Hazard Risk Communication: A Canadian Case Study

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ABSTRACT

This study examines Canada's extreme weather warning system by analyzing the experiences and perspectives of broadcast meteorologists (BMs) from across the country. In addition, a review of risk communication principles and theories underscores the importance of these components. Through this dual lens, the paper identifies similarities and differences between established theoretical frameworks and the realities of the current weather communication practice. The qualitative analysis highlights opportunities to strengthen the design and delivery of hazard-related risk messaging. The findings contribute to a better understanding of the warning system's limitations and inform evidence-based strategies to enhance its effectiveness, bolster public trust, and increase the public uptake of extreme weather warnings.
KEYWORDS: Extreme weather warning, Broadcast meteorologist, Risk communication, Canada.

1 INTRODUCTION

Risk communication and early warning systems are central to reducing the impacts of hazards across sectors and contexts. Canadian Broadcast Meteorologists (BMs) are an essential part of the extreme weather forecast system, providing timely risk communication to socially, economically, and geographically diverse communities (Agrawal & Spinney, 2025). In public health, for example, timely communication about outbreaks of infectious diseases (biological hazards) is key to mitigating the spread of pathogens with pandemic potential. For other types of natural hazards, such as floods, severe storms, or extreme weather, timely information is critical for the public and authorities alike, as these events can have the potential to disrupt critical infrastructure and services, such as power outages due to a winter storm, water contamination due to a flood, or disruptions to fuel supply so that protective action can be taken.

This paper explores extreme weather warning systems in Canada and discusses a range of risk communication frameworks that have guided understanding and analysis of the transmission and uptake of information over decades. We draw on perspectives gleaned from interviews with a small group of Canadian Broadcast Meteorologists (BMs), thematically organized here as a coupling of operational challenges and ways for managing them, to highlight risk communication as a social process, and to show the importance of BM expertise and public trust as key contributors to effective alert distribution and uptake in severe and extreme weather contexts.

Early warning systems (EWS) form a core component of disaster mitigation strategies. The degree to which EWS are established varies across hazard types. In North America, hurricane and typhoon activity is monitored extensively by the U.S. National Hurricane Center and the Canadian Hurricane Centre, both of which are relied upon in Canada. Earthquake activity with the potential to generate tsunamis is monitored by the U.S. Geological Survey and Natural Resources Canada, which recently expanded earthquake monitoring and early warning beyond the west coast provinces to include eastern Ontario and Quebec. Likewise, weather forecasting and warning is the mandate of the U.S. National Weather Service and Environment and Climate Change Canada (ECCC). These agencies employ networks of monitoring stations and instruments, radar and satellite platforms, and numerical forecast models to detect, track, and anticipate a range of meteorological and hydrological hazards, such as extreme wind, rainfall, heat and cold.

A substantial body of literature offers diverse frameworks for understanding risk communication applicable to natural hazards. These include the Transmission Model (Shannon, 1948); the Theory of Reasoned Action and its extensions (Fishbein, 1979; Sheppard et al., 1988; Trofimov, 2009); Grounded Theory (Mileti & Sorensen, 1990a); Trust-Determination Theory (Peters et al., 1997); the Elaboration Likelihood Model (Petty & Wegener, 1999); Mental Noise Theory (Lundgren & McMakin, 2008); the Protective Action Decision Model (Lindell & Perry, 2012); and the three-point guidance for effective communication proposed by Janoske et al. (2012). The three points are: (a) understanding the characteristics of an audience is essential to developing effective risk communication efforts; (b) how, when, and by whom a message is delivered impacts its effectiveness; and (c) communicators must continually adapt to changing situations.

The 'transmission model' is a linear process in which thoughts or information are transmitted from a sender through a medium to a receiver (Fig. 1). The 'grounded theory' (Fig. 2) proposes that an integrated warning system should have factors such as monitoring, detecting, and interpreting, as well as a warning method, content, and channel or medium. Furthermore, it suggested that message attributes should include content and style, and the source attributes must demonstrate credibility and familiarity. Mileti and Sorensen's (1990b) Information Processing Model shifts the focus in risk communication to the receiver and suggests that people's response to warning information follows a sequential process of six steps: hear, understand, believe, personalize, decide and confirm. The sequence may not be the same for every person, and each stage isn't necessary for a response to occur. The 'Predictive Theory of Reasoned Action' is based on individual risk perceptions and perceived control of decisions. Their behaviour is more likely to be acted when there is both personal and societal acceptance (Fig. 3). The 'Trust Determination Theory' is rooted in the audience's trust in the messenger, a vital determinant in message acceptance, risk perception, and subsequent behaviour. The 'Elaboration Likelihood Model' is a dual process where people may engage in scrutiny and analysis of the evidence in a message, or they may rely on simple heuristic rules of thumb. 'Mental Noise Theory' accounts for the decreased ability of individuals to receive and process information when they perceive themselves at risk due to mental noise during sudden-onset events. To rectify this, communication should avoid repeated messaging, jargon, acronyms, and technical terms. Lastly, the 'Protective Action Decision Model' accounts for how individuals integrate information from social and environmental cues and conform to the three pre-decision processes — reception, attention, and comprehension of warnings or threats. Although these frameworks differ in scope and complexity, they share an emphasis on understanding the intended audience of a risk message.

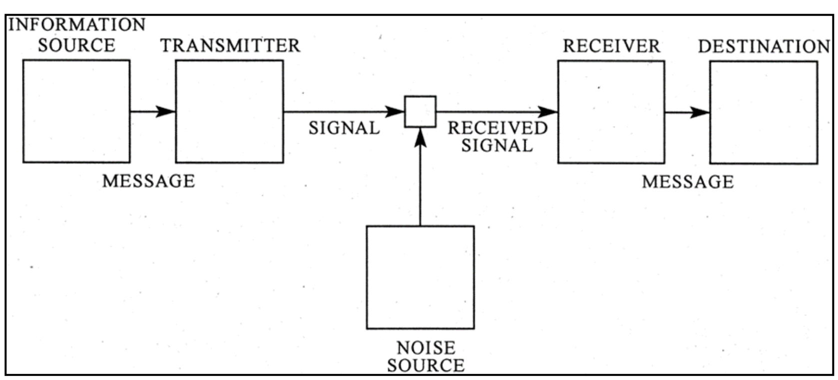

Figure 1: The Transmission Model of Communication (Shannon, 1949).

Expertise in broadcast meteorology is a temporal and socially mediated achievement, continually negotiated between scientific authority, institutional protocols, and audience expectations (Daston & Galison, 2007; Collins, 2018). BMs understand that knowing their audience is critical for designing and delivering extreme weather messaging. They note, "*If they [meteorologists] are new to the place, the lack of local knowledge may hinder their ability to convey the weather risk effectively and accurately*." In this context, the concept of intersubjectivity as a way to explain how individuals experience and constitute a shared world through mutual understanding becomes crucial (Duranti, 2010). This common ground cannot be assumed; it must be created across differing backgrounds, varying levels of trust, and diverse weather experiences. In essence, meteorologists across multiple domains and audiences must repeatedly build enough shared understanding of risk, what it is, why it matters, and what to do about it.

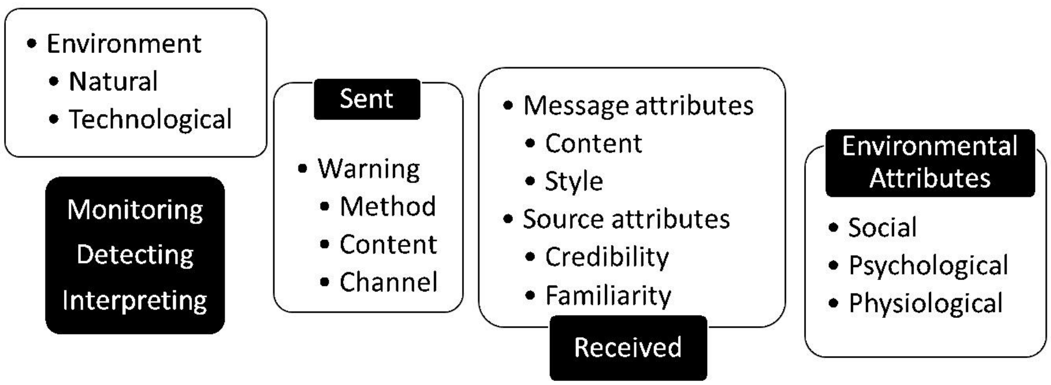

Figure 2: Grounded Theory: Risk Messaging Component Benchmarking (Mileti & Sorensen, 1990a)

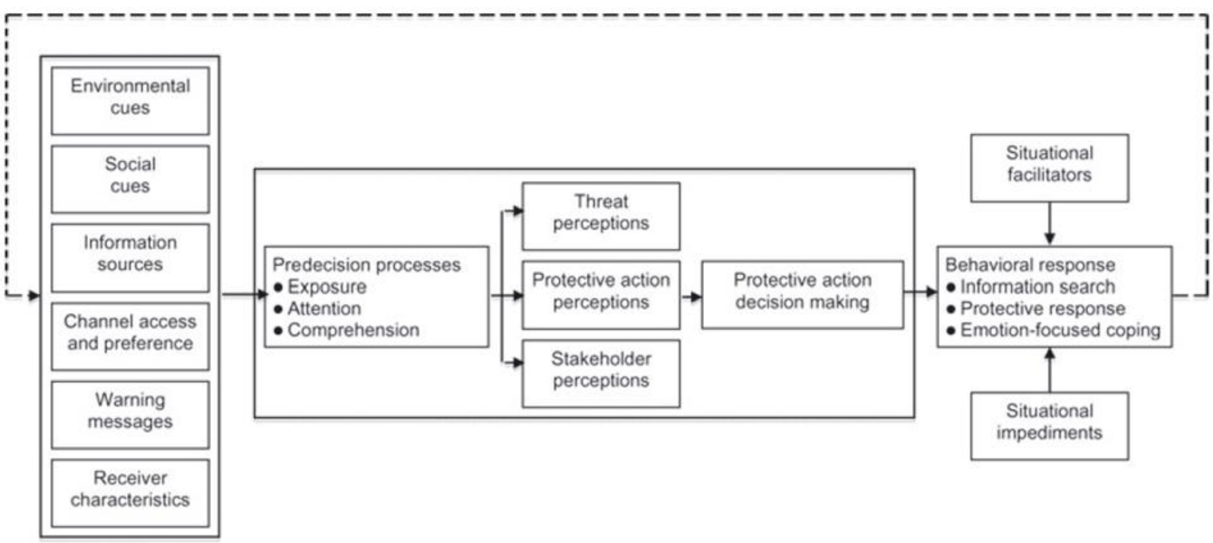

Figure 3: Protective Action Decision Model (Lindell & Perry, 2012)

2 METHOD

This study draws on 11 interviews with Canadian BMs conducted as part of a larger research project titled "A community-based approach to improve weather-related warnings in Ontario," undertaken in collaboration with the Meteorological Service of Canada. A purposeful sampling strategy was used to select participants, and interviews were conducted by the principal investigator and co-investigator. The sample included professionals employed by major national TV networks who provide weather information to the public through both daytime and evening broadcasts. Participants were based in various Canadian cities, including urban centres on the West Coast, the western prairies, southwestern Ontario, and Atlantic Canada. Interviewees' professional experience ranged from 10 to 40 years, and their educational backgrounds included degrees in meteorology, atmospheric science, broadcast journalism, or communications.

The research team employed a semi-structured interview approach and conducted virtual interviews with 11 participants via Zoom between December 2022 and April 2023. Interviews followed a consistent protocol that included a list of 20 questions while allowing space to pursue emergent themes with each participant. This balance of consistency with flexibility generated a comparable and reliable data set (Bernard, 2002) that also included perspectives deemed important to each participant. Each interview lasted between 40 minutes and just under two hours and was audio-recorded and then transcribed using AI-assisted tools (Otter.ai). Transcripts were subsequently cleaned by student research assistants, and interview data were thematically analyzed within an interpretivist framework (Upadhyay, 2012), a common anthropological approach that understands reality as subjective and socially constructed.

3 RESULTS

3.1 BM Experiences

A typical day for a BM begins with integrating model outputs, observational data, and official forecasts obtained from Environment and Climate Change Canada (ECCC) with their real-time interpretation of atmospheric patterns and local conditions. The myriad tasks include accessing and interpreting weather data, producing graphics, developing forecasts, and sharing them across TV, radio, online, and social media platforms (Facebook/ Instagram/ TikTok/ X) in both recorded and live formats. Each shift requires coordinating short-, medium-, and long-term predictions to ensure consistency across time, space, and the larger work cycle. Their reliance on triangulation and cross-referencing functions as a system of stability within the instability of weather. Through these acts, BMs navigate the boundary between what they can know and what remains uncertain, adjusting forecasts for local conditions through their embodied attentiveness to both data and the environment. BMs' interpretive work takes place within a wider media environment marked by misinformation, accusations of exaggeration, and significant public scrutiny, including gendered and racialized responses directed especially at women broadcasters and women of colour (Hallows, 2020; Perryman & Theiss, 2014). These dynamics underscore that BMs are not only interpreters of data but also managers of public perception and trust.

3.2 BM Challenges

Inter-institutional procedural suspension: A closer look at broadcast meteorological work reveals a dense bureaucratic infrastructure and a set of practices that organize not only what is communicated but also when, where, and to whom, thereby imposing significant communication challenges. The Canadian early warning system for severe and extreme weather is made up of a range of stakeholders, including alert issuers (ECCC), alert distributors and aggregators, as well as various publics who use information and make decisions to protect themselves. BMs serve as an alert distributor in this system but rely on official alerts to generate weather warnings. ECCC meteorologists, organized by their own temporal regimes made up of centralized processes of data processing, interpretations of the atmosphere, and adherence to criteria-based warning rules, to name only a few, are at times themselves waiting to ensure the necessary pieces of the atmospheric puzzle are in place before issuing an official alert for an emerging weather hazard. Once the official warning is issued, alert distributors and aggregators, such as BMs and Pelmorex's Alert Ready[1] system, respectively, spread the message in ways to promote maximum public

[1] Alert Ready is Canada's emergency alerting system. The Alert Ready system was developed with many partners, including federal, provincial and territorial emergency management officials, Environment and Climate Change Canada, Pelmorex, the broadcasting industry and wireless service providers. https://www.alertready.ca/

uptake. BMs are thus embedded within a dense web of governmental agencies and media institutions, where they aim to condense complex meteorological alerts into meaningful segments of a few minutes or a couple of hundred characters, while maintaining fidelity to ECCC's authoritative language. For example, Participant #4's experience highlights the intersection of atmospheric and media temporalities with bureaucratic structures:

> *"I know I see a tornado happening. You know, ..., like, it's absolutely a critical moment that we are out, you know, that we need to get that information back. And [my colleague] is getting that information back to Environment Canada to get that warning out. It happens all the time. And it's terrible. I hate it. But it's sometimes really difficult to get that two-way flow of information or that information flowing back to them fast enough."*

3.3 Network-Specific Structures

The work routines of broadcast meteorologists are shaped as much by the criteria set by ECCC for issuing warnings as by network-specific systems, including temporal pressures intensified by shrinking budgets and staffing cutbacks. It results in tight deadlines and heavy workflows. As Participant #6 mentioned, they are "*covering multiple provinces' worth of weather, […]. A thunderstorm warning in Alberta may coincide with a heat advisory in Manitoba or an overnight frost risk in Saskatchewan.*" BMs must synchronize their reports with these shifting temporal layers while adhering to network schedules that demand consistent delivery across regions. This can be challenging for networks that cover topics beyond weather, as the participant above described: "*I am covering three provinces' worth of weather. We are not The Weather Network that has unlimited, you know, weather content time*."

BMs also need to communicate across multiple media platforms, including television, radio, websites, and social media; each demanding a distinct temporal harmony and communicative tone. Participant #3 mentions that they use YouTube, Twitter (now X), and Instagram as the main social media channels, and that it is a challenging process:

> *"…think of Twitter, for example, it has limited character spaces, you're on air, I've given a minute and a half on the radio, I'm given 45 seconds, you try and give a detailed forecast in 45 seconds. So yeah, that is my biggest challenge every day, but I feel like I'm learning. I really feel like it's over time, like I've been doing this for more than 20 years now. But over time, I've been able to hone in on really what it is that people need to know now. And as I said, try and fill in the details and other platforms."*

3.4 Navigating Challenges

The practices in place in weather forecasting are not merely technical strategies; they are deeply entangled with questions of authorship and accountability. Participants articulated that contextualization through familiar references, a sense of humour, or links to local community events enhances message retention and fosters trust. Several participants acknowledged that while at times they may disagree with official ECCC warnings, they are careful not to express such divergences on-air, instead layering the official warning with their own professional judgment and expertise of the local environment, which frames the threat in meaningful ways. Participant #5 gives an example of how they navigate the official warnings with their expertise:

> *"In the accountability factor, like what if your message you just sent out is not accurate? For whatever reason, right? Well, so I will only treat our warnings, obviously, once Environment Canada issues them. There have been times when they've issued a watch or warning, and I don't agree with it. And I will say that now we have a snowfall warning issued for [X location]. From what I can see on the models, I don't see us reaching that 15-centimetre threshold; I see it closer to 10. But here's the warning with the highest amounts through the West End, you know, so I'll kind of add a little bit of that human factor in there and experience."*

4 DISCUSSION

The discussion of BM experiences, the operational challenges they operate under, and the different strategies they employ to manage reveals important features of conventional risk communication frameworks (Fig. 1-3). First, the frameworks show that the '*source of information*' to be communicated is an integral component of every risk communication model. BMs in Canada obtain weather information from Environment and Climate Change Canada (ECCC), the federal agency authorized to disseminate weather information to interested parties, including issuing extreme weather warnings. BMs use supplementary resources, such as commercial weather models, to customize local weather for their region. While they do not initiate official warnings themselves, they simplify complex information to enhance clarity and accessibility for the public. It is reasonable to say that BMs conform to the theoretical communication principle of having a robust information source.

BMs acknowledge that "*Forecasts are never perfect*," but sought better tools to improve the accuracy of the timing and spatial extent of impending hazards. BMs noted a lack of a 'community' of weather forecasters for periodic dialogue on various aspects of the job. They wished to have opportunities to exchange ideas and experiences with other professionals, as their counterparts do in the U.S.: "*The National Weather Service holds its annual meteorological convention in the US; we do not have anything like that in Canada.*"

Second, risk models emphasize '*the message*.' BMs across the country use the same template to convey extreme weather to the public in simple language. The main challenge involved in their job is how best to simplify the message for public comprehension without losing critical details. Some risk communication models (Petty & Wegener, 1999) suggest that the public may either prefer to use heuristic cues (source identity, colour, or visuals) or, in rare cases, engage in scrutiny and analysis of the evidence in a message. The Grounded Theory model (Mileti & Sorensen, 1990a, Fig. 2) and the Protective Action Decision Model (Lindell & Perry, 2012, Fig. 3) also account for message interpretation and comprehension as critical components of message design. Message attributes, including content, style, and familiarity, are equally important, according to both theoretical frameworks and BMs. In line with these theoretical concepts, broadcasters cultivate confidence while acknowledging uncertainty, using linguistic strategies to make the warnings more memorable, strategically adjusting tone when necessary to calibrate urgency. In doing so, they transform data outputs into social meaning, turning centimetres of snow or kilometres per hour windspeeds or millimetres of rainfall into behavioural guidance about whether to delay a commute, cancel an event, or prepare for power outages, to name a few. BMs' ability to synchronize, anticipate, and improvise ECCC warning information enables them to help audiences hear, understand, believe, and act upon the warning (Mileti & Sorensen, 1990b; Lindell & Perry, 2012).

Third, '*transmission'* of the message is critical. BMs, as alert distributors in the warning system, play a role akin to "transmitter" in the Transmission Model of Communication (Shannon, 1948, Fig. 1). This helps extend our thinking of "transmitter" in risk communication beyond equipment, cabling, and other physical tools to include social and human dimensions. For example, people and businesses living and operating in hazard-prone areas, such as floods, tornadoes, winter storms, avalanches, hurricanes, and wildfires, can use weather information to take measures to mitigate risk. BMs recognize the importance of transmitting complete weather risk information to their constituents and of building trust in that information so people heed advisories to stay safe. However, they identified several challenges to achieving this goal. The weather hazard information typically covers a large area and an approximate time of arrival for the event, with varying degrees of risk, creating uncertainty, and leading people to ignore the warning altogether. Therefore, BMs believe that high-resolution spatial weather forecast maps will improve situational awareness, thereby building trust in the information over the long term.

Fourth, the '*receiver of the message*' is a key factor in this process, as they must interpret the message and use the information to reduce hazard risk. BMs primarily broadcast weather to the public; therefore, they sometimes find it challenging to perform their duties with limited financial, technical, or personnel resources, under tight timelines, and across multiple platforms. Furthermore, the conceptual frameworks underscore the need to include social, psychological, physiological, and behavioural attributes to help recipients of the message use their context and interpret the risk information accordingly. Analysis of interview data showed that the challenges BMs experience can both hinder their ability to communicate in a timely fashion and cause confusion, limiting information processing, public uptake, and protective action. A closer look at BM expertise also helps us to see this group of alert distributors as uniquely suited, given they are familiar sources and are often deemed credible in the eyes of the public, to create parcels of information with a particular style and content to promote effective receipt, in keeping with Grounded Theory (Fig. 2). The Protective Action Decision Model (Fig. 3) recommends similar considerations, such as environmental and social cues and receiver characteristics.

Evident from the interviews is the fact that BMs shared significant common elements, such as describing communication as a process of balancing scientific accuracy with strategies that sustain audience attention and comprehension. Furthermore, across the board, BMs reveal how they transform constraint into a workable rhythm by synchronizing, improvising, and adding their informed input to the communication, while ensuring that weather information remains both scientifically reliable and socially intelligible, thereby sustaining the social pulse of a system otherwise defined by institutional time and atmospheric uncertainty. Another key common dimension was the need to navigate the dynamic nature of channels (TV, radio, online, and social media platforms (Facebook/ Instagram/ TikTok/ X) through which risk information must be communicated. Among many individual issues that came to light, gender disparities, unequal access to resources, and differences between large-urban and small-rural jurisdictions stood out. Indeed, BM expertise extends beyond interpreting data, and they bring in their personal element, including education, training, personalities, and backgrounds.

5 CONCLUSION

Risk communication and early warning systems are central to reducing the impacts of hazards across multiple sectors and contexts, including severe and extreme weather in Canada. Our analysis confirmed the contemporary relevance of traditional risk communication frameworks in weather hazard communication and showcased the importance of BMs in the Canadian early warning system, especially the value of their expertise in effectively communicating threats. The discussion has been productive not simply for illuminating BM operational challenges and how they are managed, but also for the potential the exploration creates for understanding the merit of shared comprehension, or intersubjectivity, across domains of meteorological expertise. Our efforts to highlight broadcast meteorological work in Canada enable other meteorological experts involved in the Canadian weather forecast and warning system to understand the time pressures and challenges they face, such as delivering warnings quickly or condensing complex information. In that sense, we have enhanced conceptual bridging between the ECCC and broadcast meteorology worlds, enabling increased intersubjectivity across the fields. When meteorologists across different agencies understand each other's workflows and time pressures, they may be more willing to collaborate, making forecasting and warning practices more efficient and effective. While time has long been a means of disciplining labour (Thompson, 1967), in meteorological contexts, it also becomes a medium of collaboration, and through that medium, greater shared understanding has the potential to produce more effective communication with the public, and ultimately, safer outcomes for Canadian society, especially in times of severe weather with consequences such as floods.

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