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Conceptual Paper

**Rethinking Communication in Risk Interpretation and Action**

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## **Rethinking Communication in Risk Interpretation and Action**

Shabana Khan, Jyoti L Mishra, Kuna-hui Elaine Lin & Emma E H Doyle

**Abstract:** Communication is fundamental to the transfer of information between individuals, agencies, and organizations, and therefore, it is crucial to planning and decision-making particularly in cases of uncertainty and risk. This paper brings forth some critical aspects of communication that need to be acknowledged and considered while managing risks. Most of the previous studies and theories on natural hazards and disaster management have limited perspective on communication, and hence its implication is limited to awareness, warnings, and emergency response to some selected events. This paper exposes the role of communication as a moderator of not just risk interpretation and action but also various factors responsible for shaping overall response, such as individual decision-making under uncertainty, heuristics, past experiences, learning, trust, complexity, scale and the social context. It suggests that communication is a process that influences decision-making in multiple ways, and therefore it plays a critical role in shaping local responses to various risks. It opens up the scope for using communication beyond its current use as a tool to manage emergency situations. An in-depth understanding of ongoing communication and its implications can help to plan risk management more effectively over time rather than as a short-term response.

Key words: Risk, Communication, Uncertainty, Trust, Heuristics, Experience

### **1 Introduction**

Risk communication plays a central role in making decisions; however, it is a complex process that can lead to severe consequences if poorly managed (Dawson & Johnson, 2014). Despite its noted relevance and significance, only a few studies focus on the risk communication with a limited scope for implementation, particularly in the field of natural hazards and disaster research. Many dominant models of hazards and disaster response, such as the hazard and resource model (Burton et al. 1978), pressure and release model of vulnerability (Wisner et al. 1994; 2003), place-based vulnerability (Cutter et al. 2003) or Risk Interpretation and Action (Eiser et al. 2012) do not include communication as a key factor influencing hazard or disaster response. The ongoing use of communication in managing risks and disasters is mainly in the form of an instrument for managing information flow, building awareness, disseminating warnings and generating an emergency response (Mackie 2009, 2013; Sharma and Patt 2011; Netten and van Someren 2011). The narrow perspective viewing communication as a subordinate or a tool belonging to other relevant factors has hindered the possibility to conceptualize communication in disaster management theories.

The more recent conceptual framework of Risk Interpretation and Action (RIA) by Eiser et al. (2012) notes communication as a means to achieve an outcome wherein risk interpretation and action inform policy and public engagements. While the RIA recognizes the importance of communication, it doesn't present a comprehensive understanding of communication as it does for other indicators such as trust, learning, or experience that affect risk interpretation and action. Instead of the instrumental interpretation and common usage of risk communication as discussed in the current literature, this paper proceeds to propose that communication has its specific meaning at the normative and conceptual level that significantly influences risk interpretation and responses. It is a subject and has multi-functionality that underpins all disaster management processes. It can fundamentally shape risk interpretation, affect action, modify various underlying factors that impact perception, and can also influence lateral forces that govern risk communication. Enhancing a full understanding of its multi-functionality is now essential to understanding complex disaster situations arising in the face of climate change. This paper looks into some of the critical questions of hazard response through the lenses of communication, such as, why do most people within a community fear the same risk when they may have never experienced such risk at a personal level? In which ways, and to what extent, can communication influence various factors of risk perception and actions? The paper reviews the role of communication on various factors identified in the RIA framework, such as, individual decision-making under uncertainty, heuristics, experience, learning, trust, scale, complexity, and social-cultural context, to establish the significance of communication in shaping these factors and hence modifying both perception and response to varied risks. It draws its finding from a detailed review of the literature on natural hazards, disasters, climate change and risk communication.

### **2 Risk Communication: Conceptual Background**

Derived from a Latin word "communicare" which means to care and to share, and a process that has a joint action as its purpose, communication means sharing visions, objectives, attitudes, knowledge, information and opinions (Abarquez and Murshed 2004, p.96). Risk communication, on the other hand, is defined as "an interactive process of exchange of information and opinion among individuals, groups, and institutions, often involves multiple messages about the nature of risk or expressing concerns, opinions or reactions to risk messages or to legal and institutional arrangements for risk

management” (USDHHS 2002 p.4).

The understanding and purpose of risk communication, however, are not consistent across various fields of knowledge and practices. The studies focused on healthcare, where communication of risk is a day-to-day concern, explore its significance in detail (Robinson 2002, Edward 2003, Walsh et al. 2009, Bradford et al., 2017). The literature notes that despite an initial focus on reducing potential damage, risk communication has gained importance as a need arising from increasing patient autonomy and the right to information which not only allows a population to make its choices but also helps to raise public participation in risk reduction (Edward 2003). The National Cancer Institute enlists a detailed outline of what communication can or cannot do, wherein it notes that while communication cannot compensate for inadequate opportunities, services, and gaps in technology and policies, it can apparently add to or reinforce knowledge, influence perception, prompt action, illustrate skills, advocate for policy, change myths and misconceptions, strengthen organizational relationship and can aid sustained change in risk-related behaviors and overcome barriers (National Cancer Institute n.d.). Apart from its diverse uses, the nature, benefits, and repercussions of various communications have also been explored (Walsh et al. 2009; Grigoriev 2012). Risk communication models used in this field also recognize the role of perception based on external circumstances, heuristics, uncertainty, and trust in the information provided (Mebane 2005), however, those models do not explore how risk communication itself influences these critical factors. Infanti et al. (2013) note that risk communication is central to the risk management cycle (Fig 1). They highlighted that risk communication is necessary for identifying a hazard risk analysis, developing, implementing and evaluating policies.

Fig 1: Risk Communication in Risk Management Cycle.



Source: Infanti et al. 2013, p.6

Mass communication is another field where risk communication is a routine task. Media often acts as a bridge between research output and public perception when communicating the risks (Regain 2009). The role of media in risk communication varies in several ways including (i) minimum involvement limited to reporting the facts (ii) presenting facts in a certain way to influence people’s perception, (iii) generating public attention for a certain issue of its own and (iv) encouraging risk response by proposing solutions (Lundgren and McMakin 2009, p.207). The research is limited on why and how the media should report risk communication (Mebane 2005). The media is frequently accused of issues relating to confusion, misinterpretation, hype, sensationalism or underplay of risk communication (Otway et al. 1988; Sandell et al. 2013). Studies reveal that there is a direct relation between how risks are framed and their impact on public behavior which makes it essential to incorporate media into comprehensive communication planning (Sandell et al. 2013).

The recent gain in the popularity of risk communication is attributed to its increasing relevance and a need observed in the face of imminent global threats of climate change (Khan and Kelman 2011). Climate change communication has changed overtime from convincing people about climate change to encouraging them to adopt practical measures to address the issue by raising awareness, providing information, attending concerns and supporting response (Nerlich et al. 2010). Active participation of stakeholders in this field has provoked the usage of a variety of communication channels and media including text, speeches and talks, images, films, and documentaries (Doyle 2007; Nerlich et al. 2010; Khan and Kelman 2011). However, the emphasis of communication here remains limited to its use as a tool rather than as a process that has also shaped the issue of climate change across the globe.

The evolution of risk communication in the context of natural hazards and disasters began to formalize in the 1980s (Kasperson 2005). As in other fields, in the domain of disaster management, risk communication has been understood as information provision or making people understand scientific information, and henceforth often argued to be inadequate to deal with emergencies (Ropeik 2008). It is understood as a synonymous for public awareness and public education (Abarquez and Murshed 2004). Most studies have focused on communication as one-way information flow for forecasts, warnings, false alarm or disaster messages (Mackie 2009, 2013; Sharma and Patt 2011; Netten & van Someren 2011; Chen et al. 2008; Barnes et al. 2007; Broad et al 2007; Mileti et al. 2006). Against such limited uses, recent studies have begun to identify multidimensionality of communication beyond its traditional understanding. For example, the effectiveness of communication has also been argued for when it is seen as a process of dialogue or interactions rather than instructions or information provision for public awareness (Ropeik 2008). It is also found to be distinct from public awareness due to its reciprocal nature when different stakeholders discuss, accept and decide to take action for risk (Skinner and Ramprasad 2014). Sheppard et al. (2012) also note a gap in theory and depicted varied dimensions of risk communication and identified distinct risk communication in the domain of preparedness, response, and recovery. However, application of such an elaborated version of risk communication is found limited. While the source, medium, and dimensions of communications have been noted and exploited for disaster warning, preparedness and recovery, there has been less exploration of how communication is influencing the formation of risk perception and response in different stakeholders including scientists, people, emergency managers and so on (Hale, Dulek and Hale 2005).

### **3 Risk Communication: Risk Interpretation and Action**

The Risk Interpretation and Action (RIA) framework (2012), developed under the umbrella of Integrated Research on Disaster Risk (IRDR), discusses factors such as personal experience, feelings, values, cultural beliefs and interpersonal and societal dynamics, and explores how these factors would affect personal interpretation and action taken when facing natural hazard risks (Eiser et al. 2012). The framework identifies individual decision making under uncertainty, heuristics, experience, learning, trust, scale, complexity, and social-cultural context as the main factors that influence risk interpretation and action that subsequently inform risk communication. The RIA framework is a benchmark that intends to go beyond the traditional rational model (mostly based on the cost-benefit analysis) and rather notices the role of communication in informing policy and decision-making. However, it does not address communication as ‘a factor’ that influences risk interpretation or actions. Moreover, there is a limited discussion on how risk communication would interact with the other related factors or intermediate the effects of the factors on risk interpretation and action. The following paragraphs establish the significance of communication in shaping the factors mentioned above, and hence modifying both perception and response to various risks.

#### **3.1 Communication and individual decision-making under uncertainty**

While the uncertainty of an event depends on various environmental factors, individual decision-making around uncertainty is frequently affected by how risks are being communicated or informed to an individual (Sandell et al. 2013). Sandell et al. (2013), in their case study of 2009 H1N1 pandemic, observed a significant difference in the uptake of immunization between Sweden (60%) and Australia (18%) and attributed this to how media framed the pandemic messages regarding responsibility, self-efficacy, and uncertainty. Studies note that interpretation of loss and gain are not absolute and simply by using different reference points in a verbal description, a decision maker’s preferences could be altered (Kahneman and Tversky 1979; Eiser et al. 2012). Distortions in the understanding of uncertainty also arise from varied interpretations and responses to incomplete information. Simon (1955; 1992) notes that as people are ‘rationally bounded,’ they don’t analyze all available information for opting the best course of action; instead people will analyze only a few most appropriate options and decide that is often termed as “satisficing.” It thus manifests the need to review the multidimensionality and uncertainty of the information that is communicated. For example, attributes of risk communication, such as information overload, incomplete information, the omission of relevant information (Andrienko and Andrienko 2007, Schraagen and van de Ven 2011), or lack of time (Comfort et al. 2001) can have an adverse effect on individual decision-making.

Apart from the nature of risk communication, individual perception of uncertainty is also affected by the source and mode of communication. It is noted that inability to use normal channels of communication during crisis management can also delay or hamper individual decision-making (Hale et al. 2005). Equally important is the level of engagement of various actors. Schraagen and van de Ven (2011) emphasize that one-way risk communication leads to barriers of response either due to misinterpretation or due to limited capacity, which is not fully communicated. On the other hand, an uncertainty underplayed by key stakeholders or political leaders is likely to receive less attention from the society. An individual thus not only has to take a decision on the uncertainty arising from the risk characteristics but also to the added uncertainty attributed to poor and inconsistent risk communication.

Meanwhile, it is also important to note that an individual is not just informed by the government or media for his/her risk exposure but also by his family, neighbors, and friends who may or may not be adequately informed. Thus, risk communication needs to be designed with much more attention to the understanding of the existing interpretation of hazards and local capacity to grasp information such that they can be guided to a better and accurate response. The aim of risk communication thus is not just to accurately inform people by using certain media but also to influence the existing perception, which itself is an outcome of prevailing risk communication. Lipshitz et al. (2006) also argue for the inadequacy and ignorance of the laboratory studies in decision-making to understand a dynamic situation that overlooks the effects of communication in the real world. Hence, it is not just essential but paramount to see how communication is shaping both interpretation and response to the uncertainty of risk.

### **3.2 Communication and Heuristic**

Heuristics or mental shortcuts provide the quickest connection between risk interpretation and action. Various kinds of heuristics, including affect heuristics, availability heuristics, and representativeness heuristics, directly impact the way risks are perceived and responded to (Ropeik 2009). People respond to uncertainty using a range of heuristics (Tversky and Kahneman 1973, 1974; Slovic et al 2000) – including a complacency to only expect the experienced, making people insensitive to changing risks (normalization bias, Mileti and O'Brien 1993). Risk communication can be underlined in all kinds of heuristics in the sense that people have been communicating risks, and making decisions around it for generations. Both the positive and negative connotation of risks, availability of information around certain risks, and understanding uncertainty in a certain way is communicated to them overtime, which leaves a mental impression that guides their response in the face of varied hazard exposures. The different perception and response to risks in urban and rural environments are partly attributed to the varied information and local ongoing risk communications that results in affect, availability and many cases representative heuristics.

In theory, heuristics have been studied for judgment bias partly attributed to bounded rationality or cognitive error, as well as choices coming from either conscious or subconscious domain of mind (Kim 2013). In this sense knowing about the role of heuristics in risk interpretation and action can be used for the efficient design of risk communication. Communication research has used heuristics in various contexts including in the domain of finding “cues”, heuristics in web searching, consumer behavior or political judgment over an issue (Kim 2013). Further, the use of designing risk communication based on heuristics cannot be denied, but this is assessed more carefully for risks relating to health such as HIV AIDS (Bennett et al. 2007). However, the practice of designing risk communication based on heuristics for natural hazards is found limited.

The literature gap is clear for studies looking into the influence of communication in building certain heuristics. The effect of risk communication can be seen clearly on availability heuristics for earthquake awareness and preparedness in New Zealand. Khan et al. (2012c) note that due to regular risk communication for earthquake preparedness, a relatively high awareness, and preparedness is recorded for this hazard throughout the Wellington Region despite local variations in the earthquake susceptibility, which was not the case for the other risks. Thus, understanding the general risk communication and heuristics in the society can help to design and modify new risk communication that is informed about the local hazardscape as well as by the latest scientific findings for a better response.

### **3.3 Communication and experience**

Sharma and Patt (2011) in their review of the effect of past hazard experience on responses to warnings outline that there has been a significant discrepancy to date as to what defines or constitutes ‘experience’; whereas personal experience is classified as anything from being a witness of a major event to suffering substantial losses. A majority of studies consider only one ‘type’ of experience (i.e. whether an individual experiences hazard impacts or not) and do not consider multiple, or nested experiences (e.g. Haynes, Barclay and Pidgeon 2008; Paton et al. 2001; Lindell and Prater 2000; Dooley et al. 1992). Sharma and Patt (2011) define four types of experience when accessing people’s perceptions of cyclone warnings and future compliance i.e. overall cyclone experience, past impact experience, prior warning experience and previous evacuation experience. In contrast to thinking of experience of disasters as a whole, it is clear that there are many levels and scopes of experiences. It is not just a positive or a negative experience, but the nested experiences that would diversify the ways that people constitute ‘experienced’ and learn what to do in response to a (future) communication.

Communication of experiences also widens the scope mattering what can be shared or included in the communication. A careful examination of whose experience is communicated to whom is thus needed (Kasperson, Golding and Tuler 1992). Risk experience appraisal plays an essential role in motivating people to take adaptive action against climate

change (Grothmann and Patt 2005). It is important to note that tailoring communication must be cognitive of the experiences of the audience, not just about their experience of the hazard but about their experience of past communications. The experience of a communicator also affects the perception of current risks and future communications in the context of hazards (Broad et al. 2007; Regnier 2008). The temporal aspect of experience also needs to be considered. For example, the problem with landholders prioritizing short-term effects is that they often lack the experience and/or knowledge to make informed decisions that weigh up long-term as well as short-term consequences (Eriksen and Gill 2010, p.823). It is also noted that superimposition of personal knowledge or experience over the scientifically issued statements may lead to erroneous perceptions of hazards, which can be costly in terms of lives lost, infrastructural damage and loss of reputation (Doyle, McClure, Johnston and Paton 2014). Therefore, it is vital to assess communication about existing experiences for effective response.

### **3.4 Communication and Learning**

In recent years, there has been a significant rise in the literature on social or community learning in the field of environmental governance, risk management, climate change and related issues. Learning is a dynamic process, and it is frequently modified by communication. Various kinds of learning discerned in the literature, such as associative learning based on observations of events that co-occur, and instrumental learning based on observations of the consequences of our own or other's behaviour (Eiser et al. 2012), the outdoor and experiential learning (Dickson 2000), grassroots learning (Jabeen, Johnson and Allen 2010), participatory learning (Hordijk and Baud 2011), social learning (Lebel 2009), collaborative learning (Walker, Daniels and Emborg 2008) or multi-level learning (Pahl-Wostl 2009), either include communication as part of the process or get influenced by the existing communication. In all kinds of learning, communication is noted to play a major role in the development of mind and the way knowledge is transferred over generations and space (Wigfross 1999). Thus, learning can be enhanced through an effective communication channel. For example, the Community Learning Empowerment and Resources (CLEAR) global consortium project launched by the City of Bath College aims to organize training and education resources available in cyberspace and facilitating their use as learning channels, taking advantage of the innovations in information and communications technology to enhance the quality, scale, diversity and economy of education and access (Edward 1996).

A thoughtful title of an editorial by Edwards (2003) states that 'communicating risks means patients need to learn to live with uncertainty', which signifies that communication can trigger learning. Various forms of learning at the group or community level mainly involve communication of different kinds. Both verbal and non-verbal communications play a significant role in learning. Verbal communications are used more frequently orally, such as by using early warning systems and news media (television), in writing, such as printed or electronic message including e-mails and the internet, or visually through posters and presentations. On the other hand, non-verbal communication (Fessenden-Raden et al. 1987), although acting passively, enriches and informs people about various risks. For example, traffic signals, body language, and other gestures, often guide people about danger, due to learning over time. Communication, formal or informal, may explicitly or implicitly influence community learning. For example, consultations, meeting, and debates are noted to be an important part of the process of developing outdoor education and learning (Dickson 2000). Communication thus benefits learning in multiple ways. Enhancement of social learning both in terms of level (conceptual understanding) as well as extent (interconnections between various issues) is possible by effective communication. Communication can also highlight learning needs and gaps that can make learning more efficient. It is noted that often the lessons not learned or taken into account are the result of inconsistent and unclear communication patterns and messages. It is thus important to evaluate how the messages, signals, information or knowledge are communicated in the various modes of the learning process. Besides, through analyzing past events, lessons for successful communication, advice provisions, and distributed decision-making can be learned (Doyle et al 2011).

### **3.5 Communication and Trust**

Trust is widely identified as essential element in social interactions. Kasperson, Golding and Tuler (1992) noted that the social importance of trust stems in large part from its contribution to cooperative behavior and information flow, but its concept is rarely well defined or characterized. For example, Rempel and Holmes (1986) defined trust as the degree of confidence you feel when you think about a relationship. Renn and Levine (1991) defined it as the generalized expectancy that a message received is true and reliable and the communicator demonstrates competence and honesty by conveying accurate, objective and complete information. In reviewing some research papers, Kasperson, Golding and Tuler (1992) progressively concluded that trust needs to be seen as a social phenomenon, composed of multiple dimensions, each possessing distinct cognitive, affective, behavioral and situational manifestations. Thus they proposed to conceptualize three different types of trust including cognitive trust, emotional trust, and behavioral trust.

Trust plays a major role in risk interpretation and action. "If trust is low, fear is likely to be higher and vice versa"

(Ropeik 2009, p.5). Who trusts whom and when, and how the messages are received depends on prior belief and/or the faith system that underlines previous risk communication and its effectiveness (Eiser et al. 2012). The RIA framework also notes that communication can be used as a way to improve trust. It indicates that trust develops through empowerment which may depend on interactions with agencies which are responding to community needs (behavior trust), which may then influence trust beliefs (emotional or cognitive trust), which mediates the intended outcome and response (Eiser et al. 2012). On the contrary, incompetent performance, keeping secrets and inconsistent information can destroy trust as noted in officials' behavior in case of nuclear and radiological events (Ropeik 2008). Competing for languages of communication – managerial, pluralist and communitarian – between government, market, and democracy, further add to misunderstanding and mistrust that impacts response (Halfacre et al. 2000).

On the other direction of the loop, trust is also found to impact communication (Manoj and Baker 2007), in terms of duration, understanding, and sharing of information. The effectiveness of risk communication also depends on who is communicating risk and how much people trust the competency and honesty of the agency and source (Ropeik 2009). It is noted that successful risk communication relies on aspects of mutual respect and trust between the concerned bodies, where trust is not just a function of care and competence but also an integral part of credibility (Edward 2003). Thus risk communication is likely to be more effective if delivered in a trustful environment, and at the same time, trust can further strengthen through providing consistent, accurate and efficient risk communication.

### **3.6 Communication, complexity, scale and social context**

A range of complexities partly attributed to the nature, sources, and channels of information and communication surround risk interpretation and decision-making. Kerr and Tindale (2004, p.489) note that decisions are to be made when the environment is changing, and the decision maker is 'obtaining information about it.' Lagadec (2004) highlighted that emergency managers have lost their monopoly as the public is informed through various channels including television, social media, and the Internet. It often puts decision makers under pressure to act fast and do something. Such actions, if they remain uncoordinated, add to the complexity of the existing situation. It is particularly noted in a disaster relief situation when more than one agency brings the same relief far beyond the needs that are not required and hence the materials are thrown away. Inadequate communication in this case not only results in the wastage of resources and dumps in the local environment but also fails to address residents' needs resulting into a prolonging of suffering.

Communication of such complexity is usually not a straightforward task. Uncertainty often results in dependence on others for information where others can be government agencies or fellow community members who may share or contest for their interest and values (Eiser et al. 2012). Different worldviews often conflict when communicating a risk to diverse stakeholders. Interconnections of environmental and human activities create different vulnerabilities over space and time that require not only an understanding of dominant groups of processes but also a shared understanding among stakeholders, some of whom may have conflicting views or interests depending on their understanding and access to information (Eiser et al. 2012).

The scale of risk, either spatial, temporal, or both, further complicates perception and decision-making. It has been questioned whether large-scale disasters cause more damage and have a larger impact on people, or the local and often unreported disasters cause more damage when their impacts are aggregated (La-Red et al. 2002; Lewis 1984). These risks, if communicated as interconnected (including those from climate change), could help people to see the relationship between their actions and vulnerability and thus they can make changes accordingly (Khan and Kelman 2011). Acceptance of the impact of climate change is found low at the local level as it meant, people need to change their behavior or livelihood and invest in some aspects that they currently don't see any impact on them (Nerlich et al. 2010). It is noted that downscaling of information relating to global issues including uncertainty from climate change is essential for public acceptance, participation and response (Shaw et al. 2009). However, such information also needs to be communicated by taking the account of the local socio-economic context in order to be fully accepted by the local people.

The complexity is further added by changing cultural practices, social values, and uncertain behavioral patterns over time and space. Abarquez and Murshed (2004) note that communication is a dynamic process, in which people simultaneously act as both source and recipient; however, their understanding would differ as per their individual characteristics and the social context. Social-cultural contexts play a very important role in how risk communication is received and responded to (Infanti et al. 2013). The perception of risks from various hazards have been noted to differ between minorities and a dominant group, men and women, children and elderly, the locals and migrants and so on (Khan 2012a; Infanti et al. 2013). Various social, cultural and institutional factors also act as impediments to risk communication (Kasperson, 2005). As communication takes place within a socio-cultural context, messages may be



interpreted differently across communities. Literature frequently notes that some cultures are more fatalistic than others, wherein the fatalistic attitude is underpinned by religious or spiritual beliefs of various kinds (Eiser et al. 2012). These cultures or communities do not form with the groups of some individuals but develop through their interaction and communication resulting in different social systems, which can be responsible for both their vulnerability and resilience (Eiser et al. 2012). The cultural differences don't necessarily arise from the similar experience of all individuals within a particular social context, but also out of their communication over a period with each other. Communicating such differences, gaps and opportunities can help to modify both risk interpretation and action. Hyvärinen et al (2015) emphasized that while the importance of involving local people in emergency response is widely recognized, its implementation is often fragmented due to a lack of structural attention and communications that can include a wide range of emergencies and applications of regional and cultural specific approaches adapted to local needs. Due to the reciprocal nature of communication, which includes multiple perspectives, decisions, and actions around risk, risk communication is noted to carry a political significance that ensures agreement and brings transparency (Skinner and Rampersad 2014). It means that communication needs to penetrate all of these mentioned complexities and must be empowered by the political power to make a difference at the local level.

#### 4 Discussion

The above section (3) has outlined the vital role that communication plays in each of the RIA factors: individual decision making under uncertainty, heuristics, decision making and experience, learning, trust, complexity, scale, and the social context. Thus communication can shape or alter existing risk interpretation and action either directly through awareness or warning or indirectly by impacting the factors that shape risk perception and response.

This concept of communication influencing risk interpretation and action is not novel. Ropeik (2008) defines risk communication "as actions, words and other interactions that incorporate and respect the perceptions of the information recipients, and intend to help people make more informed decisions about threats to their health and safety (p.59)." Further, the influence of communication on risk interpretation and action has been noted both in time and space. Coppola and Maloney (2009) noted that the nature and degree of risk understood and actions taken are shaped not just by the recent information provision by the government but also by the wide range of other sources and risk messages and their associated influences that are, "risk communications" that the local community is exposed to. On the other hand, influences of communication over space are clear in the distinct perceptions and responses to hazards in distant and disconnected communities, in contrast to increasing interactions between nations that has led to the globalization of disaster response (Khan 2012b).

While, the role of communication is acknowledged in the literature for its influence on risk interpretations and actions (Eiser et al. 2012; Mackie 2009, 2014; Sharma and Patt 2011; Netten and van Someren, 2011), less attention has been paid to looking at how communication is shaping risk interpretation and action that is giving a certain nature to a response, including using communication as a tool for awareness or warning. This can be seen as a vital reason for missing link of communication in the dominant hazards and disaster models that talk about risk perception and response. Having communication as an explicit factor in such models, including that of RIA (Eiser et al 2012) will not only lead one to understand its role in various perceptions and responses, but can also guide research to address gaps that arise from varied impacts of the other factors in generating certain interpretations and actions.

In between the overlapping impacts of these factors, the presence of communication is easy to note either as an underlying unmitigated or as a superimposed defining factor of perception and response. For example, in contrast to a common perception that decision-making is based on a rational choice, it is frequently noted that in a risky and uncertain environment such as that of disaster, people opt for naturalistic decision-making (see Klein 1998), which is based on past experience (Mishra, Allen and Pearman 2015). If there have been false alarms in the past, the public may not be willing to comply with the instructions communicated by officials (Anderson 1969). Here the influence of previous ongoing communication takes over the ineffectiveness of an alarm system. The superimposed nature of risk communication, on the other hand, is rather more emphasized in disaster mitigation and sustainable development goals, which emphasizes on including the vulnerable groups in planning to have their needs be addressed and voices being heard. More, recently, directives have been made by the European Commission to engage citizens for risk management (Wehn, Rusca, Evers and Lanfranchi, 2015) - a mode of engagement that could establish trust and related learning experience between both parties through communication.

The significance of communication emerges stronger in the background of poorly addressed communication. An example of ineffectively addressed communication can be found from the Mann Gulch wildfire in 1949, where 13 firemen were killed, and only one fireman, a foreman named Dodge and ranger survived the fire. The order was to

throw away just their packs and heavy tools, but despite this clear command some of the firemen had already thrown away all their equipment, while others didn't abandon their heavy tools (Weick 1996, p.304 cited in Maclean 1992, p.73). As Weick stated, there can be several reasons why people may not drop their tools even after the senior's order, i.e., not being given clear instructions, lack of trust, and complexity of the situation. Communication influences all of these factors as seen in the previous section and hence can be used to resolve these issues to a significant extent.

As noted before the nature of communication plays a crucial role in learning. It is important to ensure that trust is established during the training provided for disaster preparedness and response, between officials and citizens, so that information provided are readily accepted to make quick decisions. Moreover, this type of communication can build a sense of community, which can make people resilient. People learn from their past experience and also from other's experiences. Making videos or reports available, of how things worked better in the past, might help in educating towards effective decision-making. The multiple aspects of risk communication demand it to be an ongoing, long-term and creative process that requires comprehensive planning to be effective (Coppola and Maloney 2009).

Much of the theory and responses are based on the communication of varied experiences. If one were to explicitly focus on both communication and experience about natural hazards decision-making, then building on the model of Sharma and Patt (2011) as discussed in section 3.3, we could define four categories related to natural hazards and communications that influence further interpretation and action for a disaster. These can include communication of hazard experiences, communication of impact experiences, communication of an experience of past communications and communication of experiences of decision-making. Communication in the third category would not only include the experience of warnings but also encompass various other types of communications, such as preparedness messages, advice, recovery messages and so on. Also in the fourth category, communication of decision-making experiences refers to both an individual's experience ("I decided to do this") and experience externally imposed ("they decided that we should do this"). It brings out a bigger scope that links the experience hierarchies with cognitive heuristics. Sharma and Patt (2011) noted that experience about the credibility of past messages is likely to affect response to future warnings (e.g. affect heuristics). The experience of one place can be used to inform effective communication at other places e.g. learning from the development of 'best preparedness practices' utilizing experiences in New Zealand and elsewhere (e.g. availability heuristics) (Burgelt, Johnston and Paton 2009). Thus, the importance of past experience not only exists in how it would be saved and judged as positive or negative but also exists in how it would be internalized to form heuristics that would influence future communication and action to risk.

Given the inherent uncertainty in the information and interpretation of the information by different actors, it is vital to stimulate a flexible mechanism to allow sufficient mutual communication and information or knowledge transfer among the actors in the dialogues. Communication should address and respect the fact that varied interpretations exist and interact within the community that defines and shape response and actions taken in relation to uncertainty. It would encompass the target and mode of communication that includes public-oriented and public-science communication that would develop from uni-directional or persuasive communication to plural and multi-directional communication systems, as well as the function of communication on developing and influencing communities' risk interpretations and subsequent actions.

With the emergence of information technology and associated development, now multiple channels of communication have opened up that can ensure a more regular engagement with people as well as expertise. For example, during wildfires in California the American Red Cross used Twitter to disseminate information for preparedness (Fearn-Banks 2011). Similarly, during the Tsunami in December 2004 in Asia, victims were quicker to distribute information using different social media sites than officials (Samarajiva 2005). Although the use of social media can be quicker, there can be trust issues as chances of spreading the rumor (Oh, Agrawal, and Rao 2013) is unavoidable. Future research should explore how social media, including big data, could be used effectively to communicate, disseminate and use information on risks. At the same time, a larger population in developing countries lack education and basic infrastructure, so it is paramount that the success of risk communication is not just based on the hype created on social media which actually represents a small fraction of the larger population exposed to risk. It is therefore vital to use an appropriate channel in different social contexts.

Communication does not only play a basic role in information transfer or public awareness but also governs the way information is understood and responded to. Studies and practices have noted that risk misinterpretation and anomalies in risk behaviors can be improved through effective risk communication (Coppola and Maloney 2009). Further, evidence suggests that one-way information flow has failed to produce the desired result in terms of response to disasters. Hence it is valuable to place emphasis on interactive communication at different stages of hazard response, as well as to note the influences of such communications. Addressing communication explicitly is crucial not just for an effective response to a certain disaster event but for understanding and responding to irregularities in perception and

response to environmental risks for a sustainable future.

RIA has certainly opened up new pathways. Since its publication in 2012, the RIA framework has been utilized and built upon by a number of researchers (e.g. Bradford et al., 2017; Mora et al. 2015). The key to Eiser's RIA framework is the need to move beyond 'rational choice' models and consider how people's interpretations of risk reflect their experience, feelings, and bias. This need to move beyond 'rational' models is supported by the research of Doyle et al. (2014) and McClure et al. (2014), where people's interpretations of forecast likelihood statements were found to be not 'rational' as they are influenced by prior experience and knowledge of phenomena as well as cognitive biases. When considering the nature of uncertainty itself, Sword-Daniels et al. (2016) build on Eiser et al. (2012) by examining how uncertainty not only lies in cause and effect, but also lies within processes. Through this they demonstrate how "uncertainty is experienced, internalized and becomes embedded within decision-making and social norms over time" (p. 2), and highlight the need for greater recognition of uncertainty as a subjective embodied experience that is distinguished from objective uncertainty by the very nature of this individual internalization. Their framing of embodied uncertainty in four contexts (social identities and trauma, co-production of knowledge, institutional structure and policy; and long-term lived experience) supports our case for considering communication as a distinct element in the RIA framework, as each of these four contexts greatly influences both inter- and intra-organizational communication and inter-personal communication.

Doyle et al. (2014) used the RIA framework to recommend communication consistencies for forecasting and warning of natural hazards, and Doyle et al (2015) also considered the factors of the RIA framework when identifying elements that enhance knowledge transfer among and between stakeholders during community resilience decision-making. The people-centered and local participation approach has become increasingly popular in recent years as the public is hesitant to share information with authorities (Scolobig et al., 2015). Moreover, this type of social cohesion brings psychosocial and material support among the public (Prior & Erikson, 2013). More articles can be found with regard to RIA and communication from various perspectives such as from communicating uncertainty and complexity (Bostrom et al 2015, Kellen et al 2013) and from interpersonal relationship e.g. trust (Eiser et al., 2015; Nakayachi and Ozaki, 2015). In their recent paper on risk perceptions following the Icelandic volcanic ash crisis, Eiser et al. (2015, p.341) noted that decisions are biased by personal motives and perceived costs and benefits. Risk managers need to gather information and coordinate with technical staff to set priorities (Jolly et al., 2014). These articles present a great progression and add further insights in risk communication. In recent, Ismail-Zade et al., (2017) emphasized a fundamental need to forge a paradigm shift in disaster science in which transdisciplinary system analysis with action-oriented research is co-produced with multiple stakeholders in a fully communicative environment.

## **5 Conclusion**

A limited recognition of communication in the previous disaster management theories has led to a view of communication as a means or channel to intermediate other 'real' factors responsible for the risk interpretation and actions. This instrumental functionality view of risk communication has hindered facilitating a full understanding of the multi-functionality that risk communication actually carries not just throughout the disaster management cycle i.e. from how message (information) is formed from whom, how it is channeled, how it is received and transformed, how it is interpreted individually and collectively, and how the response is made to respond to the message and the disaster and so on, but way before and after disasters in shaping notions of disaster itself and other factors that are perceived to be the cause of disasters. This research finds that in addition to moderating risk interpretation and action directly, communication also influences the factors that shape risk interpretation and action including decision-making under uncertainty, heuristics, learning, experience, trust, complexity, scale and social context. By identifying the nature of ongoing risk communications and resultant risk interpretation and actions, risk communication cannot only be used for altering generic gaps in risk perceptions and responses, but can also be used to fill specific gaps relating to various factors, which will not just enhance the effectiveness of emergency response but also help to create sustainable livelihoods.

Understanding the functionality of the risk communication is important; however, to build a more systematic and consistent theorizing environment elaborating on the social, cultural, spiritual, relational and instrumental aspects of communication in disaster management is even more fundamental to bring a real impact on the advancement of disaster management theories of next generation. Risk communication is often not straightforward; it is full of complexity and uncertainty not only in the content of what has been communicated but also in the waves of flows inherent in the communication processes. Very preliminarily but significantly, this research proposes a new perspective and research agenda for broadening the theoretical spectrum on hazards and disasters by including communication as a primary factor. Having communication as an important factor of a hazard response model will not only directly affect the future research and funding to this missing aspect but will also create new pathways by modifying the language and

communication to fill the gaps in response.

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## References

- Abarquez I, Murshed Z (2004) Community based disaster risk management: field practitioner's handbook. ADPC, Thailand. Accessed from <http://www.adpc.net/v2007/programs/CBDRM/Publications/Downloads/Publications/12Handbk.pdf>
- Anderson WA (1969) Disaster warning and communication processes in two Communities. *Journal of Communication* 19(2):92-104
- Andrienko N, Andrienko G (2007) Intelligent visualisation and information presentation for civil crisis management. *Transactions in GIS* 11(6):889-909
- Barnes LR, Grunfest EC, Hayden MH, Schultz DM, Benight C (2007) False alarms and close calls: a conceptual model of warning accuracy. *Weather and Forecasting* 22(5):1140-1147
- Bennett A, Diodato S, Gaetano A (2007) The heuristic evaluation of a culturally-specific graphic for cross-cultural communication. IASDR07: International Association of Societies of Design Research. The Hongkong Polytechnic University. Cited on 15<sup>th</sup> September 2015 from <https://www.sd.polyu.edu.hk/iasdr/proceeding/papers/THE%20HEURISTIC%20EVALUATION%20OF%20A%20CULTURALLY-SPECIFIC%20GRAPHIC%20FOR%20CROSS-CULTURAL%20COMMUNICATION.pdf>
- Bostrom A, Joslyn S, Pavia R, Walker AH, Starbird K, Leschine TM (2015) Methods for Communicating the Complexity and Uncertainty of Oil Spill Response Actions and Tradeoffs. *Human and Ecological Risk Assessment: An International Journal* 21(3):631-645, DOI: 10.1080/10807039.2014.947867
- Bradford LEA et al (2017) There is no publicity like word of mouth... Lessons for communicating drinking water risks in the urban setting. *Sustainable Cities and Society* 29:23-40
- Broad K, Leiserowitz A, Weinkle J, Steketee M (2007) Misinterpretations of the "cone of uncertainty" in Florida during the 2004 Hurricane Season. *Bulletin of the American Meteorological Society* 88(5):651
- Burgelt PT, Johnston DM, Paton D (2009) Factors and processes influencing individual and community preparedness for a pandemic outbreak in New Zealand. No. GNS Science Report 2009/09 (p.18). Wellington, New Zealand
- Burton I, Kates RW, White GF (1978) *The environment as hazard*. 1<sup>st</sup> ed. Oxford University Press, New York
- Chen R, Sharman R, Chakravarti N, Rao HR, Upadhyaya SJ (2008) Emergency response information system interoperability: Development of chemical incident response data model. *Journal of the Association for Information Systems* 9(3):200-230 Accessed from <https://pdfs.semanticscholar.org/2562/cc845082410e5805d80324ba28b6afe64535.pdf>
- Comfort LK, Sungu Y, Johnson D, Dunn M (2001) Complex systems in crisis: Anticipation and resilience in dynamic environments. *Journal of Contingencies & Crisis Management* 9(3):144-158
- Coppola DP, Maloney EK (2009) *Communicating emergency preparedness: Strategies for creating a disaster resilient public*. CRC Press, New York
- Cutter S, Boruff BJ, Shirley WL (2003) Social vulnerability to environmental hazards. *Social Science Quarterly*. 84(2): 242-261
- Dawson IGJ, Johnson JEV (2014) Growing pains: How risk perception and risk communication research can help to manage the challenges of global population growth. *Risk Analysis*. 34(8):1378-1390
- Dickson T (2000) Can we live life without risk? *Australian Journal of Outdoor Education* 5(1):2-3
- Dooley R, Catalano S, Mishra S, Serxner D (1992) Earthquake preparedness: Predictors in a community survey. *Journal of Applied Social Psychology* 22 (6):451-70
- Doyle EEH, Johnston DM, McClure J, Paton D (2011) The communication of uncertain scientific advice during natural hazard events. *New Zealand Journal of Psychology* 40(4):39-50
- Doyle EEH, McClure J, Johnston DM, Paton D (2014) Communicating likelihoods and probabilities in forecasts of volcanic eruptions. *Journal of Volcanology and Geothermal Research* 272:1-15 Accessed from <http://www.psychology.org.nz/wp-content/uploads/NZJP-Vol.40-No.4-Distributionfinalpp39-50.pdf>
- Doyle EEH, Becker JS, Neely PD, Johnston DM, Pepperell B (2015) Knowledge transfer between communities, practitioners, and researchers: A case study for community resilience in Wellington, New Zealand. *Australasian Journal of Disaster and Trauma Studies: Practice Update*. 19(2):55-66

- Doyle J (2007) Picturing the clima(c)tic: greenpeace and the representational politics of climate change communication (1994-present). *Science as Culture* 16:129–150
- Edwards TA (1996) Community learning with an 'intelligent' college: a new way to learn." *Journal of European Industrial Training*. 20 (1). Retrieved 3 May 2014 from <http://go.galegroup.com/ps/i.do?id=GALE%7CA18194351&v=2.1&u=inbhc&it=r&p=AONE&sw=w&asid=b5758cdb58c494cb29d8bc71d3406d48>
- Edwards A (2003) Communicating risk means that patients too have to learn to live with uncertainty. *Editorial. BMJ*. 327: 691-692
- Eiser JR, Bostrom A, Burton I, Johnston DM, McClure DP, van der Pligt J, White MP (2012) Risk interpretation and action: A conceptual framework for responses to natural hazard. *International Journal of Disaster Risk Reduction* 1:5-16
- Eiser JR, et al (2015) Risk Perceptions and Trust Following the 2010 and 2011 Icelandic Volcanic Ash Crises. *Risk Analysis* 35(2):332-343
- Eriksen C, Gill N (2010) Bushfire and everyday life: Examining the awareness-action “gap” in changing rural landscapes. *Geoforum* 41(5):814–825
- Fearn-Banks K (2011) *Crisis communication: A case book approach*, 4th edn. Routledge, New York
- Fessenden-Raden J, Fitchen JM, Heath JS (1987) Providing risk information in communities: Factors influencing what is heard and accepted. *Science, Technology, & Human Values* 12(3/4): 94-101
- Grigoriev Y (2012) Mobile communications and health of population: The risk assessment, social and ethical problems. *Environmentalist* 32:193–200
- Grothmann T, Patt A (2005) Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change* 15(3):199–213
- Hale JE, Dulek RE, Hale DP (2005) Crisis response communication challenges. *Journal of Business Communication* 42(2):112-134
- Halfacre AC, Matheny AR, Rosenbaum WA (2000) Regulating contested local hazards: Is constructive dialogue possible among participants in community risk management? *Policy Studies Journal* 28(3): 648. Retrieved 3 May 2014 from <http://www.ipsonet.org/web/page/395/sectionid/374/pagelevel/2/interior.asp>
- Haynes K, Barclay J, Pidgeon N (2008) Whose reality counts? Factors affecting the perception of volcanic risk. *Journal of Volcanology and Geothermal Research* 172(3-4):259–272
- Hordijk MA, Baud ISA (2011) Inclusive adaptation: Linking participatory learning and knowledge management to urban resilience. In: Zimmermann KO (ed) *Resilient Cities, Cities and Adaptation to Climate Change*, Proceedings of the Global Forum 2010. Springer Verlag, Dordrecht, pp111-121
- Hyvärinen J et al (2015). Enhancing citizen response to crises through communication: investigating expert views. *International Journal of Emergency Management* 11(4): 302-319
- Infanti J, Sixsmith J, Barry MM, Núñez-Córdoba J, Oroviogicoechea-Ortega C, Guillén-Grima FA (2013) Literature review on effective risk communication for the prevention and control of communicable diseases in Europe. ECDC, Stockholm
- Ismail-Zadeh AT et al (2017) Forging a paradigm shift in disaster science. *Natural Hazards* 86(2):969-988
- Jabeen H, Johnson C, Allen A (2010) Built-in resilience: Learning from grassroots coping strategies for climate variability. *Environment and Urbanization* 22:415-431
- Jolly GE, Keys HJR, Procter JN, Deligne NI (2014) Overview of the co-ordinated risk-based approach to science and management response and recovery for the 2012 eruptions of Tongariro volcano, New Zealand. *Journal of Volcanology and Geothermal Research* 286:184-207 <http://doi.org/10.1016/j.jvolgeores.2014.08.028>
- Kahneman D, Tversky A. (1979) Prospect theory: An analysis of decision under risk. *Econometrics* 47:263-291
- Kasperson RE, Golding D, Tuler S (1992) Social distrust as a factor in siting hazardous facilities and communicating risks. *Journal of Social Issues* 48:161-187
- Kasperson RE (2005) Introduction and overview. In: Kasperson JE, Kasperson RE (ed) *Social Contours of Risk: Risk Analysis, Corporations and Globalizations of Risk*, Vol - II. Earthscan, London, pp 1-18
- Kerr NL, Tindale RS (2004) Group performance and decision making. *Annual Review of Psychology* 55(1):623-655
- Kim YM (2013) Heuristics. <http://www.oxfordbibliographies.com/view/document/obo-9780199756841/obo-9780199756841-0006.xml> Accessed 15 September 2015
- Khan S, Kelman I (2011) Progressive climate change and disasters: Communicating uncertainty. *Natural Hazards* 61(2): 873-877.
- Khan S (2012a) *Living in a hazardscape: A study of hazards and response in the Wellington Region, New Zealand*. Lap Lambert Academic Publishing, Germany
- Khan S (2012b) Disasters: Contributions of Hazardscape and Gaps in the Global Response Practices. *Natural hazards and Earth System Science* 12:3775-3787
- Khan S, Crozier M, Kennedy D (2012c) Influences of Place Characteristics on Hazard Perception and Individual Response in the Hazardscape of the Wellington Region. *Natural Hazards* 62 (2):501-529

- Klein GA (1998) Sources of power: How people make decisions. MIT Press: Cambridge, MA
- La-Red, OSSO, ISDR (2002) Comparative analysis of disaster databases: final report. La Red and OSSO for UNDP and ISDR, Panama City
- Lagadec P (2004) Understanding the French 2003 Heat Wave Experience: Beyond the heat, a Multi-Layered Challenge. *Journal of Contingencies and Crisis Management* 12(4):160-169
- Lebel L (2009) Fairness in adaptation: deliberation, social learning and dissent. Marie Curie Winter School on Adaptive Governance, Amsterdam
- Lewis J (1984) Environmental interpretations of natural disaster mitigation: the crucial need. *Environmentalist* 4:177–180
- Lindell MK, Prater C (2000) Household adoption of seismic hazard adjustments in two states. *International Journal of Mass Emergencies and Disasters* 18(2):317–38 Accessed from <http://www.ijmed.org/articles/312/download/>
- Lipshitz R, Klein G, Carroll JS (2006) Naturalistic decision making and organizational decision making: Exploring the intersections. *Organization Studies* 27(7):917-923
- Lundgren RE, McMakin AH (2009) Risk communication: A Handbook for Communicating Environmental, Safety, and Health Risks, 4th edn. John Wiley & Sons, Hoboken, NJ, USA
- Mackie B (2009) Health risk communication: Reporting of Avian influenza in New Zealand newspapers 2002-2008. University of Canterbury, New Zealand
- Mackie B (2014) Warning fatigue is not a myth: Understanding why people do or don't respond to warnings. *Fire Note* 122:1-4 Accessed from [http://www.bushfirecrc.com/sites/default/files/managed/resource/fire\\_note\\_122\\_low\\_res.pdf](http://www.bushfirecrc.com/sites/default/files/managed/resource/fire_note_122_low_res.pdf)
- Maclean N (1992) *Young Men and Fire*. University of Chicago Press, Chicago
- Manoj BS, Baker AH (2007) Communication challenges in emergency response. *Communications of the ACM*, 50(3):51-53
- McClure J, Doyle EEH, Velluppillai JM (2014) A tale of two cities: judgments about earthquake and aftershock probabilities across time windows. *International Journal of Disaster Risk Reduction* 14(1):15-26 <http://dx.doi.org/10.1016/j.ijdrr.2014.11.010>
- Mebane FE (2005) The importance of news media in pharmaceutical risk communication: proceedings of a workshop. *Pharmacoepidemiology and drug safety* 14: 297–306
- Mileti DS et al (2006) Annotated bibliography for public risk communication on warnings for public protective actions response and public education. revision 4. Natural Hazards Centre, University of Colorado, Boulder
- Mileti DS, O'Brien P (1993) Public response to aftershock warnings. *US Geological Survey Professional Paper* 1553(B): 31-42
- Mishra JL, Allen DK, Pearman AD (2015) Understanding decision making during emergencies: a key contributor to resilience. *EURO Journal on Decision Processes* 3(3): 397–424
- Mora K, Chang J, Beatson A, Morahan C (2015) Public perceptions of building seismic safety following the Canterbury earthquakes: A qualitative analysis using Twitter and focus groups. *International Journal of Disaster Risk Reduction* 13:1-9
- Nakayachi K, Ozaki T (2014) A method to improve trust in disaster risk managers: Voluntary action to share a common fate. *International Journal of Disaster Risk Reduction* 10(Part A):59-66
- National Cancer Institute (n.d). Making health communications program work. National Institutes of Health, U.S Department of Health & Human Services. <https://www.cancer.gov/publications/health-communication/pink-book.pdf> Accessed 6 December 2016
- Nerlich B, Koteyko N, Brown B (2010) Theory and language of climate change communication. *WIREs Climate Change* 1:97-110
- Netten N, van Someren M (2011) Improving communication in crisis management by evaluating the relevance of messages. *Journal of Contingencies and Crisis Management* 19(2):75-85
- Oh O, Agrawal M, Rao HR (2013) Community intelligence and social media services: A rumor theoretic analysis of tweets during social crises. *MIS Quarterly* 37(2): 407-A407 Accessed from <http://www.som.buffalo.edu/isinterface/papers/oh-misq-2013.pdf>
- Otway H, Haastrup P, Cannell W, Gianitsopoulos G, Paruccini M (1988) Risk communication in Europe after Chernobyl: A media analysis of seven countries. *Industrial Crisis Quarterly* 2:3-15
- Paton D, Johnston DM, Bebbington MS, Lai Chin-Diew, Houghton BF (2001) Direct and vicarious experiences of volcanic hazards: Implications for risk perception and adjustment adoption. *Australian Journal of Emergency Management Summer*: 58–63 Accessed from <https://ajem.infoservices.com.au/downloads/AJEM-15-04-11>
- Pahl-Wostl C (2009) A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. *Global Environmental Change* 19:354-365
- Prior T, Eriksen C (2013) Wildfire preparedness, community cohesion and social–ecological systems. *Global Environmental Change* 23(6):1575-1586. <http://doi.org/10.1016/j.gloenvcha.2013.09.016>

- Regain L (2009) Risk communication and media coverage of emerging contaminants. *American Water Works Association* 101(5):100-105
- Regnier E (2008) Public evacuation decisions and hurricane track uncertainty. *Management Science* 54(1):16–28
- Rempel J, Holmes J (1986) How do I trust thee? *Psychology Today* 2:28-34  
[http://www.scirp.org/\(S\(i43dyn45teexjx455qlt3d2q\)\)/reference/ReferencesPapers.aspx?ReferenceID=501088](http://www.scirp.org/(S(i43dyn45teexjx455qlt3d2q))/reference/ReferencesPapers.aspx?ReferenceID=501088)
- Renn O, Levine D (1991) Credibility and trust in risk communication. In: Kasperson RE, Stallen PM (eds), *Communicating Risks to the Public: International Perspectives*. Kluwer, Dordrecht. pp175-218
- Robinson M (2002) *Communication and Health in a Multiethnic Society*. The Policy Press, Bristol
- Ropeik D (2008) Risk Comm: More Than Facts. *IAEA Bulletin* 50(1):58-60 Accessed from <http://www.dropeik.com/dropeik/pdf/iaeabulletinarticle.pdf>
- Ropeik D (2009) Risk communication and non-Linearity. *Belle Newsletter* 15(1): 3-9 Accessed from <http://dose-response.org/wp-content/uploads/2014/05/vol15-1.pdf>
- Samarajiva R (2005) Policy commentary: Mobilizing information and communications technologies for effective disaster warning: lessons from the 2004 Tsunami. *New Media & Society* 7:731-747
- Sandell T, Sebar B, Harris N (2013) Framing risk: Communication messages in the Australian and Swedish print media surrounding the 2009 H1N1 pandemic. *Scandinavian Journal of Public Health* 41:860–865
- Schraagen J, van de Ven J (2011) Human factors aspects of ICT for crisis management. *Cognition, Technology & Work* 13(3):175-187
- Scolobig A, Prior T, Schröter D, Jörin J, Patt A (2015) Towards people-centred approaches for effective disaster risk management: Balancing rhetoric with reality. *International Journal of Disaster Risk Reduction* 12: 202-212.  
<http://doi.org/10.1016/j.ijdr.2015.01.006>
- Sharma U, Patt A (2011) Disaster warning response: the effects of different types of personal experience. *Natural Hazards* 60(2):409–423
- Shaw A, Sheppard S, Burch S, Flanders D, Wiek A, Carmichael J, Robinson J, Cohen S (2009) Making local futures tangible: synthesizing, downscaling, and visualizing climate change scenarios for participatory capacity building. *Glob Environ Chang* 19(4):447–463
- Sheppard B, Janoske M and Liu B (2012) *Understanding risk communication theory: A guide for emergency managers and communicators*. Report to Human Factors/Behavioral Sciences Division, Science and Technology Directorate, U.S. Department of Homeland Security. START, College Park, MD
- Simon HA (1955) A behavioral model of rational choice. *The Quarterly Journal of Economics* 69(1):99-118
- Simon HA (1992) What is an “explanation” of behavior? *Psychological Science* 3(3):150-161
- Skinner C and Rampersad R (2014) A revision of communication strategies for effective disaster risk reduction: A case study of the South Durban Basin, KwaZulu-Natal, South Africa. *Jamba: Journal of Disaster Risk Studies* 6(1): Art.#132 (10 pages).
- Slovic P, Monahan J, MacGregor DM (2000) Violence risk assessment and risk communication: The effects of using actual cases, providing instructions, and employing probability vs. frequency formats. *Law and Human Behavior* 24(3):271-296
- Sword-Daniels V, Eriksen C, Doyle EEH, Alaniz R, Adler C, Schenk T, Vallance S (2016) Embodied uncertainty: living with Complexity and Natural Hazards. *Journal of Risk Research*. 1-18. <http://dx.doi.org/10.1080/13669877.2016.1200659>
- Tversky A, Kahneman D (1973) Availability: A heuristic for judging frequency and probability. *Cognitive Psychology* 5(2):207-232
- Tversky A, Kahneman D (1974) Judgement under uncertainty: Heuristics and biases. *Science* 185(4157):1124-1131
- USDHHS (2002) *Communicating in a crisis: Risk communication guidelines for public officials*. US Department of Health and Human Services [USDHHS], Washington DC  
<https://www.orau.gov/cdcynergy/erc/content/activeinformation/resources/HHSRiskCommPrimer.pdf> Accessed 6 December 2016
- Walker GB, Daniels SE and Emborg J (2008) Tackling the tangle of environmental conflict: complexity, controversy, and collaborative learning. *E:CO* 10(4):17-27
- Walsh K, Jordan Z, Apolloni L (2009) The problematic art of conversation: Communication and health practice evolution. *Pract. dev. Health Care* 8(3):166–179
- Wehn U, Rusca M, Evers J, Lanfranchi V (2015) Participation in flood risk management and the potential of citizen observatories: A governance analysis. *Environmental Science & Policy* 48(0):225-236
- Weick KE (1996) Drop your tools: An allegory for organizational studies. *Administrative Science Quarterly* 41(2):301-313
- Wigforss E (1999) The role of communication in learning technologies. *ASCILITE99 Conference Proceedings*.  
<http://www.ascilite.org/conferences/brisbane99/papers/wigforss.pdf> Accessed 6 December 2016
- Wim K, Teun T, Maeyer PD (2013) Perception and Communication of Flood Risks: A Systematic Review of Empirical Research. *Risk Analysis* 33(1):24-49

- Wisner B, Blaikie P, Cannon T, Davis I (1994) *At risk: Natural hazards, people's vulnerability and disasters*, 1<sup>st</sup> edn.  
Routledge, London
- Wisner B, Blaikie P, Cannon T, Davis I (2003) *At risk: Natural hazards, people's vulnerability and disasters*, 2<sup>nd</sup> edn.  
Routledge, New York