways: it was not impact-based, and it was not action-specific (S-1, F-5)	X	X			X	X	X	X				X	X	X		X
4. The failure was located further upstream in detection itself (S-1, F-6)					X	X						X			X	
S-2. Channels, reach, and equitable access to warnings																
5. Opt-in subscription-based warning systems systematically failed to reach the majority of at-risk populations (S-2, F-3)	X	X														
6. Telecommunications infrastructure failed at the moment warnings were most needed (S-2, F-4)	X	X				X	X					X		X	X	X
7. Vulnerable populations were systematically excluded by channel design choices (S-2, F-5)	X	X		X	X	X	X			X				X	X	
8. Tourists and transient populations represent a systematic blind spot in warning architecture (S-2, F-6)	X				X	X				X		X				
S-3. Trust, Messengers, and the Credibility of Institutional Voice																
9. Pre-existing institutional distrust was a recurring constraint on warning effectiveness (S-3, F-3)			X	X			X		X		X		X	X		
10. Institutional voices were repeatedly damaged by communication that prioritised reassurance over accuracy or that lagged behind known events (S-3, F-4)				X									X	X		
11. Language and accessibility failures functioned as trust failures, signalling that certain populations were not the intended audience of official communication (S-3, F-5)			X	X			X								X	
12. Trusted messengers were rarely deployed systematically; their effective role tended to be emergent rather than designed (S-3, F-6)						X						X		X		
S-4. Uncertainty, transparency, and the management of contested narratives																
13. Forecast and ensemble uncertainty was systematically not communicated to the public (S-4, F-3)		X			X	X				X		X				
14. The downplaying dynamic recurred across institutional contexts (S-4, F-8)	X		X	X					X		X	X	X	X		

What did not work	1. Wildfires in Hawaii	2. Floods in Germany	3. Suez Canal Blockage	4. COVID-19 Pandemic and Loss of Critical Services	5. Venice Floods	6. Forest Fires in Central	7. Grenfell Tower Fire	8. WannaCry Cyberattack	9. Tōhoku Triple Disaster	10. Eyjafjallajökull	11. Deepwater Horizon Oil Spill	12. Alluvial Flooding in Madeira	13. Northern Rock Crisis	14. Hurricane Katrina	15. Indian Ocean Tsunami	16. Floods in Prague
15. Conflicting messages between agencies, between levels of government, or across time eroded the credibility of any single source (S-4, F-5)		X	X	X			X		X	X		X	X	X		
16. Information vacuums were predictably filled by rumour and misinformation (S-4, F-6)	X	X		X					X	X	X		X	X	X	
S-5. Coordination across agencies, sectors, and jurisdictions																
17. Jurisdictional fragmentation produced inconsistent warnings and decision-making bottlenecks (S-5, F-3)		X		X		X	X		X	X		X	X	X		
18. Decision-making bottlenecks at the institutional level produced communication delays downstream (S-5, F-4)		X		X		X	X	X	X				X	X		
19. Practitioner coordination repeatedly failed at the interface between sectors (S-5, F-5)		X		X		X	X			X		X		X		
20. Pre-existing personal relationships and informal networks consistently outperformed formal coordination protocols (S-5, F-6)		X				X						X		X	X	
S-6. Community agency, informal networks, and feedback loops																
21. Structured feedback loops from communities to authorities were absent in most cases (S-6, F-4)	X	X	X		X	X	X	X		X		X	X		X	
22. Community agency was systematically under-recognised and under-resourced in formal preparedness architectures (S-6, F-5)	X					X	X			X	X	X		X	X	
23. Spontaneous community response, while lifesaving, also created coordination problems for formal organisations (S-6, F-6)		X		X			X		X					X	X	
24. Vulnerable groups within communities frequently lacked even the informal networks that supported others (S-6, F-7)		X		X			X		X					X	X	

Table 11. Overview of what worked in the risk communication of the HILP case studies.

What worked	1. Wildfires in Hawaii	2. Floods in Germany	3. Suez Canal Blockage	4. COVID-19 Pandemic and Loss of Critical Services	5. Venice Floods	6. Forest Fires in Central	7. Grenfell Tower Fire	8. WannaCry Cyberattack	9. Tōhoku Triple Disaster	10. Eyjafjallajökull	11. Deepwater Horizon Oil	12. Alluvial Flooding in Madeira	13. Northern Rock Crisis	14. Hurricane Katrina	15. Indian Ocean Tsunami	16. Floods in Prague
S-1. Detection, lead time, and the conversion of warning into action																
1. Detection capacity is rarely the binding constraint (S -1, F-1)	X	X		X	X	X		X	X	X		X	X	X		X
2. Where conversion worked, it shared identifiable features (S-1, F-2)										X				X	X	
S-2. Channels, reach, and equitable access to warnings																
3. Where channel architecture achieved high warning reach, they shared identifiable design features (S-2, F-1)										X				X	X	
4. Social media operated as a parallel and often faster informal channel, partially compensating for failures in official systems (S-2, F-2)	X	X		X		X	X	X			X					
S-3. Trust, Messengers, and the Credibility of Institutional Voice																
5. Community-embedded messengers consistently outperformed institutional voices when institutional trust was low or absent (S-3, F-1)	X			X		X				X	X	X		X	X	
6. Where political and scientific communication aligned, public compliance was substantially higher (S-3, F-2)				X												
S-4. Uncertainty, transparency, and the management of contested narratives																
7. A small number of cases operationalised explicit uncertainty communication, and these are repeatedly cited as best practice (S-4, F-1)				X						X						X
8. Where official institutions made probabilistic information accessible to the public, this supported rather than undermined protective behaviour (S-4, F-2)				X						X						
S-5. Coordination across agencies, sectors, and jurisdictions																
9. A small number of cases demonstrated effective inter-agency coordination (S-5, F-1)										X					X	X
10. Co-located, integrated coordination structures produced more coherent communication (S-5, F-2)								X			X					
S-6. Community agency, informal networks, and feedback loops																

What worked	1. Wildfires in Hawaii	2. Floods in Germany	3. Suez Canal Blockage	4. COVID-19 Pandemic and Loss of Critical Services	5. Venice Floods	6. Forest Fires in Central	7. Grenfell Tower Fire	8. WannaCry Cyberattack	9. Tōhoku Triple Disaster	10. Eyjafjallajökull	11. Deepwater Horizon Oil	12. Alluvial Flooding in Madeira	13. Northern Rock Crisis	14. Hurricane Katrina	15. Indian Ocean Tsunami	16. Floods in Prague
11. Communities consistently filled vacuums left by failed or absent official communication (S-6, F-1)	X	X		X			X	X		X	X			X	X	X
12. Community-led adaptive innovation generated solutions institutional actors would not have produced (S-6, F-2)							X		X	X	X				X	
13. Pre-event community engagement shaped in-event response significantly (S-6, F-3)				X						X				X		

5. Gaps, Barriers & Needs

The evidence shows a persistent gap between what risk communication guidance recommends and what happens in practice. Across the reviewed cases, communication failures rarely resulted from a single missing message. More often, they emerged from weak translation between scientific information and public action, fragmented institutional responsibilities, limited local adaptation, insufficient inclusion of vulnerable groups, underdeveloped feedback loops, and limited preparedness before the acute phase of the crisis. This chapter synthesises the **main gaps, barriers and needs** identified across the desk review, integrating models and case-study analysis. It provides the bridge between the evidence reviewed in Chapters 2–4 and the guidelines proposed in Chapter 6.

5.1. Evidence Gaps

HILP-SPECIFIC RISK COMMUNICATION. Much of the existing literature and guidance addresses risk communication, crisis communication, public warning systems, disaster preparedness, or public health emergencies more broadly. These sources provide strong and useful principles, but they are rarely designed specifically for events that are simultaneously low-probability, high-impact, cascading, cross-sectoral, and difficult to anticipate. As a result, current guidance is often better developed for known hazards and recurrent emergencies than for rare, systemic events where probabilities are uncertain, impacts are difficult to bound, and responsibilities may be distributed across sectors, jurisdictions and countries.

BEHAVIOURAL EFFECTIVENESS. Many studies and guidance documents identify what good communication should contain: clear source attribution, affected area, timing, likely impacts, recommended protective action, accessible language, uncertainty statements, and update points. However, there is less evidence on whether messages are actually understood, trusted and acted upon by different audiences under HILP conditions. This is especially important because awareness or information-seeking does not necessarily translate into protective action. People may look for information, understand the risk, and still fail to act if the recommended behaviour is unclear, too difficult, socially unsupported, or disconnected from their resources and responsibilities.

MESSAGE PURPOSE. A related issue is that messages are not always designed or evaluated according to their specific purpose. A message intended to raise awareness, increase concern, build trust, improve preparedness, prompt immediate evacuation, sustain protective behaviour, counter misinformation, or support recovery will not necessarily work in the same way. Different message objectives require different content, tone, messengers, channels and evaluation criteria. For example, a message designed to increase acceptance of scientific evidence should not be expected automatically to produce donations, preparedness actions or compliance with emergency instructions. Behavioural effectiveness therefore requires clarity about what the message is meant to achieve, which audience it is designed for, and which psychological or practical barrier it is intended to address.

MESSAGE TESTING ACROSS HAZARD TYPES AND AUDIENCES. The evidence reviewed in this deliverable shows that different hazards activate different combinations of perceived severity, emotional response, trust, efficacy, social norms and practical barriers. Yet warning templates and preparedness campaigns are often assumed to be transferable across hazards and populations. More evidence is needed on how different message formats work for rare hazards, cascading events, compound crises, prolonged disruption, cross-border emergencies, and events involving invisible or technical risks such as contamination, cyber disruption, pandemics or infrastructure failure.

Recovery communication and post-event learning. The case-study evidence and reviewed guidance both suggest that communication systems are more developed for issuing warnings and managing the acute emergency than for supporting recovery, accountability, feedback and institutional learning. Community feedback was often absent during events and only collected later through inquiries, academic studies or formal reviews. This limits the ability to translate lived experience into better preparedness, future warning design and institutional resilience.

Role of communities and informal networks. The case studies show that community agency can be lifesaving, as in local evacuation practices, spontaneous volunteering, community-embedded messengers and trusted local intermediaries. However, the evidence also shows that community capacity is uneven. Some communities have strong informal networks, trusted leaders and practical knowledge, while others do not. Vulnerable individuals are often those with the weakest informal networks, including elderly people, disabled people, people with limited mobility, socially isolated households, digitally excluded groups and people with low trust in authorities. More evidence is needed on how formal communication systems can support community agency without assuming that all communities can self-organise equally.

Evaluation. Communication is still too often evaluated by whether a message was issued, whether a channel functioned, or whether a campaign reached a target audience. For HILP events, this is insufficient. Evaluation must also examine whether messages were relevant, findable, usable, understood, trusted, acted upon, and adapted to those least able to respond.

5.2. Practical and Institutional Barriers to Communication

The reviewed guidance shows substantial agreement on what effective risk and crisis communication should achieve. Across public warning systems, risk governance, social media guidance, public health emergency communication and crisis communication manuals, communication is repeatedly expected to be clear, timely, credible, actionable, coordinated, inclusive, transparent about uncertainty, multi-channel and evaluated (UNDRR & WMO, 2023; WHO Regional Office for Europe, 2024; CEN, 2023; OECD, 2016; Rossi et al., 2018; GFDRR, 2021; UNDP, 2024; ESM, 2024; GCS Behavioural Science Team, 2022). However, the review and case-study analysis show a persistent gap between these principles and their implementation in practice. This implementation gap is particularly important for HILP events, where communication systems must operate under uncertainty, low public familiarity, institutional fragmentation, infrastructure disruption and potentially cascading impacts. The reviewed standards provide a strong foundation, but the present analysis notes that they do not fully operationalise communication for cascading, systemic, cross-border or infrastructure-disruptive scenarios.

Difficulty of translating scientific, technical and operational information into public meaning and protective action. The evidence reviewed in Section 2.2 shows that risk communication does not work through information alone: people interpret messages through emotions, prior experience, social norms, perceived responsibility, trust in authorities, perceived ability to act, available resources and cues from peers, media and the wider environment. Awareness of a risk is therefore insufficient if people do not also understand what the risk means for them, what action is expected, why that action helps and whether it is feasible in their circumstances. For HILP events, this barrier is intensified by rarity, uncertainty and the potential for cascading consequences. People may not have prior experience or a clear mental model of the risk, while authorities may struggle to translate technical information into concrete implications for households, organisations and communities.

Persistence of hazard-centred communication where impact-centred communication is needed. Technical information about rainfall, water levels, alert colours, models, surge height, forecast indices or hazard categories may be accurate, but it does not automatically communicate likely consequences or required behaviour. HILP communication needs to translate hazards into impacts: who may be affected, where, when, how severe the consequences may be, what services

or infrastructures may fail, what protective action is required and what support exists for people who cannot act alone. The reviewed warning guidance makes this operational by identifying core alert elements. In practice, the barrier is not simply whether warnings are issued, but whether they help people understand what the situation means and what they should do.

Weak local adaptation. Many HILP events involve information produced at national, regional or specialised institutional levels, while protective action must be taken in specific places by people with different resources, languages, routines, vulnerabilities and trusted sources. Risk information becomes actionable only when it is connected to local consequences, recognisable places, available routes, feasible behaviours and locally trusted intermediaries. This is consistent with the preparedness evidence reviewed, which stresses that risk communication should combine scientific information with local knowledge, probability with scenarios and consequences, digital tools with interpersonal and community channels, and threat information with efficacy, fairness and practical support. The case-study analysis also repeatedly shows that communication failure is not only a failure of issuing information, but a failure of translating information into locally meaningful action.

Separation of communication planning from operational capacity. Risk communication guidance consistently identifies actionability as a core requirement: messages should tell people what to do, when, and how. However, the actionability of a message depends not only on how it is worded but on whether the operational infrastructure required to act on it exists and is accessible. Where evacuation is recommended, this presupposes identified routes, available and accessible transport, pre-arranged shelter, and coordinated support for older adults, people with disabilities and families without private vehicles. The evidence reviewed in this deliverable shows that these conditions are frequently absent or unknown to communicators at the point of message design. This reflects a structural tendency to treat communication as a downstream function, developed separately from the preparedness and logistics planning that determines what people can actually do when a warning arrives. For HILP events — where cascading impacts may simultaneously disrupt transport networks, overwhelm public services and sever informal support systems — this separation is particularly consequential. Communication that is technically accurate but operationally unsupported risks transferring responsibility to individuals and communities who lack the means to respond.

Institutional fragmentation. HILP events often involve multiple agencies, sectors, jurisdictions, infrastructure operators and sometimes countries. Yet communication responsibilities, information flows and coordination mechanisms are often not sufficiently established before the event. The review notes that standards such as CAP, ISO 22322, ISO 24495-1 and ETSI TS 102 182 can support interoperability and consistent message structure, especially where multiple agencies, platforms or countries are involved, but also stresses that standardisation must be paired with audience-sensitive language and local adaptation. Technical interoperability is therefore necessary but not sufficient. Agencies also need shared terminology, agreed responsibilities, coordinated spokespersons, escalation procedures and protocols for aligning public messages under uncertainty.

Under-recognition of risk communication as a specialist and evidence-informed competence. In many crises, messages are drafted, authorised or delivered by actors whose primary expertise is operational, scientific, administrative or political, rather than communication-specific. These actors are often essential public voices, but the barrier emerges when communication is treated as a matter of common sense, authority or information transmission rather than as a technical function requiring behavioural evidence, audience knowledge, message testing, plain language, trust-building and contextual adaptation. This is particularly problematic for HILP events, where the task is not only to describe a hazard, but to support sense-making and action under uncertainty, time pressure and stress. The response-phase evidence shows that crisis communication must answer practical questions about what is happening, who is affected,

what people should do, when they should act and whom they should trust, while pairing threat information with clear, feasible and effective protective action.

PERSISTENCE OF COMMON-SENSE BUT UNSUPPORTED ASSUMPTIONS ABOUT PUBLIC BEHAVIOUR, especially the "panic assumption". Crisis communication is still often shaped by the idea that publics are prone to irrational, selfish or disorderly behaviour and therefore need to be calmed or controlled. However, the evidence reviewed shows that "true panic" is rare, and that behaviours which appear chaotic from the outside are often better understood as attempts to seek safety, find information, reconnect with others or meet essential needs under constrained conditions. The review also shows that emergency behaviour is often socially organised, adaptive and shaped by information, social norms, shared identity, environmental constraints and the availability of safe options, rather than by social breakdown. When communication is guided by the panic assumption, authorities delay warnings, soften the severity of messages, withhold uncertainty, avoid worst-case information or rely on vague reassurance instead of clear instructions. These strategies may be intended to prevent disorder, but they can undermine trust and prevent protective action – leading to more casualties – while also pushing people toward unofficial sources or by making institutional communication appear incomplete or overly reassuring.

PERSISTENCE OF PREDOMINANTLY ONE-WAY COMMUNICATION. The evidence base and reviewed guidance increasingly emphasise listening, feedback, social listening, community engagement and two-way communication. WHO's emphasis on social listening, focus groups, sentiment analysis, message testing and information voids complements the OECD's call for more bidirectional communication and the JRC's observation that many warning systems remain too unidirectional. For HILP events, listening is not only a matter of participation; it is also a way to identify misinformation, unmet needs, barriers to action and local knowledge that may be essential during cascading events. The case-study analysis similarly found that structured feedback loops from communities to authorities were often absent or underdeveloped, limiting the ability of institutions to adapt messages as events evolved.

UNDER-RECOGNITION AND UNDER-RESOURCING OF COMMUNITY AGENCY. The case studies show that affected publics and local actors are often not passive recipients of communication. They can warn others, interpret local cues, provide first aid, support evacuation, share information and organise practical assistance. However, this capacity was frequently not integrated into formal preparedness architectures. In at least 7 of the 16 cases, there is documentation pointing at the fact that community agency was systematically under-recognised and under-resourced, with communities often treated as recipients of risk communication rather than as partners in its design and delivery. At the same time, community mobilisation is not automatically positive or easy to integrate. The case-study analysis notes that spontaneous volunteers in the Ahrtal were both a critical resource and a coordination challenge, that Grenfell community organisations mobilised faster than the local authority could integrate or support them, and that protest groups in Ahrtal spread misinformation and interfered with relief operations. This means that community agency should be supported and planned for but not romanticised or used as a substitute for institutional responsibility – where institutions are lacking, communities will fill in the gaps.

PSYCHOSOCIAL VULNERABILITY AND UNEQUAL CAPACITY TO ACT. The reviewed guidance stresses the need to design communication for diverse audiences and especially for vulnerable groups, including people affected by disability, exclusion, conflict, low trust, limited digital access or other barriers to receiving and using information. The case-study analysis confirms that vulnerability is not only a matter of exposure to hazard, but also of unequal access to communication, support and informal networks. Vulnerable groups frequently lacked the informal networks that supported others. The deaths in the Sinzig care home illustrate the vulnerability of people unable to self-evacuate; in Fukushima, information disparities left elderly-only households and unemployed people more vulnerable due to fewer social interactions; and in Grenfell, residents with mobility, sensory or cognitive impairments who lacked Personal Emergency Evacuation Plans were

disadvantaged by both formal warning and informal community response. The implication is that communication cannot assume equal ability to receive, understand, trust or act on a message.

Difficulty of communicating uncertainty and acting under uncertainty. HILP events often require precautionary action before impacts are fully confirmed. This creates institutional hesitation because early warnings may later be criticised as false alarms and cause individuals to discount future genuine warnings (cry wolf effect), while delayed or non-existent warnings may leave too little time for protective action or lead to mass casualties. The risk communication evidence reviewed suggests that the answer is not to hide uncertainty or wait for certainty, but to communicate uncertainty clearly: what is known, what remains uncertain, what is being done, what people should do now and when the next update will come. This is particularly important because HILP events may involve fast-changing evidence, cascading consequences and unfamiliar hazards. Overconfident reassurance, silence or unexplained changes can damage credibility, whereas transparent uncertainty communication can support trust and protective action. Because HILP events – and disasters in general – often require decisions under uncertainty, communicators face an unavoidable trade-off: warning early may later be judged as excessive if the threat does not materialise, while warning late or not at all may leave populations exposed to preventable harm. From a risk communication perspective, the priority should be the prevention of avoidable losses. This favours early, transparent and precautionary communication, accompanied by clear explanations of uncertainty, impact scenarios, recommended actions and update points.

Over-reliance on single channels or fragile communication infrastructures. Digital and mobile systems are powerful, but HILP events may disrupt electricity, mobile networks, internet access, transport or institutional communication systems. Digital systems may also exclude people with limited access, low literacy, disability, language barriers or distrust of formal authorities. The reviewed guidance therefore stresses that no single channel is sufficient and that communication strategies need redundancy to be resilient, including digital, broadcast, local, interpersonal, low-tech and no-tech options, as well as trusted local intermediaries ("micro-influencers") and accessible formats. For HILP events, communication resilience is not an optional improvement; it is a condition for reaching people when normal systems are disrupted.

Flawed evaluation and organisational learning. Many reviewed sources identify limited evidence on actual behavioural effectiveness, weak metrics and insufficient use of evaluation findings. The evidence stresses that it is not enough to know whether a message was sent or received; it is necessary to understand whether it was understood, trusted and acted upon – and this is rarely evaluated. This applies across preparedness, response and recovery. Lessons from post-event engagement are not being sufficiently collected and therefore not feeding into preparedness planning, message design, warning templates, exercises and future communication strategies. For HILP events, evaluation must examine not only message reach, but also actionability, inclusion, local relevance, trust, uncertainty comprehension, behavioural response and whether lessons are translated into institutional change.

Taken together, these barriers show that the challenge for HILP risk communication is not only to define good communication principles, but to make them operational under conditions of uncertainty, low familiarity, institutional fragmentation, unequal capacity to act and cascading impacts. The following guidelines therefore focus on the practical requirements for communication that is actionable, locally meaningful, inclusive, coordinated, transparent about uncertainty, behaviourally informed and embedded across the full preparedness–response–recovery cycle.

Box 5: Key takeaways – Gaps, Barriers & Needs

The risk communication evidence base and reviewed guidance show broad agreement on what effective HILP risk communication requires. The persistent challenge is the gap between principles and implementation.

- Technical accuracy is not the same as actionability. Messages that correctly describe a hazard but fail to explain what affected people should do, whether they can act, or what support is available are not sufficient — especially for populations whose capacity to respond is constrained.
- Institutional fragmentation remains an unsolved problem. When agencies, sectors, jurisdictions and infrastructure operators do not have pre-agreed responsibilities, shared terminology and coordination protocols, warnings become inconsistent, delayed or contradictory under pressure.
- The panic assumption distorts practice. The belief that honest, urgent communication will cause disorder leads institutions to soften messages, delay warnings and withhold uncertainty — strategies that consistently increase casualties rather than prevent disorder.
- Communication cannot be separated from operational capacity. A warning telling people to evacuate is only actionable if evacuation infrastructure, transport, shelter and support for those who cannot self-evacuate have been organised in advance.
- Vulnerability is structural, not incidental. Groups who are elderly, disabled, digitally excluded, linguistically marginalised or institutionally distrustful are systematically disadvantaged by default communication designs. Inclusion requires explicit planning before the event.
- Evaluation must go beyond reach. It is not sufficient to measure whether a message was issued or a channel functioned. Effective evaluation requires evidence that messages were understood, trusted, and acted upon — and that lessons are translated into institutional change.

6. Guidelines for HILP Risk Communication

This chapter translates the risk communication evidence from Chapters 2–5 into practical guidelines for HILP risk communication. The recommendations are **intended for all actors involved in producing, authorising, delivering, adapting and evaluating risk communication**: civil protection authorities, forecasters and scientific agencies, public health bodies, local authorities, political decision-makers, emergency services, infrastructure operators, media actors, and community organisations.

The guidelines draw on the behavioural and communication evidence reviewed in Chapter 2, the integrating frameworks discussed in Chapter 3, and the cross-case findings from Chapter 4. They go beyond any single event but **remain grounded in the practical failures and enabling conditions** identified across past cases. They also respond directly to the barriers identified in Chapter 5: the challenge of translating technical information into protective action is addressed through impact-based messaging and participatory approaches; institutional fragmentation through coordination and pre-positioning principles; the panic assumption through phase-specific behavioural guidance; and unequal capacity to act through sustained attention to vulnerable groups and operational support.

The literature on warning message design has devoted considerable attention to whether specificity improves compliance, whether behavioural instructions outperform informational ones, or whether geographic targeting matters. These questions are useful but can be misapplied as universal rules. What makes a message appropriate **depends on the combination of what is happening, who needs to act, and what they are being asked to do**. A message designed to inform the public that a situation is developing requires different content, tone and channel than one issuing an immediate evacuation instruction. As a HILP event unfolds — from early uncertainty through acute impact to cascading consequences — the communication should shift with it. The guidelines that follow are organised to reflect this: preparedness, response, recovery and cross-cutting principles each create different communication requirements.

6.1. Preparedness Communication

Preparedness communication takes place before there is an immediate threat. Its purpose is not to trigger urgent action, but to build the risk literacy, trust, relationships, habits, local knowledge and practical capacity that make later protective action possible. This is especially important for HILP events because rarity, low familiarity and long periods without direct experience can weaken preparedness and make risks feel abstract or implausible.

1. Make HILP risks meaningful before they become urgent

Who: Civil protection authorities, scientific agencies, national, regional and local authorities, schools, community organisations, media actors, local organisations.

Preparedness communication should help people understand rare, uncertain and cascading risks before an event is imminent. It should avoid relying only on technical probabilities or generic awareness-raising. Instead, it should connect HILP risks to plausible local scenarios, previous events, near misses, cascading consequences and practical preparedness steps.

Practical actions:

- Explain what kinds of HILP events may affect the community, organisation or system.
- Clarify why low probability does not mean irrelevant or impossible.
- Use scenarios, near misses, past events and cascading impact examples to make rare risks concrete.
- Explain what impacts may occur if the event materialises.
- Identify practical actions that can be taken before any warning is issued.

- Clarify what individuals, households, organisations, communities and authorities are each responsible for.
- Avoid communicating HILP risks only through abstract probability figures.

This responds directly to the evidence that rare hazards are difficult to imagine and easy to postpone, and that narratives, analogies, simulations, drills, scenarios, comparisons and past-event references may make abstract probabilities and cascading consequences more meaningful.

Implementation: Medium-term. Can begin through preparedness campaigns, school activities, local exercises and scenario-based workshops, but requires sustained engagement to prevent disaster amnesia and make HILP preparedness part of ordinary-time risk culture.

2. Build preparedness through participation, not only information

Who: National, regional and local authorities, civil protection agencies, research agencies, schools, NGOs, community groups, first responders.

Preparedness communication should move beyond one-way information campaigns. Communities should be involved in identifying risks, interpreting local vulnerabilities, testing warning messages, mapping barriers to action and designing feasible preparedness measures. This is especially important because communities hold knowledge about local geography, mobility constraints, social networks, informal care structures, trusted messengers and practical barriers that centralised communication may overlook.

Practical actions:

- Organise community workshops on local HILP risks and preparedness.
- Use school-based preparedness activities to build long-term risk culture.
- Conduct local risk mapping with residents, responders and local organisations.
- Use scenario discussions, tabletop exercises, simulations and games.
- Test preparedness and warning messages with target audiences.
- Include vulnerable groups, caretakers and support organisations in preparedness planning.
- Engage local volunteers and trusted intermediaries before crises occur.
- Treat research and stakeholder exercises – like the AGILE stress test workshops – as communication and learning processes, not only validation activities.

This aligns with the evidence that participation, co-production, local knowledge, gaming and legitimate peripheral participation can build ownership, practical relevance and locally grounded preparedness. It also reflects the case-study finding that communities were often treated as recipients of risk communication rather than as partners in design and delivery.

Implementation: Medium-term to structural. Individual participatory activities can be organised immediately, but sustained implementation requires formal mechanisms for community involvement in preparedness planning, warning design and post-event learning.

3. Identify vulnerable groups and barriers before the event

Who: National, regional and local authorities, civil protection agencies, health and social care providers, disability organisations, community organisations, emergency services.

Preparedness communication should start from the question: who may not receive, understand, trust or be able to act on this information? Vulnerability should not be treated as an afterthought or as a generic category. It should be mapped in relation to specific barriers, including disability, age, mobility, language, literacy, income, housing, digital exclusion, social isolation, care dependence and distrust of authorities.

Practical actions:

- Identify groups that may not receive warnings through standard channels.

- Identify groups that may not understand warnings because of language, literacy, disability or unfamiliarity with the hazard.
- Identify groups that may not trust official sources.
- Identify people who may need assistance to evacuate, shelter or access support.
- Map dependence on carers, medication, electricity, mobility aids, transport or institutional support.
- Work with disability organisations, care providers, migrant organisations and community groups before crises occur.
- Ensure that preparedness advice is linked to practical assistance, not only individual responsibility.
- Plan accessible formats, multilingual communication and non-digital channels in advance.

The case-study analysis shows that vulnerable groups frequently lacked the informal networks that supported others, including people unable to self-evacuate, elderly-only households, unemployed people and residents with mobility, sensory or cognitive impairments.

Implementation: Structural. Requires data-sharing arrangements, safeguarding procedures, links with health and social care providers, accessibility planning, and explicit responsibility for reaching people who cannot act without assistance.

4. Pre-position trusted messengers and communication channels

Who: Civil protection authorities, national, regional and local authorities, responders, public health bodies, media organisations, schools, employers, community leaders.

Trust cannot be improvised during a HILP event. Authorities should build relationships with trusted messengers before a crisis, including local officials, first responders, health workers, teachers, social workers, faith leaders, community organisations, local media, employers and volunteer groups.

Practical actions:

- Identify which messengers are trusted by different groups.
- Build relationships with trusted local actors before crises.
- Clarify who will communicate nationally, regionally and locally.
- Agree how official messages can be adapted locally without becoming inconsistent.
- Establish relationships with local media before events occur.
- Use schools, employers, healthcare providers and community organisations as preparedness partners and “micro-influencers” in risk communication.
- Identify channels that can reach digitally excluded groups.
- Plan how trusted messengers will receive official information quickly during a crisis.

This responds to the repeated finding that trust is a precondition for warning acceptance, preparedness and cooperation, and that credibility depends not only on expertise but also empathy, recognisable sources, consistency, transparency and prior relationships.

Implementation: Medium-term. Can begin through local stakeholder mapping and partnership agreements, but requires regular contact, joint exercises and visible ordinary-time communication to build trust before a crisis.

5. Prepare communication protocols, templates and exercises in advance

Who: Civil protection authorities, forecasters, scientific agencies, emergency services, infrastructure operators, public health authorities, national, regional and local authorities.

Preparedness should include the development and testing of message templates, coordination protocols and escalation procedures before a crisis occurs. These should be adapted to different hazards and communication objectives but should follow a consistent structure.

Practical actions:

- Define thresholds for public communication.
- Clarify responsibilities for drafting, approving and issuing messages.
- Agree terminology and warning levels across agencies.
- Develop templates for impact-based warnings.
- Develop templates for uncertainty communication.
- Establish update procedures and correction procedures.
- Define contact points between civil protection authorities, scientific agencies and infrastructure operators.
- Prepare translation, accessibility and local adaptation processes.
- Test communication protocols through exercises and stress tests.
- Review templates after exercises and real events.

Implementation: Immediate to medium-term. Templates and approval checklists can be updated quickly, while full implementation requires interagency agreement, exercises, training and periodic review.

6. Match communication expectations to detection and forecasting capacity

Who: Scientific agencies, forecasters, civil protection authorities, infrastructure operators, political decision-makers.

Risk communication can only be effective if the underlying monitoring, detection and forecasting systems can provide timely and usable signals. Where the main barrier is weak detection capacity, poor model resolution, missing monitoring infrastructure or lack of real-time situational awareness, better message design alone cannot compensate.

Practical actions:

- Identify hazards for which detection or forecast resolution is the main bottleneck.
- Explain the limits of monitoring and forecasting systems before crises occur.
- Avoid implying that all hazards are equally forecastable.
- Communicate uncertainty around low-detection or low-resolution hazards clearly.
- Invest in monitoring, detection and data-sharing capacity where gaps prevent timely warnings.
- Develop fallback communication procedures for sudden-onset or poorly detectable hazards.
- Connect scientific detection systems with civil protection decision thresholds and public warning protocols.

Implementation: Structural. Requires investment in monitoring and detection capacity, scientific–operational data-sharing, and communication protocols that make clear what can and cannot be forecast.

6.2. Response Communication

Response communication takes place when an event is imminent, unfolding or already producing impacts. Its aim is to support rapid sense-making and protective action under uncertainty, time pressure and emotional stress. HILP events make this task especially difficult because they may be unfamiliar, technically complex, cascading, invisible, cross-border or fast-changing.

1. Communicate early, even when uncertainty remains

Who: Forecasters, scientific agencies, civil protection authorities, political decision-makers, emergency managers.

HILP events often require precautionary communication before impacts are fully certain. Waiting for certainty can leave too little time for protective action. Communicators may be criticised either for issuing warnings that do not materialise or for failing to warn before serious harm occurs. In

HILP contexts, the priority should be to prevent avoidable losses through early, transparent and proportionate communication.

Practical actions:

- Communicate before impacts are fully confirmed when credible risk indicators justify precaution.
- Explain what is known.
- Explain what remains uncertain.
- Explain what could happen if the event escalates.
- Explain why precautionary action is being recommended.
- State what people should do now.
- Provide a clear time for the next update.
- Update messages as evidence changes.
- Avoid waiting for certainty when protective action requires lead time.
- Avoid vague reassurance when specific action is needed.

The aim is not to eliminate false alarms, but to make uncertainty understandable and actionable. Honest uncertainty communication can support trust, while silence or overconfident reassurance can damage credibility.

Implementation: Immediate. Can be introduced through spokesperson guidance, message templates and update schedules using a standard uncertainty formula: what is known, what is uncertain, what is being done, what people should do now and when the next update will come.

2. Use impact-based warnings as the default for public communication

Who: Forecasters, scientific agencies, civil protection authorities, national, regional and local authorities, emergency services.

Public warnings should translate technical hazard information into expected impacts and protective actions. Information about rainfall, water levels, wind speed, hazard categories or model outputs is not enough if people cannot understand what it means for them.

Practical actions:

- State what is happening.
- State where it is happening, using recognisable locations.
- State who is affected.
- Describe expected impacts in practical terms.
- Explain what services, roads, buildings or infrastructures may be affected.
- State when action is needed.
- Give one main protective action where possible.
- Give one main next step for people to take after receiving the warning.
- Explain why the action matters.
- Provide information for people who cannot follow the recommended action without assistance.
- Provide a reliable update point.

The case-study recommendations specifically call for forecasters and scientific agencies to adopt impact-based language as the default register for public warnings, because technically accurate hazard-language warnings repeatedly failed to prompt protective action across several cases.

Implementation: Immediate to medium-term. Warning templates can be updated immediately to include impact and action fields; medium-term implementation requires forecaster training, shared terminology between scientific and civil protection agencies, and testing with target audiences.

3. Pair threat information with feasible action

Who: Communication teams, civil protection authorities, public health bodies, emergency services, national, regional and local authorities.

Warnings should not only communicate danger. They should make action feel possible, effective and urgent. Threat information without feasible action can increase fear, denial, fatalism or disengagement. Communication should therefore combine threat appraisal with coping appraisal: people need to understand that the risk is serious and relevant, but also that the recommended action is useful and possible.

Practical actions:

- Explain the seriousness of the threat.
- Explain why the threat is relevant to the audience.
- Give a clear protective action.
- Explain why that action reduces harm.
- Make the action realistic and specific.
- State whether the action is urgent.
- Provide alternatives or support for people who cannot act alone.
- Avoid messages that increase concern without explaining what people can do.
- Avoid overly broad instructions such as “be careful” or “stay alert” unless paired with specific actions.

Every response message should answer:

- what should I do,
- should I do it now,
- how do I do it,
- why does it help,
- what should I do if I cannot follow the instruction,
- and where can I get help or more information?

Implementation: Immediate. Can be operationalised through message checklists requiring every warning to include one main protective action, a reason for that action and support options for people who cannot act alone.

4. Avoid the panic assumption

Who: Political leaders, emergency managers, civil protection authorities, police, fire and ambulance services, media spokespersons.

Communication should not be based on the assumption that the public will panic if given clear or severe information. The evidence reviewed shows that “true panic” is rare, and that behaviour sometimes labelled as panic often reflects attempts to seek safety, find information, reconnect with others, obtain essential resources or help others under constrained conditions.

Practical actions:

- Do not delay warnings because of fear that the public will panic.
- Do not soften language when serious action is needed.
- Do not withhold uncertainty or worst-case information when it is relevant to protective action.
- Avoid vague reassurance when clear instructions are needed.
- Avoid command-only communication without explanation.
- Avoid treating the public as a problem to be controlled.
- Acknowledge fear and concern without equating them with panic.
- Explain what people can do to protect themselves and others.
- Support safe mutual aid and community action.

- Provide practical information that reduces confusion and unsafe improvisation.

Instead of calming or controlling the public, response communication should inform, enable and coordinate public action.

Implementation: Immediate to medium-term. Can begin through spokesperson briefings and crisis communication training; fuller implementation requires embedding behavioural evidence into emergency communication protocols and decision-making processes.

5. Speak with one voice, but do not hide uncertainty

Who: Civil protection authorities, scientific agencies, public health bodies, political decision-makers, infrastructure operators, media partners.

During HILP events, multiple agencies may be involved. Conflicting messages from different authorities can undermine trust and delay action. Institutions should therefore align terminology, warning levels, recommended actions, source attribution, spokespersons and update cycles.

Practical actions:

- Agree which organisation is responsible for which type of public message.
- Use shared terminology across agencies.
- Align warning levels, colours and action categories.
- Use agreed spokespersons or coordinated spokesperson roles.
- Coordinate update schedules.
- Make the source of each message clear.
- Explain uncertainty consistently across agencies.
- Avoid contradictory public advice.
- Use interoperable systems where possible, including Common Alerting Protocol (CAP).
- Establish procedures for correcting or reconciling conflicting messages.

“Speaking with one voice” should not mean suppressing uncertainty. It means that the public receives coherent guidance about what is known, what is uncertain, what is being done and what action is required.

Implementation: Medium-term to structural. Requires pre-agreed coordination protocols, shared terminology, joint communication cells, cross-agency approval routes and mechanisms for resolving conflicting public messages.

6. Use multiple channels and plan for communication failure

Who: Civil protection authorities, telecom operators, broadcasters, national, regional and local authorities, emergency services, infrastructure operators, community organisations.

No single channel is sufficient for HILP communication. Digital systems, mobile alerts, apps and social media can extend reach, but they may fail during power outages, network disruption or cyber incidents. They may also miss people with limited digital access, low literacy, disabilities, language barriers or low trust in formal institutions.

Practical actions:

- Use mobile alerts where available.
- Use radio and television.
- Use official websites and social media.
- Use sirens, public address systems or local loudspeakers where appropriate.
- Use local authorities and first responders as trusted channels.
- Use community organisations and local intermediaries as “micro-influencers”.
- Use schools, workplaces, care institutions and healthcare providers.
- Plan door-to-door communication for groups who may not receive or act on remote warnings.

- Maintain low-tech and no-tech communication options.
- Plan for power, mobile network, internet and transport disruption.
- Ensure communication is accessible to people with disabilities and language barriers.

Communication resilience is not optional for HILP events. Cascading impacts may disrupt the very systems normally used to communicate risk, and vulnerable groups are often not reached through digital channels.

Implementation: Structural. Requires investment in redundant systems, agreements with broadcasters and telecoms, offline communication capacity, accessible formats and procedures for reaching people when digital channels fail.

7. Create real-time feedback loops

Who: Civil protection authorities, local authorities, emergency services, community organisations, media teams, digital platform managers.

Response communication should not be one-way. Authorities need mechanisms to understand whether people have received, understood, trusted and acted on messages. They also need information about local impacts, blocked routes, unmet needs, misinformation, accessibility problems and groups that are being missed or particularly vulnerable or impacted.

Practical actions:

- Use social listening to identify rumours, concerns and information gaps.
- Use call centres or hotlines to collect questions and needs.
- Use community liaison officers.
- Work with trusted intermediaries who can report local barriers and misunderstandings.
- Use local authority reporting channels.
- Use volunteer coordination platforms where appropriate.
- Use two-way disaster apps where feasible.
- Integrate field reports from responders.
- Monitor whether vulnerable groups are receiving and acting on warnings.
- Escalate feedback quickly into message updates and operational decisions.

The case-study analysis found that risk communication often operated as one-way transmission, with few formalised mechanisms for communities to communicate back except through post-event inquiries, testimony or research.

Implementation: Medium-term. Can begin through social listening and liaison roles, but requires formal protocols for collecting, validating, escalating and responding to community feedback during events.

8. Monitor and respond to misinformation and conflicting cues

Who: Communication teams, public health authorities, civil protection agencies, media partners, social media teams, community organisations.

HILP events create information gaps. Where official information is delayed, incomplete or hard to interpret, rumours, speculation and misinformation can spread quickly. Communication teams should monitor information voids, rumours, misleading visuals, conspiracy narratives and conflicting public cues.

Practical actions:

- Monitor social media, media coverage and community feedback for misinformation.
- Identify information voids before they are filled by rumours.
- Correct misleading claims quickly and specifically.
- Link corrections to practical protective guidance.
- Use trusted messengers to repeat corrections.

- Coordinate corrections across agencies.
- Avoid amplifying misinformation unnecessarily.
- Monitor whether media images or public visuals conflict with official guidance.
- Provide credible alternative visuals, maps or explanations where needed.

Misinformation management should not rely only on correcting false claims after they spread. It should also anticipate likely misunderstandings and maintain a credible information environment.

Implementation: Immediate to medium-term. Basic monitoring and rapid correction can begin immediately; medium-term implementation requires dedicated social listening capacity, coordination with media partners and trusted intermediaries, and pre-agreed procedures for correcting misleading claims.

6.3. Recovery Communication

Recovery communication begins when the immediate threat has passed or stabilised, but it should not be treated as an afterthought. HILP events often have long-term, uneven and cascading consequences. Recovery communication should support safety, services, trust repair, accountability, psychosocial recovery, public learning and future preparedness.

1. Continue communicating after the acute emergency

Who: Civil protection authorities, national, regional and local authorities, public health bodies, infrastructure operators, recovery agencies, political decision-makers.

Communication should not stop once the immediate hazard is over. Affected people still need information about safety, services, health risks, damaged infrastructure, assistance, recovery timelines and future risk.

Practical actions:

- Provide regular updates after the acute phase.
- Explain whether it is safe to return.
- Communicate continuing health or environmental risks.
- Provide information about drinking water, transport, schools, workplaces and damaged infrastructure.
- Explain how to access housing, financial assistance, compensation and psychological support.
- Communicate relocation or rebuilding options where relevant.
- Explain what remains uncertain or under investigation.
- Provide timelines for further updates.
- Keep communication accessible to displaced and vulnerable groups.

Post-event communication should explain what remains unsafe, what services are available, what is still uncertain, what is being investigated and when further updates will be provided.

Implementation: Immediate to medium-term. Recovery communication should be planned as part of the response from the beginning, with regular updates, clear responsibility for recovery information and accessible channels for affected groups.

2. Communicate accountability without defensiveness

Who: Political leaders, civil protection authorities, public agencies, infrastructure operators, inquiry bodies.

After a HILP event, publics often need explanation, not only updates. Authorities should communicate what happened, what was known, what decisions were made, what worked, what failed, what remains under investigation and what will change.

Practical actions:

- Acknowledge harm and loss.
- Explain decisions in clear, non-defensive language.
- State what was known at different points in the event.
- Explain what remains under investigation.
- Correct errors openly.
- Avoid premature blame before evidence is established.
- Avoid hiding behind complexity to avoid responsibility.
- Avoid vague promises that "lessons will be learned".
- Communicate what concrete changes will follow.
- Show how affected communities will be informed about progress.

Recovery communication should support trust repair through transparency, empathy and evidence of institutional learning.

Implementation: Medium-term. Requires protocols for post-event explanation, public-facing lessons learned, transparent update cycles and mechanisms for communicating what has changed as a result of reviews and inquiries.

3. Include affected communities in recovery and learning

Who: National, regional and local authorities, recovery agencies, infrastructure operators, civil protection authorities, NGOs, community organisations.

Affected communities should have structured opportunities to report unmet needs, identify communication failures, question decisions, contribute local knowledge and participate in future risk reduction. This is important because official systems may not fully understand how warnings were received, which groups were missed, what barriers prevented action or what misinformation circulated locally.

Practical actions:

- Hold community meetings in affected areas.
- Conduct participatory evaluations.
- Use surveys, interviews and public debriefs.
- Work with local organisations and trusted intermediaries.
- Include vulnerable groups and people who were missed by official communication.
- Collect feedback on warning clarity, trust, actionability and accessibility.
- Identify misinformation, rumours and unmet needs that emerged during the event.
- Feed community findings into revised warning templates, preparedness materials and exercises.
- Report back to communities on what has changed because of their feedback.

The case-study analysis found that community feedback was rarely institutionalised after events, even though affected populations can identify communication failures, unmet needs, inaccessible support, misinformation and groups that were missed.

Implementation: Medium-term to structural. Individual engagement activities can be organised after events, but meaningful implementation requires local standing arrangements for community feedback, participatory evaluation and integration of findings into future planning.

4. Preserve memory and convert experience into preparedness

Who: Civil protection agencies, schools, national, regional and local authorities, museums and memorial bodies, media organisations, community organisations.

Because HILP events are rare, their lessons can fade quickly once the immediate crisis has passed. Recovery communication should help preserve institutional and social memory without creating fatalism or blame. It should show what happened, why it mattered, which actions reduced harm, what barriers remained and what should be done differently next time.

Practical actions:

- Communicate what exactly has been learned from the event.
- Explain what exact changes are being made to address vulnerabilities.
- Identify who is responsible for implementing changes.
- Show how community experience contributed to learning.
- Integrate lessons into preparedness campaigns and exercises.
- Use schools, local media, museums, memorials or anniversaries to support public memory.
- Share examples of effective protective action without blaming those who could not act.
- Update future preparedness guidance based on post-event learning.

Post-event communication is therefore a bridge back to preparedness, not an endpoint.

Implementation: Medium-term. Requires after-action communication, public-facing learning materials, integration into exercises and education, and follow-up communication showing how lessons have changed preparedness practice.

6.4. Cross-Cutting Principles

The following principles apply across preparedness, response and recovery. They should guide all HILP risk communication, regardless of hazard type or phase.

1. Build and protect trust as communication infrastructure

Who: civil protection authorities, scientific agencies, national, regional and local authorities, political decision-makers, emergency services, media organisations and community organisations.

Trust is both a precondition and a consequence of HILP risk communication. Authorities that have not built trust before a crisis cannot improvise it during one: populations with pre-existing reasons to distrust official sources (whether rooted in historical experience, perceived neglect, or documented institutional failures) will receive the same warning differently. At the same time, every act of communication either strengthens or erodes the trust available for the next one. Transparency, consistency, empathy and honest acknowledgement of uncertainty build trust over time. Inaccurate reassurance, withheld information, and contradictions between agencies can destroy it.

Practical actions:

- Build relationships with communities, media organisations and local actors before crises occur.
- Avoid prioritising reassurance over accuracy.
- Correct errors openly and explain why guidance changes.
- Acknowledge uncertainty rather than projecting false confidence.
- Ensure communication demonstrates care for affected populations, not only institutional credibility.
- After events, communicate what went wrong, what has changed, and why.

Implementation: Structural. Trust is not built through single communications or campaigns. It requires consistent behaviour across all phases and over time; between events as much as during them. Institutions should treat trust-building as an organisational responsibility, not a communication afterthought.

2. Treat communication as a specialist function

Who: Public authorities, emergency management organisations, political decision-makers, scientific agencies, infrastructure operators.

Risk communication should not be treated as common sense or as the simple transfer of expert information to the public. It is a specialist function requiring behavioural evidence, audience knowledge, plain language, message testing, trust-building, uncertainty communication and contextual adaptation.

Practical actions:

- Include trained communicators in crisis structures.
- Give communication teams access to scientific and operational information.
- Involve behavioural and social-science expertise.
- Train spokespersons before events.
- Train political and operational leaders in evidence-based risk communication.
- Test messages with target audiences.
- Use plain-language review processes.
- Evaluate behavioural outcomes, not only message reach.
- Challenge unsupported assumptions about public behaviour, including the panic assumption.

This is particularly important because unsupported assumptions about public behaviour can lead to delayed, softened or overly reassuring messages.

Implementation: Structural. Requires resourcing communication teams, formal roles in crisis structures, training for spokespersons and decision-makers, and integration of behavioural and social-science expertise into emergency management.

3. Define messages by their intended behavioural purpose

Who: Communication teams, behavioural experts, civil protection authorities, public health bodies, campaign designers, national, regional and local authorities and organisations.

Messages should be designed according to what they are meant to achieve. A message intended to raise awareness is different from a message intended to increase concern, build trust, encourage household planning, motivate registration for alerts, recruit volunteers, support community preparedness, or change any other specific behaviour.

Practical actions:

- Define the target audience.
- Specify the intended outcome of the message.
- Identify the practical, emotional, social or institutional barrier the message is addressing.
- Define the desired behaviour, decision or form of engagement.
- Select the most appropriate messenger for the audience.
- Select the most appropriate channel or combination of channels.
- Decide whether the message is intended to inform, reassure, warn, motivate, correct misinformation, change behaviour, or support recovery.
- Define how success will be evaluated.

This is important because different messages produce different effects. A message designed to increase scientific understanding should not be expected automatically to produce preparedness behaviour, donations, evacuation or compliance with emergency instructions, for example. Behavioural effectiveness therefore requires clarity about the purpose of the message and the mechanism through which it is expected to work.

Implementation: Immediate to medium-term. Can be introduced through message planning checklists, campaign briefs and approval templates requiring each message to specify its target audience, purpose, desired action and evaluation criterion.

4. Make every message relevant, findable, understandable and usable

Who: All communicators.

HILP risk communication should follow plain-language principles. People should be able to get what they need (relevant), easily find (findable) and understand (understandable) what they find, and use the information to make decisions (usable). This means messages should be concise, structured and action-oriented.

Practical actions:

- Make the source clear.
- Make the target audience clear.
- State where the message applies.
- State when action is needed.
- Explain what may happen.
- State what people should do.
- Explain why the action matters.
- Explain what to do if people cannot act alone.
- Provide a clear update point.
- Use headings, visual hierarchy and accessible formats.
- Avoid unnecessary technical language and acronyms.
- Test whether the audience can find and use the key information.

Every message should allow the audience to answer: is this for me, what does it mean, what should I do, and where do I go next?

Implementation: Immediate. Can be introduced through plain-language checklists informed by ISO 24495-1 standards, message templates and review procedures before publication.

5. Design for cascading and compound impacts

Who: Civil protection authorities, infrastructure operators, scientific agencies, cross-border coordination bodies, public health bodies.

HILP events often trigger secondary impacts across infrastructure, health, transport, finance, communications, energy, water, supply chains and social systems. Communication should therefore not be limited to the initiating hazard. It should anticipate cascading effects and potentially conflicting protective actions.

Practical actions:

- Identify likely secondary hazards.
- Identify critical infrastructure dependencies.
- Identify possible service disruptions.
- Identify cross-border information needs.
- Identify vulnerable groups affected by cascading failures.
- Clarify who communicates about each impact.
- Prepare messages for compound or concurrent events.
- Anticipate conflicting protective actions.
- Update messages as cascading impacts evolve.
- Include infrastructure operators in communication planning and exercises.

Multi-hazard, cascading and compound risk are repeated themes in the evidence base, noting that HILP communication must anticipate secondary hazards, concurrent crises, cross-border impacts, infrastructure disruption and potentially conflicting protective actions.

Implementation: Medium-term to structural. Requires resilience stress testing (AGILE Stress Tests), resilience and scenario planning, joint exercises with infrastructure operators and cross-border actors, and communication protocols that cover expected secondary impacts rather than only the initiating hazard.

6. Coordinate across agencies, sectors and borders

Who: National, regional and local authorities, civil protection authorities, emergency services, scientific agencies, infrastructure operators, public health bodies, cross-border authorities, media partners.

HILP communication should be coordinated before events occur. Coordination should include not only emergency services and civil protection, but also infrastructure operators, public health bodies, transport, utilities, schools, hospitals, care institutions, media and neighbouring jurisdictions.

Practical actions:

- Designate a communication liaison role within each participating agency, responsible for exchanging information with counterpart organisations, flagging inconsistencies between messages before they reach the public, and maintaining a shared operational picture of what has been communicated, to whom, and when.
- Agree shared terminology.
- Agree warning levels and action categories.
- Identify lead and supporting communication authorities.
- Agree spokesperson roles.
- Define escalation thresholds.
- Define message approval processes.
- Use interoperable alert systems where possible.
- Establish public-facing update points.
- Create protocols for conflicting information.
- Prepare translation and accessibility procedures.
- Establish cross-border communication arrangements.
- Exercise communication coordination before real events.

This reflects an important focus on interagency alignment including critical infrastructure, public information and public inclusion in information gathering, and cross-border coordination.

Implementation: Structural. Requires formal interagency agreements, joint communication protocols, shared terminology, exercises, and mechanisms for aligning public messages across sectors and jurisdictions.

7. Combine official authority with trusted local adaptation

Who: National, regional and local authorities, first-responders and emergency services, community organisations, media partners, schools, local organisations.

Messages should remain consistent at the official level, but they must also be adapted locally. Local actors can translate guidance into familiar language, place names, routes, examples and feasible actions. They make guidance practically actionable — specifying where shelter is available, which routes are safe, and where aid can be found. They surface barriers and needs that do not reach formal channels. And they are often trusted precisely because they are embedded in the community rather than perceived as a distant institutional source. Their role is to make the official message credible and usable.

Practical actions:

- Define the authoritative core message centrally.
- Map local trusted actors and the communities they can reach, including non-digital communication channels.
- Allow local actors to adapt examples, place names and practical guidance.
- Use local authorities, responders and community organisations to reinforce messages.
- Provide local intermediaries with timely official information.
- Train local intermediaries in accurate message adaptation.

- Collect feedback from local actors on whether guidance is realistic.
- Prevent local adaptation from producing contradictory instructions.
- Ensure centralised messages do not become too generic to be useful.

This requires a balance: local adaptation should not produce contradictory guidance, but centralised communication should not be so rigid that it becomes irrelevant to local realities.

Implementation: Medium-term to structural. Requires pre-agreed core messages, local adaptation protocols, trained local intermediaries and feedback mechanisms to ensure local adaptation remains accurate and consistent.

8. Evaluate whether communication produced the desired effect

Who: Civil protection authorities, communication and media teams, researchers, local authorities.

Evaluation should examine whether communication was timely, understood, trusted, actionable, inclusive, locally relevant, accessible, coordinated, transparent about uncertainty and effective in supporting protective behaviour.

Practical actions:

- Evaluate whether messages reached intended audiences.
- Evaluate whether audiences understood the message.
- Evaluate whether audiences trusted the source.
- Evaluate whether the recommended action was clear.
- Evaluate whether people were able to act.
- Identify who was missed.
- Identify what barriers remained.
- Identify what misinformation emerged.
- Assess whether vulnerable groups could act.
- Assess whether uncertainty was understood.
- Assess whether feedback was used.
- Track whether lessons changed future practice.

This responds to the finding that communication should be evaluated not only by whether messages were sent or received, but by whether they were understood, trusted and acted upon.

Implementation: Immediate to medium-term. Basic evaluation questions can be added immediately to reviews and exercises; medium-term implementation requires agreed indicators, audience testing, post-event evaluation protocols and mechanisms for translating findings into policy and practice.

6.5. Summary of the Guidelines

Overall, the guidelines in this chapter emphasise that effective HILP risk communication is not simply a matter of communicating more. It requires communication that is prepared in advance, designed for a clearly defined purpose, grounded in behavioural evidence, adapted to local contexts, coordinated across institutions, transparent about uncertainty, inclusive of vulnerable groups, and evaluated according to whether it enables protective action. The summary below provides an overview of the proposed guidelines, organised by communication phase and by cross-cutting principles that apply across the full preparedness–response–recovery cycle.

Table 12. Summary of the risk communication guidelines, organised by phase.

Preparedness Communication
1. Make HILP risks meaningful before they become urgent

2.	Build preparedness through participation, not only information
3.	Identify vulnerable groups and barriers before the event
4.	Pre-position trusted messengers and communication channels
5.	Prepare communication protocols, templates and exercises in advance
6.	Match communication expectations to detection and forecasting capacity
Response Communication	
1.	Communicate early, even when uncertainty remains
2.	Use impact-based warnings as the default for public communication
3.	Pair threat information with feasible action
4.	Avoid the panic assumption
5.	Speak with one voice, but do not hide uncertainty
6.	Use multiple channels and plan for communication failure
7.	Create real-time feedback loops
8.	Monitor and respond to misinformation and conflicting cues
Recovery Communication	
1.	Continue communicating after the acute emergency
2.	Communicate accountability without defensiveness
3.	Include affected communities in recovery and learning
4.	Preserve memory and convert experience into preparedness
Cross-Cutting Principles	
1.	Build and protect trust as communication infrastructure
2.	Treat communication as a specialist function
3.	Define messages by their intended behavioural purpose
4.	Make every message relevant, findable, understandable and usable
5.	Design for cascading and compound impacts
6.	Coordinate across agencies, sectors and borders
7.	Combine official authority with trusted local adaptation
8.	Evaluate whether communication produced the desired effect

7. Conclusions & Next Steps

HILP events are not simply more extreme versions of ordinary emergencies. They combine features — low probability, high impact, cascading consequences, uncertain timelines, cross-sector dependencies — that challenge communication systems in distinctive ways.

The central argument of this deliverable is that these **challenges cannot be addressed through more information alone**. The evidence reviewed in Chapters 2 to 5 show consistently that communication failures in HILP events are rarely caused by absent warnings or missing data. They are caused by the inability to convert technical information into public understanding and protective action; by institutional fragmentation that produces inconsistent or delayed messages; by assumptions about public behaviour that lead communicators to withhold or soften what people need to hear; and by the absence of the trust, relationships and channel infrastructure required to make communication effective when it is most needed.

This deliverable has approached **risk communication as a continuous cycle**. Before an event, the challenge is to build the risk literacy, trust, relationships and practical capacity that make later action possible. During an event, it is to support rapid sense-making and protective action under uncertainty and time pressure. After an event, it is to explain continuing risk, support recovery, repair trust and convert experience into future preparedness. Different phases create different communication requirements, and the guidelines in Chapter 6 are organised accordingly. This phase-based structure, grounded in the CERC model and the TWS reviewed in Chapter 3, provides a flexible framework (not a rigid script) to be adapted to different events and contexts.

Several findings deserve particular emphasis. **Trust** is both a precondition and a consequence of risk communication: it cannot be improvised during a crisis, and every act of communication either strengthens or erodes it for the next one. The **panic assumption** (the common belief that honest, urgent communication produces irrational public behaviour) is **not supported by evidence** and has caused measurable harm across multiple cases by delaying warnings and softening messages when clarity and immediate action were most needed. **Vulnerable groups** are systematically disadvantaged not by individual circumstances alone, but by communication architectures designed around average users, assumed channel access and implied capacity to act independently. And the **effectiveness of communication** must be measured by whether messages were received, but also by whether they were understood, trusted and acted upon.

The guidelines in Chapter 6 are intended as practical tools for all actors involved in producing, authorising, delivering, adapting and evaluating HILP risk communication. They do not provide a universal formula: **HILP events are too diverse and context-dependent for a single prescription**.

The effectiveness of a message depends not on maximising any single quality (e.g., the most specific, the most urgent, the most behavioural), but on a **combination of what is happening, who needs to act, and what they are being asked to do, suited to the phase of the event**. A message designed to inform the public that a situation is developing requires different content, tone and channel than one issuing an immediate evacuation instruction or supporting recovery decisions weeks later.

As a HILP event unfolds and its scope expands, the communication must shift with it. What the guidelines offer is an **evidence-based foundation for communication** that is prepared in advance, designed for a clear purpose, phase-appropriate, locally adapted, inclusive of those least able to act, transparent about uncertainty, and continuously evaluated and improved. The two summary boxes below condense the core principles and the main persistent barriers that these guidelines aim to address.

Persistent barriers

Hazard-centred messaging that does not translate into public meaning or protective action.

Communication planning separated from the operational capacity required to act on warnings.

Institutional fragmentation with no pre-agreed responsibilities, terminology or coordination protocols.

Opt-in or single-channel warning architectures that systematically exclude the most vulnerable.

The panic assumption: the unfounded belief that honest, urgent communication causes disorder.

Predominantly one-way communication with no structured feedback from communities.

Failure to pre-position trust, community messengers and accessible formats before events occur.

Evaluation focused on reach rather than on understanding, trust and behavioural response.

Principles for HILP risk communication

First and accurate: communicate early, even under uncertainty; correct errors openly.

Impact-based: translate hazard information into consequences and required action.

Action-specific: tell people what to do, when, how, and whether they can realistically do it.

Transparent about uncertainty: state what is known, what is not, and when the next update will come.

Trusted and trust-building: use credible sources and pre-positioned community messengers.

Phase-appropriate: match content and tone to the stage of the event and the action needed.

Inclusive: design for those least able to receive, understand or act on standard messages.

Multi-channel and resilient: no single channel is sufficient; plan for infrastructure failure.

Evaluated: measure whether messages were understood, trusted and acted upon.

Next steps

The guidelines presented in this deliverable provide an **evidence-based foundation for HILP risk communication**. Together with D5.1 and D5.2, this deliverable forms part of a broader WP5 approach to HILP preparedness — connecting evidence-based planning, capacity development, and risk communication as complementary dimensions of readiness.

The next phase of work will build on this foundation across several directions. The structure and components of risk communication messages — rather than their specific content — will be further explored across different HILP types and crisis phases. This includes examining what elements effective messages share, how message design should adapt as an event evolves from early uncertainty through acute impact to recovery, and what formats best support different communication purposes at each phase. The barriers identified in Chapter 5 will also receive further analytical attention, with particular focus on the three priorities identified in the T5.3 description: interagency alignment, public inclusion in information gathering, and cross-border coordination. Understanding how barriers manifest in practice, and what conditions allow them to be overcome, is necessary to translate the guidelines into operational approaches. This work will draw on retrospective analysis of HILP events in selected territories of the AGILE case studies. Examining how risk communication was conducted in past events in those specific contexts will allow the evidence base to be tested against local institutional realities and will provide grounded examples for refining both the guidelines and the message design work.

Together, these directions aim to move from risk communication principles toward more context-sensitive and operationally useful guidance, while maintaining sufficient breadth to accommodate the diversity of HILP types, institutional contexts and communication challenges.

8. References

Abreu dos Santos, B., Moutinho, A., Raposo, A., Vasconcelos, L., & Ferreira, J. C. (2025, May 26–29). Public participation and risk culture in Portugal: Insights from a national survey on risk perception and collaborative governance [Poster presentation]. *34th Annual Conference of the Society for Risk Analysis* – Europe, University of Alicante, Alicante, Spain.

Aguirre, B. E., Wenger, D., & Vigo, G. (1998). A test of the emergent norm theory of collective behavior. Sociological Forum, 13(2), 301–320.

Agyepong, L. A., & Liang, X. (2022). Mapping the knowledge frontiers of public risk communication in disaster risk management. Journal of Risk Research. https://doi.org/10.1080/13669877.2022.2127851

Aldrich, D. P., & Meyer, M. A. (2015). Social capital and community resilience. American Behavioral Scientist, 59(2), 254–269. https://doi.org/10.1177/0002764214550299

Alexander, D. (2013) 'Volcanic ash in the atmosphere and risks for civil aviation: a study in European crisis management', International Journal of Disaster Risk Science, 4(1), pp. 9–19. DOI: 10.1007/s13753-013-0003-0.

Anthony, K. E., Strait, L. P., Petrun Sayers, E. L., Albert, L., Beckham, J. R., Cameron, C. G., & Cox, E. G. (2023). The ethic of first and second things in communicating risk and safety. In T. L. Sellnow & D. D. Sellnow (Eds.), Communicating risk and safety. De Gruyter Mouton.

Austin, M.L. Laferriere, R.R. (2011) 'The Importance of Stakeholder Outreach and Risk Communications in a Major Oil Spill: A Case Study of the Deepwater Horizon MC-252 Oil Spill', 2011 International Oil Spill Conference, 2011(1), pp. 2011-301.

Bada, M. Nurse, J.R.C. (2019) 'The Social and Psychological Impact of Cyber-Attacks', in Benson, V. and McAlaney, J. (eds.) Emerging Cyber Threats and Cognitive Vulnerabilities. London: Academic Press / Elsevier. [Pre-publication manuscript.]

Baioni, D. (2011) 'Human activity and damaging landslides and floods on Madeira Island', Natural Hazards and Earth System Sciences, 11(11), pp. 3035–3046. Available at: https://doi.org/10.5194/nhess-11-3035-2011

Barr, D., Drury, J., Bell, L., Devynck, N., Gayretli, Ç., Lalli, S., & Linfield, H. (2024). Explaining a collective false alarm: Context and cognition in the Oxford Street crowd flight incident. European Journal of Social Psychology, 54(7), 1515–1530. https://doi.org/10.1002/ejsp.3105

Beedasy, J. Samur Zúñiga, A.F. Chandler, T. Slack, T. (2020) 'Online community discourse during the Deepwater Horizon oil spill: an analysis of Twitter interactions', International Journal of Disaster Risk Reduction, 51, p. 101870.

Bird, D.K. Gísladóttir, G. (2012) 'Residents' attitudes and behaviour before and after the 2010 Eyjafjallajökull eruptions: a case study from southern Iceland', Bulletin of Volcanology, 74(6), pp. 1263–1279. DOI: 10.1007/s00445-012-0595-z.

Bird, D.K. Gísladóttir, G. (2018) 'Responding to volcanic eruptions in Iceland: from the small to the catastrophic', Palgrave Communications, 4, article 151. DOI: 10.1057/s41599-018-0205-6.

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, article 101896. DOI: 10.1016/j.ijdrr.2020.101896.

Bird, D.K. Gísladóttir, G. Dominey-Howes, D. (2011) 'Different communities, different perspectives: issues affecting residents' response to a volcanic eruption in southern Iceland', Bulletin of Volcanology, 73(9), pp. 1209–1227. DOI: 10.1007/s00445-011-0464-1.

Bol, G.-F. (2021) 'The COVID-19 pandemic: agile versus blundering communication during a worldwide crisis', EMBO Reports, 22(6), e53182. DOI: 10.15252/embr.202153182.

Bostrom, A., Böhm, G., & O'Connor, R. E. (2018). Communicating risks: Principles and challenges. In M. Raue, E. Lermer, & B. Streicher (Eds.), Psychological perspectives on risk and risk analysis. Springer. https://doi.org/10.1007/978-3-319-92478-6_11

Boyce-Jacino, C., Peters, E., Galvani, A. P., & Chapman, G. B. (2022). Large numbers cause magnitude neglect: The case of government expenditures. Proceedings of the National Academy of Sciences, 119(28), Article e2203037119. https://doi.org/10.1073/pnas.2203037119

Brodie, M. Weltzien, E. Altman, D. Blendon, R.J. Benson, J.M. (2006) 'Experiences of Hurricane Katrina evacuees in Houston shelters: Implications for future planning', American Journal of Public Health, 96(5), pp. 1402–1408. doi:10.2105/AJPH.2005.084475.

Bruni, F. Llewellyn, D.T. (eds.) (2009). The Failure of Northern Rock: A Multi-dimensional Case Study. SUERF Studies, No. 2009/1. Vienna: SUERF - The European Money and Finance Forum. [ISBN 978-3-902109-46-0]

Budd, L. Griggs, S. Howarth, D. Ison, S. (2011) 'A fiasco of volcanic proportions? Eyjafjallajökull and the closure of European airspace', Mobilities, 6(1), pp. 31–40. DOI: 10.1080/17450101.2011.532650.

Camara Municipal do Funchal. (2011) Funchal, Madeira Island, Portugal: Making Cities Resilient Campaign Submission. Geneva: UNISDR. Available at: https://www.unisdr.org/campaign/resilientcities/uploads/city/attachments/2900-10095.pdf

Camerer, C. F., & Kunreuther, H. (1989). Decision processes for low probability events: Policy implications. Journal of Policy Analysis and Management, 8(4), 565–592. https://doi.org/10.2307/3325045

Cavaleri, L. Bajo, M. Barbariol, F. Bastianini, M. Benetazzo, A. Bertotti, L. Chiggiato, J. Ferrarin, C. Trincardi, F. Umgiesser, G. (2020) 'The 2019 Flooding of Venice and Its Implications for Future Predictions', Oceanography, 33(1), pp. 42–49. DOI: 10.5670/oceanog.2020.105.

Carter, H., Drury, J., Rubin, G. J., Williams, R., & Amlôt, R. (2013a). Communication during mass casualty decontamination: Highlighting the gaps. International Journal of Emergency Services, 2(1), 29–48.

Carter, H., Drury, J., Rubin, G. J., Williams, R., & Amlôt, R. (2013b). The effect of communication on anxiety and compliance during mass decontamination. Disaster Prevention and Management, 22(2), 132–147.

Carter, H., Drury, J., Rubin, G. J., Williams, R., & Amlôt, R. (2014a). Effective responder communication improves efficiency and psychological outcomes in a mass decontamination field experiment: Implications for public behaviour in the event of a chemical incident. PLOS ONE, 9(3), Article e89846. https://doi.org/10.1371/journal.pone.0089846

Carter, H., Drury, J., Rubin, G. J., Williams, R., & Amlôt, R. (2015). Applying crowd psychology to develop recommendations for the management of mass decontamination. Health Security, 13(1), 45–53.

Casagli, N., Intrieri, E., Tofani, V., Gigli, G., & Raspini, F. (2021). Landslide detection, monitoring and prediction with remote-sensing techniques. Nature Reviews Earth & Environment, 2, 51–64. https://doi.org/10.1038/s43017-020-00105-3

Chavula, P., Kayusi, F., Lungu, G., & Uwimbabazi, A. (2025). The current landscape of early warning systems and traditional approaches to disaster detection. LatIA. https://latia.ageditor.uy/index.php/latia/article/view/77

Centre for Research on the Epidemiology of Disasters (CRED). (2024) 2023: Disasters in Numbers. Brussels: Centre for Research on the Epidemiology of Disasters (Emergency Events Database - EM-DAT).

CEN. (2023). CWA 18005:2023: Guidelines for effective social media messages in crisis and disaster management. European Committee for Standardization.

Chen, C. Zhang, C. Lindell, M.K. Wang, Y. Qiu, Q. Wang, H. Zhang, G. (2025) 'Alerts and warnings under disrupted communication infrastructure: Lahaina residents' immediate responses to the 2023 wildfire', International Journal of Disaster Risk Reduction, 131, 105884.

Clarke, L. (2002). Panic: Myth or reality? Contexts, 1(3), 21–26. https://doi.org/10.1525/ctx.2002.1.3.21

Cole, T.W. Fellows, K.L. (2008). Risk communication failure: A case study of New Orleans and Hurricane Katrina, Southern Communication Journal, 73(3), pp. 211–228. https://doi.org/10.1080/10417940802219702

Combs, B., & Slovic, P. (1979). Newspaper coverage of causes of death. Journalism Quarterly, 56(4), 837–843. https://doi.org/10.1177/107769907905600420

Coombs, W. T. (1999). Ongoing crisis communication: Planning, managing, and responding. SAGE.

Copernicus Marine Environment Monitoring Service. (2019) Record Venice Acqua Alta: Copernicus Supports Flood Monitoring and Storm Surge Forecasts. Copernicus Marine Service News, 7 December 2019. Available at: https://marine.copernicus.eu/news/record-venice-acqua-alta-copernicus-supports-flood-monitoring-and-storm-surge-forecasts

Croft, J., Teufel, C., & Fletcher, P. C. (2022). Risking everything in obsessive-compulsive disorder: An analogue decision-making study. Scientific Reports, 12, Article 1282. https://doi.org/10.1038/s41598-022-05279-8

Cubeddu, F. (2025). Risk and emergency communication. Encyclopedia, 5(4), Article 183. https://doi.org/10.3390/encyclopedia5040183

Dake, K. (1992). Myths of nature: Culture and the social construction of risk. Journal of Social Issues, 48(4), 21–37. https://doi.org/10.1111/j.1540-4560.1992.tb01943.x

Dallo, I. A. (2022). Understanding the communication of event-related earthquake information in a multi-hazard context to improve society's resilience [Doctoral dissertation, ETH Zurich].

Dallo, I., & Marti, M. (2021). Why should I use a multi-hazard app? Assessing the public's information needs and app feature preferences for multi-hazard warnings. International Journal of Disaster Risk Reduction, 57, Article 102197. https://doi.org/10.1016/j.ijdrr.2021.102197

Dallo, I., Stauffacher, M., & Marti, M. (2022). Actionable and understandable? Evidence-based recommendations for the design of (multi-)hazard warning messages. International Journal of Disaster Risk Reduction, 74, Article 102917. https://doi.org/10.1016/j.ijdrr.2022.102917

Damasio, A. R. (1994). Descartes' error: Emotion, reason, and the human brain. Putnam.

Damasio, A. R., Everitt, B. J., & Bishop, D. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex. Philosophical Transactions of the Royal Society B: Biological Sciences, 351(1346), 1413–1420. https://doi.org/10.1098/rstb.1996.0125

Davidson, L., Carter, H., Drury, J., Amlôt, R., & Haslam, S. A. (2025). How the Social Identity Approach can improve interoperability in multi-agency emergency response teams. Journal of Contingencies and Crisis Management, 33(2), Article e70050. https://doi.org/10.1111/1468-5973.70050

Dehaene, S., Izard, V., Spelke, E., & Pica, P. (2008). Log or linear? Distinct intuitions of the number scale in Western and Amazonian indigene cultures. Science, 320(5880), 1217–1220. https://doi.org/10.1126/science.1156540

Dehghani, A., Ghomian, Z., Rakhshanderou, S., Khankeh, H., & Kavousi, A. (2022). Process and components of disaster risk communication in health systems: A thematic analysis. Jàmbá: Journal of Disaster Risk Studies, 14(1), Article 1367. https://doi.org/10.4102/jamba.v14i1.1367

de Queiroz, M. (2010) 'MADEIRA: Disaster blamed on chaotic urban planning', Inter Press Service. Available at: https://www.ipsnews.net/2010/02/madeira-disaster-blamed-on-chaotic-urban-planning/

de Saille, S. Matanle, P. (2016) Fukushima - The Triple Disaster and Its Triple Lessons: What can be learned about regulation, planning, and communication in an unfolding emergency? INGSA Case Studies. Auckland: International Network for Government Science Advice (INGSA).

de Wolf, D. Mejri, M. (2013) 'Crisis communication failures: The BP Case Study', International Journal of Advances in Management and Economics. Available at: http://www.managementjournal.info.

Donovan, A.R. Oppenheimer, C. (2011) 'The 2010 Eyjafjallajökull eruption and the reconstruction of geography', The Geographical Journal, 177(1), pp. 4–11. DOI: 10.1111/j.1475-4959.2010.00379.x.

Donovan, A.R. Oppenheimer, C. (2012) 'Governing the lithosphere: insights from Eyjafjallajökull concerning the role of scientists in supporting decision-making on active volcanoes', Journal of Geophysical Research: Solid Earth, 117(B3), B03214. DOI: 10.1029/2011JB009080.

Doocy, S. Rofi, A. Moodie, C. Spring, E. Bradley, S. Burnham, G. Robinson, C. (2007) 'Tsunami mortality in Aceh Province, Indonesia', Bulletin of the World Health Organization, 85(2), pp. 273–278.

Dootson, P., Greer, D., Mehta, A., & Tippett, V. (2021). Managing problematic visual content during natural hazards. Bushfire and Natural Hazards CRC.

Douglas, M. (1970). Natural symbols: Explorations in cosmology. Barrie & Rockliff.

Douglas, M., & Wildavsky, A. (1982). Risk and culture: An essay on the selection of technological and environmental dangers. University of California Press.

Drury, J. (2018). The role of social identity processes in mass emergency behaviour: An integrative review. European Review of Social Psychology, 29(1), 38–81. https://doi.org/10.1080/10463283.2018.1471948

Drury, J. (2026). The psychology of crowd behavior. Annual Review of Psychology, 77, 339–364. https://doi.org/10.1146/annurev-psych-012125-121447

Drury, J., & Reicher, S. (2000). Collective action and psychological change: The emergence of new social identities. British Journal of Social Psychology, 39(4), 579–604. https://doi.org/10.1348/014466600164642

Drury, J., Carter, H., Cocking, C., Ntontis, E., Tekin Guven, S., & Amlôt, R. (2019). Facilitating collective psychosocial resilience in the public in emergencies: Twelve recommendations based on the social identity approach. Frontiers in Public Health, 7, Article 141. https://doi.org/10.3389/fpubh.2019.00141

Drury, J., Cocking, C., & Reicher, S. (2009). The nature of collective resilience: Survivor reactions to the 2005 London bombings. International Journal of Mass Emergencies and Disasters, 27(1), 66–95.

Drury, J., Novelli, D., & Stott, C. (2013). Psychological disaster myths in the perception and management of mass emergencies. Journal of Applied Social Psychology, 43(11), 2259–2270. https://doi.org/10.1111/jasp.12176

Dryhurst, S., Schneider, C. R., Kerr, J., Freeman, A. L. J., Recchia, G., van der Bles, A. M., Spiegelhalter, D., & van der Linden, S. (2020). Risk perceptions of COVID-19 around the world. Journal of Risk Research, 23(7–8), 994–1006. https://doi.org/10.1080/13669877.2020.1758193

Dufty, N. (2021). Disaster education, communication and engagement. Wiley.

Duží, B. Vikhrov, D. Kelman, I. Stojanov, R. Jurčička, D. (2017) 'Household measures for river flood risk reduction in the Czech Republic', Journal of Flood Risk Management, 10(2), pp. 253–266. https://doi.org/10.1111/jfr3.12132

Dynes, R. R. (1970). Organized behavior in disaster. Heath Lexington Books.

Ehrenfeld, J.M. (2017) 'WannaCry, Cybersecurity and Health Information Technology: A Time to Act', Journal of Medical Systems, 41(7), 104.

Eisenman, D.P. Cordasco, K.M. Asch, S. Golden, J.F. Glik, D. (2007) 'Disaster planning and risk communication with vulnerable communities: Lessons from Hurricane Katrina', American Journal of Public Health, 97(S1), pp. S109–S115. doi:10.2105/AJPH.2005.084335.

European Stability Mechanism. (2024). Public crisis communication: Principles for public institutions. European Stability Mechanism.

European Union Agency for Cybersecurity (ENISA). (2017) WannaCry Ransomware: First Ever Case of Cyber Cooperation at EU Level. Athens: ENISA. Available at: https://www.enisa.europa.eu/news/enisa-news/wannacry-ransomware-first-ever-case-of-cyber-cooperation-at-eu-level

Fathollahzadeh, A., Babaie, J., Salmani, I., Morowatisharifabad, M. A., & Khajehaminian, M. R. (2024). Challenges of disaster risk communication from the perspectives of experts and affected people: A conventional content analysis. International Journal of Disaster Risk Reduction, 108, Article 104553. https://doi.org/10.1016/j.ijdrr.2024.104553

Fathollahzadeh, A., Salmani, I., Morowatisharifabad, M. A., Khajehaminian, M. R., Babaie, J., & Fallahzadeh, H. (2023). Models and components in disaster risk communication: A systematic literature review. Journal of Education and Health Promotion, 12, Article 87. https://doi.org/10.4103/jehp.jehp_277_22

Fekete, A. (2021) 'Motivation, satisfaction, and risks of operational forces and helpers regarding the 2021 and 2013 flood operations in Germany', Sustainability, 13(22), p. 12587. https://doi.org/10.3390/su132212587

Fekete, A. Sandholz, S. (2021) 'Here comes the flood, but not failure? Lessons to learn after the heavy rain and pluvial floods in Germany 2021', Water, 13(21), p. 3016. https://doi.org/10.3390/w13213016

Fetherstonhaugh, D., Slovic, P., Johnson, S. M., & Friedrich, J. (1997). Insensitivity to the value of human life: A study of psychophysical numbing. Journal of Risk and Uncertainty, 14, 283–300. https://doi.org/10.1023/A:1007744326393

Financial Services Authority (FSA), Internal Audit Division (2008). The Supervision of Northern Rock: A Lessons Learned Review. London: FSA.

Finucane, M. L., Alhakami, A., Slovic, P., & Johnson, S. M. (2000). The affect heuristic in judgments of risks and benefits. Journal of Behavioral Decision Making, 13(1), 1–17.

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1978). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Sciences, 9, 127–152. https://doi.org/10.1007/BF00143739

Fonseca, M. N. da, Silva, L. P. da, & Tedim, F. M. S. (2025). Flood risk communication: Challenges and opportunities in Brazilian cities. International Journal of Disaster Risk Reduction, 119, Article 105292. https://doi.org/10.1016/j.ijdrr.2025.105292

Fragoso, M. Trigo, R.M. Pinto, J.G. Lopes, S. Lopes, A. Ulbrich, S. Magro, C. (2012) 'The 20 February 2010 Madeira flash-floods: synoptic analysis and extreme rainfall assessment', Natural Hazards and Earth System Sciences, 12(3), pp. 715–730. Available at: https://doi.org/10.5194/nhess-12-715-2012

Freimuth, V. S., Linnan, H. W., & Potter, P. (2000). Communicating the threat of emerging infections to the public. Emerging Infectious Diseases, 6(4), 337–347. https://doi.org/10.3201/eid0604.000403

Fritz Institute. (2005) Recipient Perceptions of Aid Effectiveness: Rescue, Relief and Rehabilitation in Tsunami Affected Indonesia, India and Sri Lanka. San Francisco: Fritz Institute.

GCS Behavioural Science Team. (2022). Crisis communication: A behavioural approach. Government Communication Service, Cabinet Office. https://www.communications.gov.uk/publications/crisis-communication-a-behavioural-approach/

Gershon, R. R. M., Hogan, E., Qureshi, K. A., Doll, L., & Sherman, M. F. (2007). Factors associated with emergency medical services scope of practice for emergency medical technicians. Prehospital and Disaster Medicine, 22(2), 132–139.

GFDRR. (2017). Guidelines for community participation in disaster recovery. Global Facility for Disaster Reduction and Recovery.

GFDRR. (2021). Communication during disaster recovery: Guidance for practitioners. Global Facility for Disaster Reduction and Recovery.

Ghafur, S. Grass, E. Jennings, N.R. Darzi, A. (2019) 'The challenges of cybersecurity in health care: the UK National Health Service as a case study', The Lancet Digital Health, 1(1), pp. e10–e12.

Ghafur, S. Kristensen, S. Honeyford, K. Martin, G. Darzi, A. Aylin, P. (2019) 'A retrospective impact analysis of the WannaCry cyberattack on the NHS', npj Digital Medicine, 2, 98.

Gisondi, M.A. Barber, R. Faust, J.S. Raja, A. Strehlow, M.C. Westafer, L.M. Gottlieb, M. (2022) 'A deadly infodemic: social media and the power of COVID-19 misinformation', Journal of Medical Internet Research, 24(2), e35552. DOI: 10.2196/35552.

Goltz, J. D., & Roeloffs, E. (2020). Imminent warning communication: Earthquake early warning and short-term forecasting in Japan and the US. In K. Yamori (Ed.), Integrated disaster risk management (pp. 121–153). Springer. https://doi.org/10.1007/978-981-13-2318-8_8

Governo Regional da Madeira. (2010) Official Report from Regional Government of Madeira, 23 February 2010 [Situation report]. Funchal: Secretaria Regional do Turismo e Transportes, ReliefWeb. Available at: https://reliefweb.int/disaster/fl-2010-000031-prt

Granger Morgan, M., Fischhoff, B., Bostrom, A., Lave, L., & Atman, C. J. (1983). Communicating risk to the public. Environmental Science & Technology, 17(12), 604A–609A.

Greer, D., Dootson, P., Mehta, A., & Tippett, V. (2020a). Emergency warning messages: How do community members comprehend them? Hazard Note 79. Bushfire and Natural Hazards CRC.

Greer, D., Dootson, P., Mehta, A., & Tippett, V. (2020b). Emergency warning messages: Encouraging readiness to act. Hazard Note 80. Bushfire and Natural Hazards CRC.

Greer, D., Dootson, P., Miller, S., & Tippett, V. (2020c). Emergency warning messages: Do colours and icons improve community readiness to act? Hazard Note 81. Bushfire and Natural Hazards CRC.

Gregg, C.E. Houghton, B.F. Paton, D. Lachman, R. Lachman, J. Johnston, D.M. Wongbusarakum, S. (2006) 'Natural warning signs of tsunamis: Human sensory experience and response to the 2004 Great Sumatra earthquake and tsunami in Thailand', Earthquake Spectra, 22(S3), pp. S671–S691.

Grenfell Tower Inquiry. (2019) Phase 1 Report: Report of the Public Inquiry into the Fire at Grenfell Tower on 14 June 2017. London: Crown Copyright.

Grenfell Tower Inquiry. (2024) Phase 2 Report: Report of the Public Inquiry into the Fire at Grenfell Tower on 14 June 2017. London: Crown Copyright.

Griffin, R. J., Dunwoody, S., & Neuwirth, K. (1999). Proposed model of the relationship of risk information seeking and processing to the development of preventive behaviors. Environmental Research, 80(2), S230–S245. https://doi.org/10.1006/enrs.1998.3940

Guerreiro, J. Fonseca, C. Salgueiro, A. Fernandes, P. Lopez Iglésias, E. de Neufville, R. Mateus, F. Castellnou Ribau, M. Sande Silva, J. Moura, J.M. Castro Rego, F. Mateus, P. (2022) Análise e apuramento dos factos relativos aos incêndios que ocorreram em Pedrógão Grande, Castanheira de Pera, Ansião, Alvaiázere, Figueiró dos Vinhos, Arganil, Góis, Penela, Pampilhosa da

Serra, Oleiros e Sertã, entre 17 e 24 de junho de 2017: Relatório final. Comissão Técnica Independente, Assembleia da República, Lisboa.

Hagemeier-Klose, M., & Wagner, K. (2009). Evaluation of flood hazard maps in print and web mapping services as information tools in flood risk communication. Natural Hazards and Earth System Sciences, 9, 563–574. https://doi.org/10.5194/nhess-9-563-2009

Halpern, D. F., Blackman, S., & Salzman, B. (1989). Using statistical risk information in decision making. In R. E. Petty, T. M. Ostrom, & T. C. Brock (Eds.), Cognitive responses in persuasion (pp. 191–207). Lawrence Erlbaum.

Haque, C. E., Choudhury, M.-U.-I., & Khan, M. S. (2024). Social learning and collective action in flood-hazard management in Manitoba, Canada. Environmental Hazards. Advance online publication. https://doi.org/10.1080/17477891.2024.2400131

Hatayama, M., & Nakai, F. (2020). Using computer simulation for effective tsunami risk communication. In K. Yamori (Ed.), Integrated disaster risk management (pp. 39–50). Springer. https://doi.org/10.1007/978-981-13-2318-8_3

Heide, E. A. (2004). Common misconceptions about disasters: Panic, the "disaster syndrome," and looting. In M. O'Leary (Ed.), The first 72 hours: A community approach to disaster preparedness (pp. 337–380). iUniverse.

Helbing, D., Farkas, I., & Vicsek, T. (2000). Simulating dynamical features of escape panic. Nature, 407, 487–490. https://doi.org/10.1038/35035023

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. https://doi.org/10.1080/13669877.2019.1569097

Hertwig, R., & Erev, I. (2009). The description–experience gap in risky choice. Trends in Cognitive Sciences, 13(12), 517–523. https://doi.org/10.1016/j.tics.2009.09.004

Hertwig, R., Barron, G., Weber, E. U., & Erev, I. (2004). Decisions from experience and the effect of rare events in risky choice. Psychological Science, 15(8), 534–539. https://doi.org/10.1111/j.0956-7976.2004.00715.x

Hertwig, R., Pachur, T., & Kurzenhäuser, S. (2005). Judgments of risk frequencies: Tests of possible cognitive mechanisms. Journal of Experimental Psychology: Learning, Memory, and Cognition, 31(4), 621–642. https://doi.org/10.1037/0278-7393.31.4.621

Hopkins, N., Reicher, S., Stevenson, C., Pandey, K., Shankar, S., & Tewari, S. (2019). Social relations in crowds: Recognition, validation and solidarity. European Journal of Social Psychology, 49(6), 1283–1297. https://doi.org/10.1002/ejsp.2586

House of Commons Committee of Public Accounts. (2018) Cyber-attack on the NHS. HC 787, Session 2017–2019. London: House of Commons.

House of Commons Treasury Committee. (2008) The Run on the Rock. Fifth Report of Session 2007-08, HC 56-I. London: The Stationery Office.

Inal Onal, E., Tekeli-Yeşil, S., & Okay, N. (2022). The use of Twitter by official institutions in disaster risk communication and resilience. Journal of Emergency Management and Disaster Communications, 3(1), 25–40. https://doi.org/10.1142/S2689980922500087

Independent Panel for Pandemic Preparedness and Response (2021) COVID-19: Make it the Last Pandemic. Geneva: WHO. Available at: https://theindependentpanel.org

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 Reduction, 46, Article 101510. https://doi.org/10.1016/j.ijdrr.2020.101510

ISPRA. CPSM. CNR-ISMAR. (2020) Novembre 2019: un mese di maree eccezionali. Dinamica e anomalia dell'evento del 12 novembre 2019. Rome: ISPRA. Available at: https://www.isprambiente.gov.it/files2020/notizie/ispra_cpsm_cnr_novembre_2019_maree_eccezionali.pdf

Iwahori, T. (2020). Disaster education based on legitimate peripheral participation theory. In K. Yamori (Ed.), Integrated disaster risk management (pp. 83–103). Springer. https://doi.org/10.1007/978-981-13-2318-8_6

Jackson, D. Huang, M. Fernando, H. Ansari, G. Howarth, M. Mesaros, C. Penning, T. Elferink, C. (2019) 'Using Precision Environmental Health Principles in Risk Evaluation and Communication of the Deepwater Horizon Oil Spill', New Solutions: A Journal of Environmental and Occupational Health Policy, 28(4), pp. 599–616.

Jan, M. A., Ullah, S. I., Ullah, W., Ullah, S., Ali, A., Tariq, H., Fernando, T., & Saeed, M. (2025a). Testing and evaluation of Pakistan's pioneer disaster risk communication app: A case study of PDMA Madadgar android-based app. Frontiers in Communication, 10, Article 1572206. https://doi.org/10.3389/fcomm.2025.1572206

Jan, M. A., Ullah, S. I., Ullah, W., Ullah, S., Tariq, H., Fernando, T., Ali, A., & Rahman, Z. U. (2025b). Analyzing and conceptualizing Pakistan's pioneering disaster risk communication mobile application: A case study of PDMA Madadgar. Frontiers in Communication, 10, Article 1593319. https://doi.org/10.3389/fcomm.2025.1593319

Jin, Y., & Spence, P. R. (2020). Crisis communication research in the digital age. In H. D. O'Hair & M. J. O'Hair (Eds.), The handbook of applied communication research. Wiley.

Johnson, B. B., & Swedlow, B. (2021). Cultural theory's contributions to risk analysis: A thematic review with directions and resources for further research. Risk Analysis, 41(3), 429–455. https://doi.org/10.1111/risa.13299

Kahan, D. M. (2012). Cultural cognition as a conception of the cultural theory of risk. In S. Roeser, R. Hillerbrand, P. Sandin, & M. Peterson (Eds.), Handbook of risk theory (pp. 725–759). Springer. https://doi.org/10.1007/978-94-007-1433-5_28

Kahneman, D., & Tversky, A. (1972). Subjective probability: A judgment of representativeness. Cognitive Psychology, 3(3), 430–454. https://doi.org/10.1016/0010-0285(72)90016-3

Kahneman, D., & Tversky, A. (1979). Prospect theory: An analysis of decisions under risk. Econometrica, 47(2), 263–291. https://doi.org/10.2307/1914185

Kapucu, N. (2006) 'Interagency communication networks during emergencies: Boundary spanners in multiagency coordination', American Review of Public Administration, 36(2), pp. 207–225. https://doi.org/10.1177/0275074005280605

Kasperson, R. E., Kasperson, J. X., Pidgeon, N., & Slovic, P. (2022). The social amplification of risk framework: New perspectives. Risk Analysis, 42(7), 1367–1380.

Kasperson, R. E., Renn, O., Slovic, P., Brown, H. S., Emel, J., Goble, R., Kasperson, J. X., & Ratick, S. (1988). The social amplification of risk: A conceptual framework. Risk Analysis, 8(2), 177–187. https://doi.org/10.1111/j.1539-6924.1988.tb01168.x

Kerber, S. Alkonis, D. (2024a) Lahaina Fire Comprehensive Timeline Report. Columbia, MD: Fire Safety Research Institute.

Kerber, S. Alkonis, D. (2024b) Lahaina Fire Incident Analysis Report. Columbia, MD: Fire Safety Research Institute.

Khan, S., Mishra, J., Ahmed, N., Onyige, C. D., Lin, K. E., Siew, R., & Lim, B. H. (2022). Risk communication and community engagement during COVID-19. International Journal of Disaster Risk Reduction, 74, Article 102903. https://doi.org/10.1016/j.ijdrr.2022.102903

Knoblauch, T. A. K., Stauffacher, M., & Trutnevyte, E. (2018). Communicating low-probability high-consequence risk, uncertainty and expert confidence: Induced seismicity of deep geothermal energy and shale gas. Risk Analysis, 38(4), 694–709. https://doi.org/10.1111/risa.12872

Koks, E.E. van Ginkel, K.C.H. van Marle, M.J.E. Lemnitzer, A. (2022) 'Brief communication: Critical infrastructure impacts of the 2021 mid-July western European flood event', Natural Hazards and Earth System Sciences, 22, pp. 3831–3838. https://doi.org/10.5194/nhess-22-3831-2022

Kreibich, H. Thieken, A.H. (2009) 'Coping with floods in the city of Dresden, Germany', Natural Hazards, 51(3), pp. 423–436. https://doi.org/10.1007/s11069-007-9200-8

Kreibich, H. Thieken, A.H. Petrow, T. Müller, M. Merz, B. (2005) 'Flood loss reduction of private households due to building precautionary measures: Lessons learned from the Elbe flood in August 2002', Natural Hazards and Earth System Sciences, 5, pp. 117–126. https://doi.org/10.5194/nhess-5-117-2005

Kuligowski, E. (2024). Hazard Note 5: Community comprehension, perception and use of maps during bushfires. Natural Hazards Research Australia.

Larson, H. J., Gakidou, E., & Murray, C. J. L. (2022). The vaccine-hesitant moment. New England Journal of Medicine, 387(1), 58–65. https://doi.org/10.1056/NEJMra2106441

Laska, S. Morrow, B.H. (2006) 'Social vulnerabilities and Hurricane Katrina: An unnatural disaster in New Orleans', Marine Technology Society Journal, 40(4), pp. 16–26.

Lauterjung, J. Koltermann, P. Wolf, U. Sopaheluwakan, J. (2010) 'The UNESCO-IOC framework: establishing an international early warning infrastructure in the Indian Ocean region', Natural Hazards and Earth System Sciences, 10, pp. 2623–2629.

Lee, F., & Yamori, K. (2020). Gaming approach to disaster risk communication: Development and application of the "Crossroad Game." In K. Yamori (Ed.), Integrated disaster risk management (pp. 51–64). Springer. https://doi.org/10.1007/978-981-13-2318-8_4

Lee, J.M-Y. Wong, E.Y-C. (2021) 'Suez Canal blockage: an analysis of legal impact, risks and liabilities to the global supply chain', MATEC Web of Conferences, 339, p. 01019. https://doi.org/10.1051/matecconf/202133901019

Lejano, R. P., Haque, C. E., & Berkes, F. (2021). Co-production of risk knowledge and improvement of risk communication: A three-legged stool. International Journal of Disaster Risk Reduction, 64, Article 102508. https://doi.org/10.1016/j.ijdrr.2021.102508

Leone, V. Elia, M. Lovreglio, R. Correia, F. Tedim, F. (2023) 'The 2017 extreme wildfire events in Portugal through the perceptions of volunteer and professional firefighters', Fire, 6(4), 133. DOI: 10.3390/fire6040133.

Lichtenstein, S., Slovic, P., Fischhoff, B., Layman, M., & Combs, B. (1978). Judged frequency of lethal events. Journal of Experimental Psychology: Human Learning and Memory, 4(6), 551–578. https://doi.org/10.1037/0278-7393.4.6.551

Lim, J. R. (2022). Why people adopt climate change adaptation and disaster risk reduction behaviors: Integrated model of risk communication and results from hurricanes, floods, and wildfires. Bulletin of the American Meteorological Society, 103(10), E2440–E2469. https://doi.org/10.1175/BAMS-D-21-0087.1

Lindell, M. K., & Perry, R. W. (2012). The protective action decision model: Theoretical modifications and additional evidence. Risk Analysis, 32(4), 616–632. https://doi.org/10.1111/j.1539-6924.2011.01647.x

Lionello, P. Barriopedro, D. Ferrarin, C. Nicholls, R.J. Orlić, M. Raicich, F. Reale, M. Umgiesser, G. Vousdoukas, M. Zanchettin, D. (2021b) 'Extreme floods of Venice: characteristics, dynamics, past and future evolution', Natural Hazards and Earth System Sciences, 21, pp. 2705–2731. DOI: 10.5194/nhess-21-2705-2021.

Lionello, P. Nicholls, R.J. Umgiesser, G. Zanchettin, D. (2021a) 'Venice flooding and sea level: past evolution, present issues, and future projections' (introduction to the special issue), Natural Hazards and Earth System Sciences, 21, pp. 2633–2641. DOI: 10.5194/nhess-21-2633-2021.

Liu, W. Zhao, X. Zhan, M. Hernandez, S. (2024) 'Streaming disasters on TikTok: Examining social mediated crisis communication, public engagement, and emotional responses during the 2023 Maui wildfire', Public Relations Review, 50(5), 102512.

Long, F. Majumdar, A. Carter, H. (2023) 'Understanding levels of compliance with emergency responder instructions for members of the Public involved in emergencies: Evidence from the Grenfell Tower fire', International Journal of Disaster Risk Reduction, 84, 103374. Available at: https://doi.org/10.1016/j.ijdrr.2022.103374.

Lopes, S. Fragoso, M. Lopes, A. (2020) 'Heavy rainfall events and mass movements in the Funchal area (Madeira, Portugal): spatial analysis and susceptibility assessment', Atmosphere, 11(1), p. 104. Available at: https://doi.org/10.3390/atmos11010104

Loss, J. Boklage, E. Jordan, S. Jenny, M.A. Weishaar, H. El Bcheraoui, C. (2021) 'Risikokommunikation bei der Eindammung der COVID-19-Pandemie: Herausforderungen und Erfolg versprechende Ansatze', Bundesgesundheitsblatt, 64, pp. 294-303. DOI: 10.1007/s00103-021-03283-3.

MacDonald, R. (2005) 'How women were affected by the tsunami: A perspective from Oxfam', PLOS Medicine, 2(6), p. e178.

Maier, M., Harris, A. J. L., Kellen, D., & Singmann, H. (2025). Decision making under extinction risk. Cognitive Psychology, 159, Article 101735. https://doi.org/10.1016/j.cogpsych.2025.101735

Malik, A., Khan, M. L., & Quan-Haase, A. (2021). Public health agencies outreach through Instagram during the COVID-19 pandemic: Crisis and emergency risk communication perspective. International Journal of Disaster Risk Reduction, 61, Article 102346. https://doi.org/10.1016/j.ijdrr.2021.102346

Maui Emergency Management Agency. (2024) After-Action Report: Maui Wildfires 2023. Wailuku, HI: County of Maui.

Mawson, A. R. (2005). Understanding mass panic and other collective responses to threat and disaster. Psychiatry, 68(2), 95–113. https://doi.org/10.1521/psyc.2005.68.2.95

Mayer, R. C., Davis, J. H., & Schoorman, F. D. (1995). An integrative model of organizational trust. Academy of Management Review, 20(3), 709–734. https://doi.org/10.2307/258792

Mayes, D.G. Wood, G.E. (2008) 'Lessons from the Northern Rock episode.' Economie Internationale, 114, pp. 5-27.

McAdoo, B.G. Dengler, L. Prasetya, G. Titov, V. (2006) 'Smong: How an oral history saved thousands on Indonesia's Simeulue Island during the December 2004 and March 2005 tsunamis', Earthquake Spectra, 22(S3), pp. S661–S669.

McClelland, G. H., Schulze, W. D., & Coursey, D. L. (1993). Insurance for low-probability hazards: A bimodal response to unlikely events. Journal of Risk and Uncertainty, 7, 95–116. https://doi.org/10.1007/BF01065317

McClelland, G. H., Schulze, W. D., & Hurd, B. (1990). The effect of risk beliefs on property values: A case study of a hazardous waste site. Risk Analysis, 10(4), 485–497. https://doi.org/10.1111/j.1539-6924.1990.tb00534.x

McMillan, L., Pescaroli, G., Gordon, M., & Linkov, I. (2026). High-impact, low-probability events: Research landscape and future opportunities. Natural Hazards. Advance online publication. https://doi.org/10.1007/s11069-026-08107-8

Mehta, A. (2022). Hazard Note 110: Choosing powerful words that signal risk and encourage action. Bushfire and Natural Hazards CRC. https://www.bnhcrc.com.au/hazardnotes/110

Meyer, R., & Kunreuther, H. (2017). The ostrich paradox: Why we underprepare for disasters. Wharton School Press.

Michie, S., van Stralen, M. M., & West, R. (2011). The behaviour change wheel: A new method for characterising and designing behaviour change interventions. Implementation Science, 6, Article 42. https://doi.org/10.1186/1748-5908-6-42

Mileti, D. S., & Sorensen, J. H. (1990). Communication of emergency public warnings: A social science perspective and state-of-the-art assessment. Oak Ridge National Laboratory.

Milne, A. Wood, G. (2009) 'Shattered on the Rock? British financial stability from 1866 to 2007.' Journal of Banking Regulation, 10(2), pp. 89--127.

Ministry of Environment of the Czech Republic. (2004) August 2002 Catastrophic Flood in the Czech Republic. Prague: Ministry of Environment of the Czech Republic / T. G. Masaryk Water Research Institute.

Moussaïd, M., Kapadia, M., Thrash, T., Sumner, R. W., Gross, M., Helbing, D., & Hölscher, C. (2016). Crowd behaviour during high-stress evacuations in an immersive virtual environment. Journal of the Royal Society Interface, 13(122), Article 20160414. https://doi.org/10.1098/rsif.2016.0414

Mohr, S. Ehret, U. Kunz, M. Ludwig, P. Caldas-Alvarez, A. Daniell, J.E. Ehmele, F. Feldmann, H. Franca, M.J. Gattke, C. Hundhausen, M. Knippertz, P. Küpfer, K. Mühr, B. Pinto, J.G. Quinting, J. Schäfer, A.M. Scheibel, M. Seidel, F. Wisotzky, C. (2023) 'A multi-disciplinary analysis of the exceptional flood event of July 2021 in central Europe — Part 1: Event description and analysis', Natural Hazards and Earth System Sciences, 23, pp. 525–551. https://doi.org/10.5194/nhess-23-525-2023

Mulder, F., van Manen, S. M., & RiskPACC Consortium. (2025). Integrating risk perception and action to enhance civil protection–citizen interaction: RiskPACC collaborative framework. RiskPACC.

National Audit Office. (2009) The Nationalisation of Northern Rock. HC 298, Session 2008-09. London: The Stationery Office.

National Audit Office. (2017) Investigation: WannaCry Cyber Attack and the NHS. HC 414, Session 2017–2019. London: National Audit Office.

National Institute of Standards and Technology. (2005). Final report on the collapse of the World Trade Center towers (NIST NCSTAR 1). U.S. Department of Commerce.

National Weather Service. (2006) Service Assessment: Hurricane Katrina, August 23–31, 2005. Silver Spring, MD: National Oceanic and Atmospheric Administration.

Neville, F. G., & Reicher, S. D. (2011). The experience of collective participation: Shared identity, relatedness and emotionality. Contemporary Social Science, 6(3), 377–396. https://doi.org/10.1080/21582041.2012.627277

Neville, F., Templeton, A., Smith, J. R., & Louis, W. R. (2021). Social norms, social identities and the COVID-19 pandemic: Theory and recommendations. Social and Personality Psychology Compass, 15(5), Article e12596. https://doi.org/10.1111/spc3.12596

Nguyen, H.T. Wiatr, T. Fernandez-Steeger, T.M. Reicherter, K. Rodrigues, D.M.M. Azzam, R. (2012) 'Landslide hazard and cascading effects following the extreme rainfall event on Madeira Island (February 2010)', Natural Hazards. Available at: https://doi.org/10.1007/s11069-012-0387-y

Nick, F.C. Wenzel, L. Wenzel, A. Kuhlicke, C. (2023) 'Collaborative disaster response to critical infrastructure: The case of the 2021 floods in Germany', International Journal of Disaster Risk Reduction, 91, p. 103710. https://doi.org/10.1016/j.ijdrr.2023.103710

Ni, M., Xia, L., Wang, X., & Pan, S. (2025). Psychological influences and implications for household disaster preparedness: A systematic review. International Journal of Disaster Risk Reduction. Advance online publication.

Ntontis, E., Drury, J., Amlôt, R., Rubin, G. J., & Williams, R. (2021). Community resilience and flooding in UK guidance: A critical review of concepts, definitions and their implications. Journal of Contingencies and Crisis Management, 29(1), 2–13. https://doi.org/10.1111/1468-5973.12310

Norris, F. H., Stevens, S. P., Pfefferbaum, B., Wyche, K. F., & Pfefferbaum, R. L. (2008). Community resilience as a metaphor, theory, set of capacities, and strategy for disaster readiness. American Journal of Community Psychology, 41(1–2), 127–150. https://doi.org/10.1007/s10464-007-9156-6

OECD. (2016). Trends in risk communication policies and practices. OECD Reviews of Risk Management Policies. OECD Publishing. https://doi.org/10.1787/9789264260467-en

OECD. (2023) Taming wildfires in the context of climate change: the case of Portugal. OECD Environment Policy Papers, No. 37. OECD Publishing, Paris. DOI: 10.1787/859bb47a-en.

Ortiz, G., Aznar-Crespo, P., & Aledo, A. (2024). Developing and pilot-testing warning messages for risk communication in natural disasters. Environment Systems and Decisions, 44, 239–258. https://doi.org/10.1007/s10669-023-09924-z

Pachur, T. (2024). The availability heuristic revisited: How media coverage and personal experience shape risk judgments. Psychological Review. Advance online publication.

Pachur, T., Hertwig, R., & Steinmann, F. (2012). How do people judge risks: Availability heuristic, affect heuristic, or both? Journal of Experimental Psychology: Applied, 18(3), 314–330. https://doi.org/10.1037/a0028279

Palma-Oliveira, J. M., Gaspar, R., & Mendes, J. M. (2017). Riscos: Da comunicação da resposta à resposta da comunicação. Riscos e Alimentos, 14, 7–20.

Palma-Oliveira, J. M., Trump, B. D., & Linkov, I. (2021). Why did risk communication fail for the COVID-19 pandemic, and how can we do better? In I. Linkov, J. M. Keenan, & B. D. Trump (Eds.), COVID-19: Systemic risk and resilience (pp. 195–208). Springer. https://doi.org/10.1007/978-3-030-71587-8_12

Panama Maritime Authority. (2023) Final Marine Safety Investigation Report: M/V 'Ever Given', R-026-2021-DIAM. Panama City: Panama Maritime Authority. Available at: https://gcaptain.com/wp-content/uploads/2023/07/Final-Investigation-Report-Ever-Given-23-March-2021.pdf

Parida, D., Moses, S., & Rahaman, K. R. (2021). Analysing media framing of cyclone Amphan: Implications for risk communication and disaster preparedness. International Journal of Disaster Risk Reduction, 59, Article 102272. https://doi.org/10.1016/j.ijdrr.2021.102272

Perfors, A., & Van Dam, N. T. (2018). Real-world decisions often involve "black swan" choices with extremely low probability chances of catastrophic loss. Proceedings of the 40th Annual Meeting of the Cognitive Science Society.

Pescaroli, G., Dryhurst, S., & Karagiannis, G. M. (2025). Bridging gaps in research and practice for early warning systems: New datasets for public response. Frontiers in Communication, 10, Article 1451800. https://doi.org/10.3389/fcomm.2025.1451800

Peters, E., Dieckmann, N. F., Dixon, A., Hibbard, J. H., & Mertz, C. K. (2008). Less is more in presenting quality information to consumers. Medical Care Research and Review, 64(2), 169–190. https://doi.org/10.1177/1077558707070640020301

Pidgeon, N., Kasperson, R. E., & Slovic, P. (Eds.). (2003). The social amplification of risk. Cambridge University Press.

PreventionWeb. (2025). Disaster risk communication and the psychology of preparedness. United Nations Office for Disaster Risk Reduction.

Pratson, L.F. (2023) 'Assessing impacts to maritime shipping from marine chokepoint closures', Communications in Transportation Research, 3, p. 100083. https://doi.org/10.1016/j.commtr.2022.100083

Proulx, G., & Sime, J. D. (1991). To prevent "panic" in an underground emergency: Why not tell people the truth? Fire Safety Science, 3, 843–852. https://doi.org/10.3801/IAFSS.FSS.3-843

Quarantelli, E. L. (1954). The nature and conditions of panic. American Journal of Sociology, 60(3), 267–275. https://doi.org/10.1086/221536

Qu, S. She, Y. Zhou, Q. Verschuur, J. Zhao, L-T. Liu, H. Xu, M Wei, Y-M. (2024) 'Modeling the dynamic impacts of maritime network blockage on global supply chains', The Innovation, 5(4), p. 100653. https://doi.org/10.1016/j.xinn.2024.100653

Rahn, M., Tomczyk, S., Schopp, N., & Schmidt, S. (2021). Warning messages in crisis communication: Risk appraisal and warning compliance in severe weather, violent acts, and the COVID-19 pandemic. Frontiers in Psychology, 12, Article 557178. https://doi.org/10.3389/fpsyg.2021.557178

Raue, M., Lermer, E., & Streicher, B. (Eds.). (2018). Psychological perspectives on risk and risk analysis. Springer. https://doi.org/10.1007/978-3-319-92478-6

Reicher, S. (1996). "The Battle of Westminster": Developing the social identity model of crowd behaviour in order to explain the initiation and development of collective conflict. European Journal of Social Psychology, 26(1), 115–134. https://doi.org/10.1002/(SICI)1099-0992(199601)26:1<115::AID-EJSP740>3.0.CO;2-Z

Reicher, S. D. (1984). The St. Pauls' riot: An explanation of the limits of crowd action in terms of a social identity model. European Journal of Social Psychology, 14(1), 1–21. https://doi.org/10.1002/ejsp.2420140102

Reicher, S. D. (1987). Crowd behaviour as social action. In J. C. Turner, M. A. Hogg, P. J. Oakes, S. D. Reicher, & M. S. Wetherell (Eds.), Rediscovering the social group: A self-categorization theory (pp. 171–202). Basil Blackwell.

Reynolds, B., & Seeger, M. W. (2005). Crisis and emergency risk communication as an integrative model. Journal of Health Communication, 10(1), 43–55. https://doi.org/10.1080/10810730590904571

Rhein, B. Kreibich, H. (2025) 'Causes of the exceptionally high number of fatalities in the Ahr valley, Germany, during the 2021 flood', Natural Hazards and Earth System Sciences, 25, pp. 581–589. https://doi.org/10.5194/nhess-25-581-2025

Ripley, A. (2008). The unthinkable: Who survives when disaster strikes — and why. Crown Publishers.

Ribeiro, L.M. Rodrigues, A. Lucas, D. Viegas, D.X. (2020) 'The impact on structures of the Pedrógão Grande fire complex in June 2017 (Portugal)', Fire, 3(4), 57. DOI: 10.3390/fire3040057.

Rogers, R. W. (1975). A protection motivation theory of fear appeals and attitude change. Journal of Psychology, 91(1), 93–114. https://doi.org/10.1080/00223980.1975.9915803

Rogers, R. W. (1983). Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation. In J. Cacioppo & R. Petty (Eds.), Social psychophysiology: A sourcebook (pp. 153–176). Guilford Press.

Rossi, R., Galla, M., Pasquinelli, M., & Taroni, F. (2018). Best practices on public warning systems for climate-induced natural hazards. Publications Office of the European Union. https://doi.org/10.2760/014409

San-Miguel-Ayanz, J. Oom, D. Artes, T. Viegas, D.X. Fernandes, P. Faivre, N. Freire, S. Moore, P. Rego, F. Castellnou, M. (2020) 'Forest fires in Portugal in 2017', in Casajus Valles, A., Marin Ferrer, M., Poljanšek, K. and Clark, I. (eds.) Science for disaster risk management 2020: acting today, protecting tomorrow, EUR 30183 EN. Publications Office of the European Union, Luxembourg, pp. 413–430. DOI: 10.2760/571085.

Samansiri, S., Fernando, T., & Ingirige, B. (2023). Critical failure factors of flood early warning and response systems (FEWRS): A structured literature review and interpretive structural modelling analysis. Geosciences, 13(5), Article 137. https://doi.org/10.3390/geosciences13050137

Sauer, M. A., Truelove, S., Gerste, A. K., & Limaye, R. J. (2021). A failure to communicate? How public messaging has strained the COVID-19 response in the United States. Health Security, 19(1), 65–74.

Sato, A. (2016) Nuclear Disasters and Risk Communication: Learning from Fukushima. UNU-IAS Policy Brief, No. 5. Tokyo: United Nations University Institute for the Advanced Study of Sustainability (UNU-IAS).

Schlumberger, J. Ferrarin, C. Jonkman, S.N. Diaz Loaiza, M.A. Antonini, A. Fatorić, S. (2022) 'Developing a framework for the assessment of current and future flood risk in Venice, Italy', Natural Hazards and Earth System Sciences, 22, pp. 2381–2400. DOI: 10.5194/nhess-22-2381-2022.

Sekiya, N. (2020) 'Chapter 3: Risk Communication for Radiation Hazards', in Final Report by Investigation Commission on the Fukushima Nuclear Accident. 10-year Investigation Commission on the Fukushima Nuclear Accident.

Shin, H.S. (2009) 'Reflections on Northern Rock: the bank run that heralded the global financial crisis.' Journal of Economic Perspectives, 23(1), pp. 101-119.

Shiroshita, H. (2020). Do developed countries learn DRR from developing countries? In K. Yamori (Ed.), Integrated disaster risk management (pp. 105–120). Springer. https://doi.org/10.1007/978-981-13-2318-8_7

Simon-Friedt, B.R. Howard, J.L. Wilson, M.J. Gauthé, D. Bogen, D. Nguyen, D. Frahm, E. Wickliffe, J.K. (2016) 'Louisiana residents' self-reported lack of information following the Deepwater Horizon oil spill: Effects on seafood consumption and risk perception', Journal of Environmental Management, 180, pp. 526–537.

Siegrist, M., & Árvai, J. (2020). Risk perception: Reflections on 40 years of research. Risk Analysis, 40(S1), 2191–2206. https://doi.org/10.1111/risa.13599

Simon, H. A. (1955). A behavioral model of rational choice. Quarterly Journal of Economics, 69(1), 99–118. https://doi.org/10.2307/1884852

Simon, H. A. (1956). Rational choice and the structure of the environment. Psychological Review, 63(2), 129–138. https://doi.org/10.1037/h0042769

Simon, H. A. (1957). Models of man: Social and rational. Wiley.

Sjöberg, L. (1998). World views, political attitudes and risk perception. Risk: Health, Safety & Environment, 9(2), 137–152.

Sjöberg, L. (2005). The perceived risk of terrorism. Risk Management, 7, 43–61. https://doi.org/10.1057/palgrave.rm.8240215

Slovic, P. (1987). Perception of risk. Science, 236(4799), 280–285. https://doi.org/10.1126/science.3563507

Slovic, P., & Peters, E. (2006). Risk perception and affect. Current Directions in Psychological Science, 15(6), 322–325. https://doi.org/10.1111/j.1467-8721.2006.00461.x

Slovic, P., & Weber, E. U. (2002). Perception of risk posed by extreme events. In Risk management strategies in an uncertain world. Palisades, NY: Columbia University.

Slovic, P., Finucane, M. L., Peters, E., & MacGregor, D. G. (2002). The affect heuristic. In T. Gilovich, D. Griffin, & D. Kahneman (Eds.), Heuristics and biases: The psychology of intuitive judgment (pp. 397–420). Cambridge University Press.

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1984). Behavioral decision theory perspectives on risk and safety. Acta Psychologica, 56(1–3), 183–203. https://doi.org/10.1016/0001-6918(84)90018-0

Smart, W. (2018) Lessons Learned Review of the WannaCry Ransomware Cyber Attack. London: Department of Health and Social Care/ NHS England.

Sowby, R.B. Porter, B.W. (2024) 'Water Supply and Firefighting: Early Lessons from the 2023 Maui Fires', Water, 16(4), 600.

Spahn, H. Hoppe, M. Vidiarina, H.D. Usdianto, B. (2010) 'Experience from three years of local capacity development for tsunami early warning in Indonesia: Challenges, lessons and the way ahead', Natural Hazards and Earth System Sciences, 10, pp. 1411–1429.

Stewart, I. S. (2024). Advancing disaster risk communications. Earth-Science Reviews, 249, Article 104677. https://doi.org/10.1016/j.earscirev.2024.104677

Stimpson, J.P. Srivastava, A. Tamirisa, K. Kaholokula, J.K. Ortega, A.N. (2025) 'Crisis Communication About the Maui Wildfires on TikTok: Content Analysis of Engagement With Maui Wildfire–Related Posts Over 1 Year', JMIR Formative Research, 9, e67515.

Stott, C., & Reicher, S. (1998). Crowd action as intergroup process: Introducing the police perspective. European Journal of Social Psychology, 28(4), 509–529. https://doi.org/10.1002/(SICI)1099-0992(199807/08)28:4<509::AID-EJSP877>3.0.CO;2-C

Sun, Y. (2020). New approaches toward tsunami risk preparedness in Japan. In K. Yamori (Ed.), Integrated disaster risk management (pp. 17–38). Springer. https://doi.org/10.1007/978-981-13-2318-8_2

Sundh, J. (2024). Human behavior in the context of low-probability high-impact events. Humanities and Social Sciences Communications, 11, Article 902. https://doi.org/10.1057/s41599-024-03403-9

Sutton, J., & Kuligowski, E. D. (2019). Alerts and warnings on short messaging channels: Guidance from an expert panel process. Natural Hazards Review, 20(2), Article 04019002. https://doi.org/10.1061/(ASCE)NH.1527-6996.0000324

Takenouchi, K. (2020). Collaborative community weather information. In K. Yamori (Ed.), Integrated disaster risk management (pp. 65–82). Springer.

Telford, J. Cosgrave, J. Houghton, R. (2006) Joint Evaluation of the International Response to the Indian Ocean Tsunami: Synthesis Report. London: Tsunami Evaluation Coalition.

Thieken, A.H. Bubeck, P. Heidenreich, A. von Keyserlingk, J. Dillenardt, L. Otto, A. (2023) 'Performance of the flood warning system in Germany in July 2021 — insights from affected residents', Natural Hazards and Earth System Sciences, 23, pp. 973–990. https://doi.org/10.5194/nhess-23-973-2023

Thieken, A.H. Kreibich, H. Müller, M. Merz, B. (2007) 'Coping with floods: Preparedness, response and recovery of flood-affected residents in Germany in 2002', Hydrological Sciences Journal, 52(5), pp. 1016–1037. https://doi.org/10.1623/hysj.52.5.1016

Thieken, A.H. Müller, M. Kreibich, H. Merz, B. (2005) 'Flood damage and influencing factors: New insights from the August 2002 flood in Germany', Water Resources Research, 41(12), W12430. https://doi.org/10.1029/2005WR004177

Tierney, K. J., Lindell, M. K., & Perry, R. W. (2001). Facing the unexpected: Disaster preparedness and response in the United States. Joseph Henry Press.

Tierney, K. Bevc, C. Kuligowski, E. (2006) 'Metaphors matter: Disaster myths, media frames, and their consequences in Hurricane Katrina', The Annals of the American Academy of Political and Social Science, 604, pp. 57–81. https://doi.org/10.1177/0002716205285589

Tippett, V., Greer, D., Mehta, A., Dootson, P., Bradley, L., Miller, S., & Murray, S. (2021). Towards protective action: Effective risk and warning communication during natural hazards—Final project report. Bushfire and Natural Hazards CRC.

Tupper, A., Fearnley, C. J., & Kelman, I. (2023). Translating warnings into actions: How we can improve early warning systems to protect communities. UCL Warning Research Centre. https://www.ucl.ac.uk/sts/sites/sts/files/ucl_report_-_translating_warnings_into_actions_april2023.pdf

Turner, J. C., Hogg, M. A., Oakes, P. J., Reicher, S. D., & Wetherell, M. S. (1987). Rediscovering the social group: A self-categorization theory. Basil Blackwell.

Tversky, A., & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. Cognitive Psychology, 5(2), 207–232. https://doi.org/10.1016/0010-0285(73)90033-9

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. Science, 185(4157), 1124–1131. https://doi.org/10.1126/science.185.4157.1124

UNDP. (2024). Communications guide for crisis or emergencies. United Nations Development Programme.

U.S. House of Representatives Select Bipartisan Committee (2006) A Failure of Initiative: Final Report of the Select Bipartisan Committee to Investigate the Preparation for and Response to Hurricane Katrina. House Report 109-377. Washington, DC: U.S. Government Printing Office.

United Nations Office for Disaster Risk Reduction, & World Meteorological Organization. (2023). Global status of multi-hazard early warning systems 2023. United Nations Office for Disaster Risk Reduction.

UK COVID-19 Inquiry. (2025) Modules 2, 2A, 2B, 2C: Core Decision-Making and Political Governance. Volume I: Introduction and Key Events from January 2020 to May 2022. Volume II: Key Themes, Lessons and Recommendations. Report by The Rt Hon the Baroness Hallett DBE. London: UK COVID-19 Inquiry.

Ulmer, R.R. Pyle, A.S. (2021) 'Finding renewal in the midst of disaster: The case of the deepwater horizon oil spill', Public Relations Review, 47(1), p. 102001.

Umgiesser, G. Bajo, M. Ferrarin, C. Cucco, A. Lionello, P. Zanchettin, D. Papa, A. Tosoni, A. Ferla, M. Coraci, E. Morucci, S. Crosato, F. Bonometto, A. Valentini, A. Orlić, M. Haigh, I.D. Nielsen, J.W. Bertin, X. Fortunato, A.B. Pérez Gómez, B. Alvarez Fanjul, E. Paradis, D. Jourdan, D. Pasquet, A. Mourre, B. Tintoré, J. Nicholls, R.J. (2021) 'The prediction of floods in Venice: methods, models and uncertainty', Natural Hazards and Earth System Sciences, 21, pp. 2679–2704. DOI: 10.5194/nhess-21-2679-2021.

van der Linden, S. (2014). On the relationship between personal experience, affect and risk perception: The case of climate change. European Journal of Social Psychology, 44(5), 430–440. https://doi.org/10.1002/ejsp.2008

van der Linden, S. (2015). The social-psychological determinants of climate change risk perceptions: Towards a comprehensive model. Journal of Environmental Psychology, 41, 112–124. https://doi.org/10.1016/j.jenvp.2014.11.012

Vávra, J. Lapka, M. Cudlínová, E. Dvořáková-Líšková, Z. (2017) 'Local perception of floods in the Czech Republic and recent changes in state flood management strategies', Journal of Flood Risk Management, 10(2), pp. 238–252. https://doi.org/10.1111/jfr3.12156

Verschuur, J. Koks, E.E. Hall, J.W. (2022) 'Ports' criticality in international trade and global supply-chains', Nature Communications, 13, p. 4351. https://doi.org/10.1038/s41467-022-32070

We Are Here Venice. (2020) Whose City Is It Anyway? A Report on the Position of Venice's Resident Population. Written by C. Smith and J. Da Mosto. Venice: We Are Here Venice. Available at: https://www.weareherevenice.org/wp-content/uploads/2020/07/Whose-city-is-it-anyway_digital_en.pdf

Webster, R. K., Brooks, S. K., Smith, L. E., Woodland, L., Wessely, S., & Rubin, G. J. (2020). How to improve adherence with quarantine: Rapid review of the evidence. Public Health, 182, 163–169. https://doi.org/10.1016/j.puhe.2020.03.007

Weichselgartner, J. (2005) 'Mitigating flood hazards: Lessons learned from the Elbe River flood 2002 in Germany', in Proceedings of the International Symposium on Urban-Rural Planning in Asian Mega-Cities, The University of Tokyo, Tokyo, Japan, 2 April, pp. 59–66.

Weyrich, P. (2020). To act or not to act: Warning communication and decision-making in response to weather-related hazards [Doctoral dissertation, ETH Zurich].

WHO Regional Office for Europe. (2024). Risk communication, community engagement and infodemic management in public health emergencies: Guidance for action. World Health Organization Regional Office for Europe.

World Health Organization (2021) Listings of WHO's Response to COVID-19. Geneva: WHO. Available at: https://www.who.int/news/item/29-06-2020-covidtimeline

Witte, K. (1992). Putting the fear back into fear appeals: The extended parallel process model. Communication Monographs, 59(4), 329–349. https://doi.org/10.1080/03637759209376276

Wood, E., & Miller, S. K. (2020). Cognitive dissonance and disaster risk communication. Journal of Emergency Management and Disaster Communications, 2(1), 1–18. https://doi.org/10.1142/S2689980920500062

Xue, K., Cao, S., Liu, Y., Xu, D., & Liu, S. (2022). Disaster-risk communication, perceptions and relocation decisions of rural residents in a multi-disaster environment: Evidence from Sichuan, China. Habitat International, 127, Article 102646. https://doi.org/10.1016/j.habitatint.2022.102646

Xue, W., Hine, D. W., Loi, N. M., Thorsteinsson, E. B., & Phillips, W. J. (2014). Cultural worldviews and environmental risk perceptions: A meta-analysis. Journal of Environmental Psychology, 40, 249–258. https://doi.org/10.1016/j.jenvp.2014.07.002

Yamori, K. (2020b). Pitfall of disaster information. In K. Yamori (Ed.), Integrated disaster risk management (pp. 1–15). Springer. https://doi.org/10.1007/978-981-13-2318-8_1

Yamori, K. (Ed.). (2020a). Integrated disaster risk management. Springer. https://doi.org/10.1007/978-981-13-2318-8

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. https://doi.org/10.1080/01292986.2021.2007274

Zezere, J.L. Pereira, S. Tavares, A.O. Bateira, C. Trigo, R.M. Quaresma, I. Santos, P.P., Santos, M. and Verde, J. (2014) 'DISASTER: A GIS database on hydro-geomorphologic disasters in Portugal', *Natural Hazards, 72*(2), pp. 503–532. Available at: https://doi.org/10.1007/s11069-013-1018-y

Zezere, J.L. Pereira, S. Tavares, A.O. Quaresma, I. Santos, P.P. Santos, M. Verde, J. Andrade, A.I. Costeira, R. Oliveira, S.C. (2020) 'Material damage caused by high-magnitude rainfall based on insurance data: comparing two flooding events in the Lisbon Metropolitan Area and Madeira Island, Portugal', *International Journal of Disaster Risk Reduction, 48*, p. 101567. Available at: https://doi.org/10.1016/j.ijdrr.2020.101567