



Risk Information Sources for Snow Disaster Risk Preparedness in Scotland

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Abstract Heavy snow disruptions are common and costly occurrences in the UK, including Scotland. Yet, heavy snow remains an underresearched aspect of disaster risks in Scotland. This study critically examined the 2018 heavy snow event in Scotland referred to as the “Beast from the East” (BfE) in order to explore the different sources of information used by the public in preparation for and response to heavy snow emergencies. Our study also examined the effectiveness of BfE risk communication between authorities and the public and sought to determine if there is a relationship between risk information received and the intention to mitigate risk. Data were collected through a semistructured survey from ($n = 180$) residents of the Annandale and Eskdale region of Dumfries and Galloway, Scotland. Our analysis shows that public authority information sources were the most sought-after information sources, followed by online and web sources. We found statistically significant differences between groups (such as age, gender, and mobility/disability) in terms of using risk information sources. Further analysis shows that the relationship between information received and the intention to mitigate risks is not linear but influenced by intervening variables such as work pressures, financial commitment, and stakeholders’ expectations. We argue that where full adherence to official risk advice is required, policymakers should carefully consider issues around these three factors.

Keywords Disaster preparedness · Heavy snow · Risk information sources · Risk perception · Scotland

1 Introduction

As communities continue to face risks from environmental hazards such as floods, heavy snow, and extreme heat (Huber and Gullede 2011), they must make decisions to reduce the threats from these risks, especially in emergencies. In the UK and Scotland, public service authorities such as the Met Office, Scottish Environment Protection Agency (SEPA), and local authorities are responsible for communicating risk messages to the public under the Civil Contingency Act 2004. The act requires these authorities to warn, inform, and advise the public in preparation for and in the event of an emergency. Communicating relevant and timely information alongside preparedness strategies with the public will help citizens develop the appropriate level of risk awareness, which is a fundamental step in disaster preparedness (Steelman et al. 2015; Cahyanto et al. 2016; Bronfman et al. 2019). Research suggests a positive relationship between risk perception and preparedness (Miceli et al. 2008; Cliff et al. 2009; Paul and Bhuiyan 2010). Therefore, the lack of access to timely information, which the public relies upon to make risk judgments, can compromise the ability of individuals and communities to respond effectively to environmental threats. Also, as communities are not homogeneous, it is essential to understand how they differ in their use of risk information sources for risk preparedness.

Existing risk communication research has tended to focus on the perspectives of the information sender, including their perceived view of the receiver’s information source preferences to the neglect of actual choices

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from the receiver's perspective (Palttala et al. 2012), although there are exceptions (Burger et al. 2013; Steelman et al. 2015; DeYoung et al. 2016). Burger et al. (2013) examined local communities' use of information sources to prepare for and respond to Super Storm Sandy in New Jersey, United States. Steelman et al. (2015) surveyed 873 local community members in the United States and Mexico to explore recipient perspectives of information used on five large wildfires in 2009 and 2010. DeYoung et al. (2016) studied hurricane evacuation in North Carolina from the perspective of the information recipients. Burger et al. (2013), Steelman et al. (2015), and DeYoung et al. (2016) provide valuable insight into receivers' preferences of information sources in the United States and Mexico. Likewise, research on risk perception has focused on the relationship between risk perception and risk preparedness (Miceli et al. 2008). More scientific attention is still needed to understand recipient perspectives of information used during a snow event and how public groups (by age, gender, and disabilities) differ in their use of risk information sources in the United Kingdom's local context.

This study investigated the public experience of the 2018 heavy snow event in the UK referred to as "Beast from the East" (BfE). The BfE is an interesting case study due to the scale (national) and unusual intensity of the event. The BfE affected most of the United Kingdom with new low temperatures recorded in the sub-zeros and heavy snowfall between 24 February to 4 March 2018 (Greening and Hodgson 2019). The new record low temperatures prompted the Met Office to issue the first-ever red weather warnings in Scotland, thereby stretching local resources. The red warning alert¹ was in place for several hours on multiple occasions during this event. A red warning means a considerable disruption to travel, critical supplies (energy, water), and property and infrastructure with potential risk to life (Met Office 2018). There were widespread school closures during which roads, offices, shops, and factories across the country were also closed, and with power cuts and minor accidents reported in the news (Guardian 2018). The advice for the public was to avoid any form of travel, where possible, and to follow the official advice provided by emergency services and local authorities. Thus, the BfE in Scotland presents a highly relevant context to study the information sources that different public groups rely upon for risk information in Scotland.

The aim of this study was to examine: (1) what sources of information are used by local communities to access risk information about heavy snow in Scotland; and (2) to understand how public groups differ across age, gender,

and mobility/disability in terms of their use of risk information sources during a snow disaster. Understanding the use of information sources in snow disaster preparedness in the UK context is essential for two reasons. First, it provides valuable insight into whether information sources vary depending on the type of hazard. Second, the intensity of a disaster, the nature of its impact (including those affected), and trust in national authorities can shape people's attitude to disaster and how they use and search for risk information. Therefore, this study provides helpful insight into the information-seeking behaviors of people in Scotland and will allow researchers to determine if they differ from those living elsewhere. The article contributes to the disaster risk and community resilience literature by examining risk communication's role from the communication studies perspective. The other two risk communication perspectives are those of the science and technology studies and management perspectives (Adekola et al. 2019).

2 Risk Communication and Information Sources, Risk Perception, and Intention to Act

Threats from environmental hazards often prompt a sense of need for risk information to understand better the nature of the hazard. This sense of need is referred to as perceived information insufficiency—a gap between current knowledge and information need (Griffin et al. 2004). This is then followed by information search by those who perceive themselves to be at risk by using multiple media sources to help make sense of the risk (Sommerfeldt 2015). Where there is no direct experience of risk, how the risk is encoded, transmitted, and decoded plays a key role in how the public makes sense of the risk signals. The social amplification of risk framework (SARF) as articulated by Kasperson et al. (1988) and the disaster risk communication literature see the media as a critical information source both before and after a disaster (Holmes et al. 2009; Burger et al. 2013). The SARF, which relies on the structure of communication theory (Shannon and Weaver 1949), illustrates how risk signals are encoded, passed on, received, and interpreted by various sources (Kasperson and Kasperson 2012).

Television, radio, and newspapers are traditional (mainstream) means of communication (Spence et al. 2011; Austin et al. 2012), and play a critical role in informing the public about risk, providing updates, and serving as a watchdog for risk information (Fig. 1). Social media play a role in informing or misinforming the public and are now the first source of publicly provided material (Jin et al. 2014). They have also become sources of information for traditional media and allow the public to be both receivers

¹ A full weather warning scale can be found on the MetOffice website: <https://www.metoffice.gov.uk/weather/guides/warnings>.

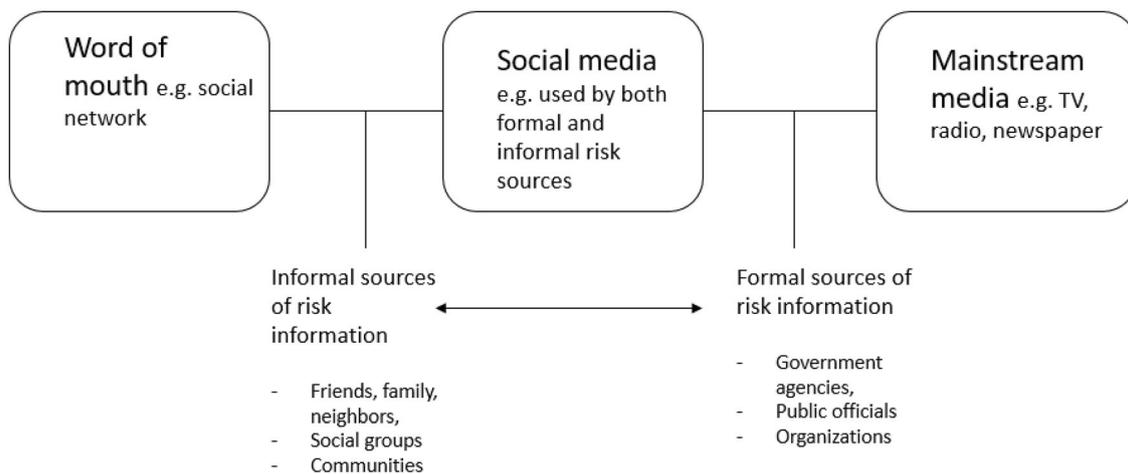


Fig. 1 Communication sources for risk information. *Source* Adapted from Spence et al. (2011), Austin et al. (2012), and Steelman et al. (2015)

and senders. Online and social media are instrumental in getting localized information, checking on friends and family, and orchestrating relief efforts following a disaster (Austin et al. 2012). Mobile media provide an additional advantage in information sharing and alerts, real-time coverage of risk events, and directing the public away from disaster areas. From this perspective, the information provider may be from official and unofficial sources (Fitzpatrick and Mileti 1994). Family, friends, and neighbors are often highlighted as valuable and trusted information sources (Burnside et al. 2007). Word of mouth is a beneficial source of information that would not necessarily come from authorities (Sutton et al. 2008). Both official and nonofficial sources may use mainstream and social media when communicating with the public. Figure 1 differentiates between formal and informal sources of risk information.

The use of formal and informal information sources has been recognized within the literature. In their study, Burger et al. (2013) found television, radio, friends, and web/e-mail to be the most used sources of information by locals during Superstorm Sandy. In their study of five large fires, Steelman et al. (2015) found that family/friends/neighbors, mass media, and maps were the most used sources of information. DeYoung et al. (2016), in their study of hurricane evacuation in North Carolina, observed that television and radio information sources were the most used sources in that context. DeYoung et al. (2016) identified females and younger residents as the demographic groups that favored multiple sources from which to gather information in contrast to males and older residents. A study by Communicating with Disaster Affected Communities network found that radio was the most used source of information when communicating with communities in the aftermath of Cyclone Idai in Mozambique (CDAC 2019).

Another study by International Organization for Migration shows that the most used sources of information during a flooding event in Pakistan and elsewhere are friends and family, mobile phones, television, and radio (IOM 2014). Other identified sources were through the army, aid workers, newspapers, religious leaders/institutions, community leaders, and government official documents.

Communicating about risk can be challenging because people interpret risk from competing perspectives (objective vs. subjective). People comprehend risk through an informational mechanism, and this can either be through the analytic (scientific) or the experiential system, also known as “risk as analysis” and “risk as feelings” (Slovic et al. 2004). People use a variety of psychological mechanisms to make a judgment about risks. There are “mental short-cuts” called heuristics and risk images (Tversky and Kahneman 1974) that are modified continuously by several variables, including media reports and peer influences. Knowledge, experience, values, attitudes, and emotions also influence judgment about the seriousness and acceptability of risks (Slovic 2010; Madhuri et al. 2015; Hoffmann and Mutarak 2017; Rakib et al. 2017). Furthermore, trust and credibility (Frewer et al. 2003), power and expertise (Adekola 2020), and the phase of a disaster (Ryan 2013, 2018) play vital parts in shaping how a risk message is received and understood.

The relationship between risk communication, risk perception, and intention to act or take mitigating steps is conceptualized by the social cognitive model (Paton 2005) and protective action decision making framework (Lindell and Perry 2012). The social cognitive model identifies several factors (such as personal, environmental, and social conditions) that enable disaster risk preparedness. For example, the level of motivation combined with self-efficacy acts to shape intentions and preparedness for disaster

risk (Paton 2005). The protective action decision making framework, on the other hand, argues that the protective action decision-making process (exposure, attention, and interpretation) interacts with situational factors (threat, protective action, and stakeholder perceptions) to produce a behavioral response (Lindell and Perry 2012). In this context, clarity of information, language used, power, expertise, and trust (Adekola 2020) can affect how recipients understand risk information, and take appropriate action to protect themselves or others (Hansson et al. 2020). Similarly, Abunyawah et al. (2019) indicate that accessible, comprehensive, and tailored disaster information strongly influences intentions to prepare for disasters. The social-mediated crisis communication model (Austin et al. 2012) highlights the importance of the social network in facilitating information exchange.

Age, gender, and disability also disproportionately affect capabilities and opportunities to respond effectively to disaster risk reduction (Mayhorn 2005; Cutter 2017; Berget et al. 2020). Age-related perceptual and cognitive changes, such as attention and memory, may also impede understanding disaster-related communication (Mayhorn 2005). Cutter (2017) highlighted how gendered violence exacerbates the impact of disasters, and Berget et al. (2020) suggested that how disabled groups receive risk information is dependent on the type of impairment—cognitive, physical, sensory, or mental health—that may present challenges to comprehension, attention, language, and social skills (Berget et al. 2020)

3 Methodology

This study was carried out in the Annandale and Eskdale area, the eastern part of Dumfries and Galloway (Fig. 2). This area was identified as the most impacted area in the region during the BfE by a regional council official.² Annandale and Eskdale cover 156,286 ha, about a quarter of the Dumfries and Galloway region. Its neighbors are Nithsdale, South Lanarkshire, Scottish Borders, and Cumbria. The southern border of the area consists of the Solway Firth coastline. According to the Dumfries and Galloway Health and Social Care Strategic Needs Assessment report (2016–2019), more than half of the population lives in rural or remote areas with over 40,000 people living in the Annandale and Eskdale regional area (Dumfries and Galloway Council Integration Joint Board 2018).

At the time of the BfE event, there were several communication initiatives by both the Scottish Government and

Dumfries and Galloway Council to help individuals and communities prepare for weather-related emergencies.³ The Dumfries & Galloway Virtual Operations Support Team, for instance, is a communication tool used to provide key safety messages and real-time information to the public during emergencies while countering misinformation. It also aids better situational awareness for resilience practitioners by gathering useful data and information from the audience. Through its media outlets (for example, websites, Twitter, and Facebook pages), the Scottish Government provides advice to the public on weather-related emergencies.

This study strictly followed the University of Glasgow ethical committee approval process. Data were collected using a semistructured postal survey between June and July 2018, three months after the BfE disruption in the Dumfries and Galloway region of Scotland. A postal survey enabled the researchers to reach a larger population set as the study location is in a rural and dispersed community setting. We considered an online survey, but determined that this could eliminate an essential segment of the (aging) population.

One thousand postal questionnaires were sent out to residents within postcode areas DG11 and DG10 in the Dumfries and Galloway edited electoral register. There are approximately about 5000 residences within these areas. D&G has 15 postcode areas, with DG10 and DG11 covering the Moffatt and Lockerbie areas, respectively. Participants were given three weeks to return their responses in a prepaid envelope. One hundred eighty completed surveys were returned, representing 18% of the 1000 postal surveys sent out. Three of the 1000 envelopes were returned as failed deliveries.

Average wages in D&G are significantly lower than average wages in Scotland (Crichton Institute 2014). Due to the aging population (at least 22% of the population are above 65 years old), wages would most likely be just one element of the income equation (Hill and Clelland 2015). About 33% of the adult population (16 years and above) of the Dumfries and Galloway area have no qualifications. This is higher than Scotland's average of 27% (Dumfries and Galloway Council 2020).

Table 1 reflects the study respondents' characteristics, and this was compared with existing data in the surveyed, regional, and national areas. Data for the latter were extracted from the 2011 census and the Crichton Institute's Annandale and Eskdale local area profile. The data suggest a similar gender split in Annandale and Eskdale area, Dumfries and Galloway, and Scotland with a slightly higher number of females than males (a difference of around 3%) with 2% more males than females in this study. In terms of the study participants' age characteristics, 18 to

² Resilience and Community Safety Manager at Dumfries and Galloway Council. Informal face to face discussion on suitable study site.

³ See, for example, readyscotland.gov, dumgla.gov.uk, dgvost.uk.

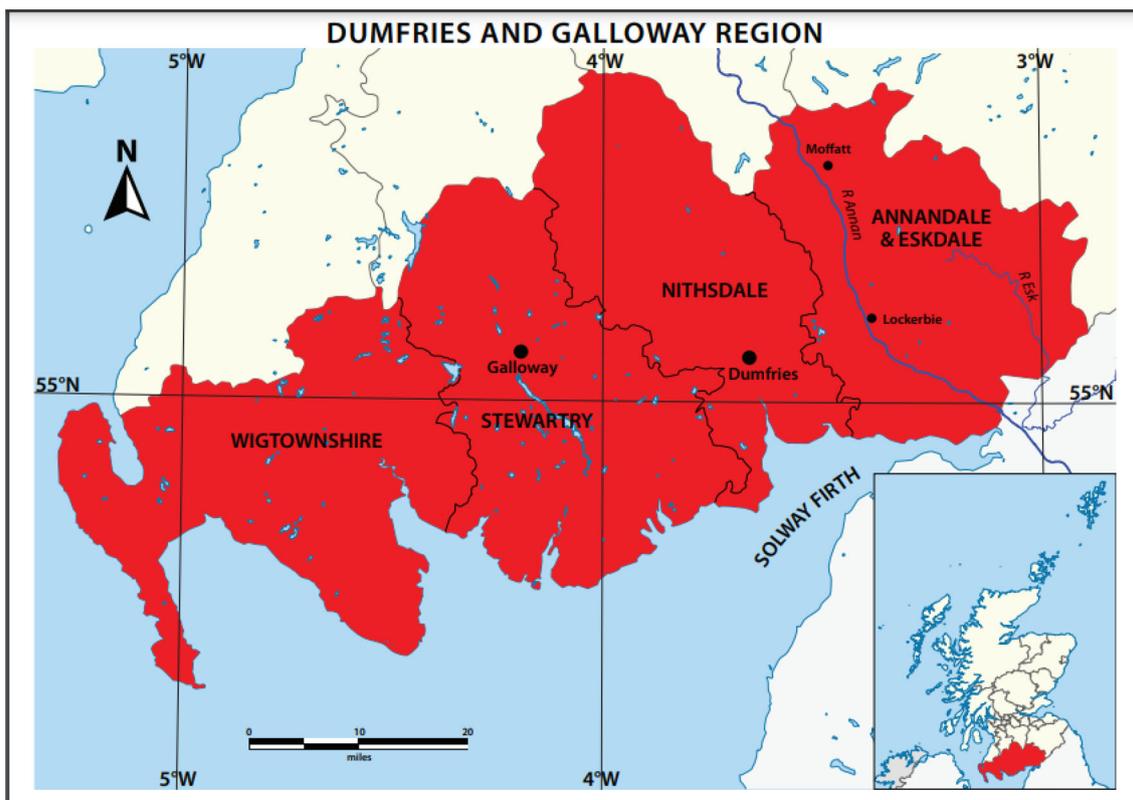


Fig. 2 Map of Dumfries and Galloway in southwestern Scotland

Table 1 Respondents and regional characteristics in Dumfries and Galloway, Annandale and Eskdale, and Scotland

Sample	Gender			Age					A long-term health problem or disability		
	Male	Female	Missing Info	18–24	25–40	41–60	60+	Missing Info	Non-disabled	Disabled	Missing/prefer not to Say
Surveyed	51.7%	47.2%	1.1%	3.3%	6.7%	33.9%	55.6%	0.6%	75.6%	13.9	10.5%
Sample	Male	Female	Missing Info	0–24	25–44	45–64	65+	Missing Info	Non-disabled	Disabled/long term illness	Missing/Prefer not to Say
Annandale and Eskdale Area	48.8%	51.2%	0%	25.9%	21.6%	30.4%	22.1%	–	79%	21%	–
Dumfries and Galloway	48.5%	51.5%	0%	26.2%	21.7%	30.2%	21.8%	0.1%	68%	22%	–
Scotland	48.5%	51.5%	0%	29.2%	26.4%	27.4%	16.8%	0.2%	80.4%	19.7%	–

24-year old accounted for 3.3%, and 25 to 40-year old accounted for 6.7% of those surveyed. 41 to 60-year old made up 33.9% and 60+ years made up 55.6% of those surveyed. This means an over-representation of the 60+ years and under-representation of the under 40 years in this study when compared to the official regional data. This discrepancy is taken into account when interpreting our

data. In terms of ability, the proportion of people with a form of identified disability in the Annandale and Eskdale area, Dumfries and Galloway, and Scotland are 21%, 22%, and 19.7%, respectively; these are higher than the 13.9% of our respondents who identified themselves as having some form of disability.

These data were first entered into an excel spreadsheet and then transferred to IBM SPSS statistics 24 for analysis. Qualitative text in the comment box (of the semistructured survey) was reviewed to shed further insights into the quantitative data. Qualitative quotes are taken Verbatim. The cross-group analysis was conducted using descriptive statistics and codebooks and identifying mean, median, and mode. Missing values were excluded. We compared means using Kruskal Wallis, nonparametric, and one-way analysis of variance techniques (Siegel and Castellan 1988) to compare across gender, age, and disability. Nonparametric testing does not assume the distribution of data (Pallant 2013) and is useful for this study given the differences in the number of respondents that identified themselves as nondisabled ($n = 136$) and disabled groups ($n = 25$). Therefore, we take care in accepting or making interpretations between disabled and nondisabled groups due to the nature of the data distribution.

4 Results and Discussion

The primary data reflect questions around public use of information sources in preparation for and response to the BfE, and the BfE risk communication effectiveness. Our analysis also reflects on the relationship between risk information received and intention to act.

4.1 Prior Experience of Heavy Snow

We first sought to understand the respondents' previous experience with the snow event as an "experience," which is identified as a critical factor in shaping risk perception and behavior (Lawrence et al. 2014). Respondents were asked to select all that apply from a list of possible answers.

Our analysis suggests that most of the respondents had experienced previous heavy snowfall disruption in the past. This is expected as cold and heavy snow disruptions are common occurrences in Scotland during winter. Among those with experience, 130 respondents had experienced disruption to daily lives, 22 respondents had experienced damage to property and belongings, 6 respondents had experienced physical and 1 respondent encountered mental health challenges following a substantial snow disruption. The remaining 38 of 180 (21%) respondents in this study indicated that they had no prior experience with heavy snowfall, which may be explained by migration into the region from other warmer regions. The Dumfries and Galloway Health and Social Care Strategic Needs Assessment report (2016–2019) estimates that the net annual average migration into the area is 604 migrants

(Dumfries and Galloway Council Integration Joint Board 2018).

4.2 Use of Information Sources During the "Beast from the East"

To determine the use of information sources in the search for risk information during the BfE, we asked respondents where they would go for information about heavy snow if there were a warning alert. Respondents were asked to choose all that applied from a series of potential information sources (Table 2).

Data from the respondents suggest that most of the respondents used public authority sources such as the MET Office (80.6%) and Transport Scotland (46.7%), and online and web sources (47.2%). Recent advances in information and communication technologies mean that public authorities use both mainstream (TV, radio) and social media when communicating with the public about disaster risk. Due to critical information communication disruption during and after environmental disasters, however, other studies such as Burger et al. (2013), Steelman et al. (2015), and DeYoung et al. (2016) found that the public relied more on traditional sources and channels of information (TV, radio, friends) in environmental-related emergencies. Other used sources of information are social media (35.6%), friends, family, and neighbors (30.6), and emergency services (22.2%). The local newspaper (7.8%), local councils (4.4%), community center (2.2%), and members of the community council (1.1%) rated lower. There was no distinction made between information "sources" and "channels," and therefore, it should be considered a limitation in this study. The option of mainstream media (such as TV and radio) was not explicit, but some of the respondents noted TV and Radio in the "other" option. Further research should consider making this distinction between information "sources" and "channels" for a more thorough analysis.

One interesting finding is that despite the over-representation of 60+ years old respondents in this study, online sources for risk information sources were used extensively, suggesting that this age group is increasingly seeking information using the Internet and web sources. This is similar to several studies such as König et al. (2018), van Deursen and Helsper (2015), and Simonova et al. (2020). For example, König et al. (2018), in their study involving over 60,000 Europeans above the age of 50, found a considerable proportion of Internet use among the elderly. Age, as well as prior experience of Internet use, social network, regional context, and social structure were found to be key determinants of the elderly use of the Internet and web sources (Deursen and Helsper 2015). Simonova et al. (2020) also found a relationship between age and Internet

Table 2 Actual and intended use of information sources

Information sources	No. of actual usage		No. of intended usage	
	Frequency	Percentage	Frequency	Percentage
MET Office	145	80.6	121	67.2
Online and web	85	47.2	101	56.1
Transport Scotland	84	46.7	76	42.2
Social media e.g. Facebook	64	35.6	56	31.1
Friends, family, and neighbors	55	30.6	41	22.8
Emergency services e.g. police, fire	40	22.2	40	22.2
Local newspaper	14	7.8	12	6.7
Others	13	7.2	18	10
Local council officials	8	4.4	14	7.8
Community forum/center	4	2.2	5	2.8
Member of the community council	2	1.1	3	1.7

use, with older people using the Internet mostly for socializing, information search, and explorative purposes with additional benefits such as improvement in cognitive flexibility (Mohta and Hadler 2020). Our results suggest that Internet and web sources are increasingly becoming an important source of disaster risk information among the elderly population and should be exploited to communicate about disaster risk to elderly groups, considering its cognitive-improvement benefits.

We found no statistically significant differences in respondents' selection of intended sources of use and actual use of information sources. We distinguish between "intended sources" and "actual use" of information sources as people may want to use specific sources but may be constrained in terms of resources to do so, for example, by lacking either permanent or temporary access to the Internet for social media use. It must be noted that the nature of access or constraint to sources/channels of information will impact on the intention to use that sources/channels of information. For instance, where there is access constraint to certain channel/source of information, the intention to use that source/channel is likely to be low and vice versa. Our data show a substantial increase in the actual number of respondents who used MET Office and Transport Scotland information sources when compared with the intended usage of the sources. On the other hand, there was a 9% reduction between intended (56.1%) and actual (47.2%) use of online and web sources. Local newspaper sources moved two ranks upwards from the bottom three when comparing between intended and actual usage of information sources. Steelman et al. (2015) found that the newspaper was the second most used source in their study of five wildfires, with newspapers becoming

more prominent as an information source as the disaster prolongs (Quarantelli 2002).

We compared groups across gender, age, and disability using the Kruskal-Wallis nonparametric technique (Pallant 2013) to identify any differences in the use of information sources. If the significance level is less than 0.05 ($p < 0.05$), a statistically significant difference exists between groups. Our analysis found statistically significant differences in the use of information sources between age and gender and no statistically significant difference in the use of information sources between nondisabled and disabled groups. Further analysis is presented in Table 3.

In terms of gender, there was a statistically significant difference ($p = 0.02$), with male respondents having a higher mean rank value (95.35) when compared to female (83.09) in the use of MET Office sources. Women scored a higher mean rank value for the use of social media (95.19) compared to male groups (87.78), but this was not statistically significant ($p = 0.09$). This finding aligns with the result of Shaw and Gant (2002) and Booker (2018), who noted a slightly higher percentage of female use of social media when compared to males in a developed country context. Future research should consider the extent to which this finding compares to the context of developing countries, where women experience greater difficulty in accessing IT services and have lower IT skills that create conditions for greater reliance on search for information from their local network. Larger sets of data may be needed to ascertain any differences in how males and females use social media in search of disaster risk information.

In terms of age group, we found a statistically significant difference between age groups in their use of emergency services sources (for example, police and fire) and social media. The mean rank rated highly for 41 to 60-year old,

Table 3 Differences across gender, age, and disability in the use of information sources

Information sources	MET Office	Online and Web	Transport Scotland	Social Media	Friends, Family, and Neighbors	Emergency Services	Local Newspaper	Others	Local Council Officials	Community Forum/Center	Members of Community Council
<i>Gender</i>											
M	78 (53%)	38 (45%)	53 (63%)	30 (47%)	29 (54%)	24 (60%)	8 (57%)	7 (54%)	4 (50%)	2 (50%)	1 (50%)
F	66 (45%)	46 (54%)	29 (35%)	32 (50%)	23 (43%)	15 (38%)	6 (43%)	4 (31%)	4 (50%)	1 (25%)	1 (50%)
Prefer not to say	2 (1%)	1 (1%)	2 (2%)	1 (2%)	2 (4%)	1 (3%)	0	2 (15%)	0	1 (25%)	0
Total	146	85	84	64	54	40	14	13	8	4	2
<i>Age</i>											
18–24	4 (3%)	5 (6%)	3 (4%)	3 (5%)	0	1 (2%)	0	0	1 (17%)	0	0
25–40	11 (8%)	9 (11%)	6 (11%)	6 (9%)	3 (6%)	3 (8%)	0	4 (31%)	1 (17%)	0	0
41–60	47 (32%)	29 (34%)	19 (23%)	22 (34%)	18 (33%)	10 (25%)	6 (38%)	9 (69%)	2 (25%)	1 (25%)	0
60+	83 (57%)	42 (19%)	55 (66%)	32 (50%)	32 (59%)	25 (63%)	8 (57%)	0	4 (50%)	2 (50%)	2 (100%)
Prefer not to say	1 (0.7%)	0	1 (1%)	1 (2%)	1 (2%)	1 (2%)	0	0	0	1 (25%)	0
Total	146	85	84	64	54	40	14	13	8	4	2
<i>Nondisabled/disabled (ND/D)</i>											
ND	128 (88%)	65 (77%)	57 (68%)	50 (78%)	38 (70%)	31 (76%)	11 (79%)	7 (54%)	7 (88%)	3 (75%)	2 (100%)
D	2 (1%)	14 (17%)	13 (16%)	8 (13%)	9 (17%)	4 (10%)	2 (14%)	4 (31%)	0	0	0
Prefer not to say	16 (11%)	6 (7%)	14 (17%)	6 (9%)	7 (13%)	5 (13%)	1 (7%)	2 (15%)	1 (13%)	1	0
Total	146	85	84	64	54	40	14	13	8	4	2

which scored the highest mean rank score of (102.10) in the use of emergency services. Other ratings are 25 to 40 years (99.67), 18 to 24 years (84.83), and 60+ years (80.79). In terms of the use of social media, 18 to 24 years scored the highest mean rank score of (147.50), followed by 25 to 40 years (117.67), 41 to 60 years (104.95), and 60+ years scoring the lowest mean score for social media use (74.11). This suggests that social media is a beneficial information source for the younger population. Despite differences in social media use, there were no significant differences between age, gender, and disability in the use of online and web sources.

4.3 Usefulness, Reliability, and Clarity of Information Received during the “Beast from the East”

We asked respondents to rate the usefulness, reliability, and clarity of the information received (Table 4). Public authority sources rated highest in terms of usefulness, reliability, and clarity of the risk information communicated with the public regarding heavy snow. Online and web sources, social media, family, friends, and neighbors, and emergency services sources are also rated highly. Family, friends, and neighbors were particularly found to be most useful during the early stages of a disaster but less often as the disaster progressed (Rundblad et al. 2010). Local newspapers and other sources rated highly in terms of clarity only, as the data suggest that these sources are often not relied upon or used in the case of snow emergencies. Local council officials, community centers, and community council members also rated low in terms of usefulness, reliability, and clarity of information.

We further compared the reliability, clarity, and usefulness of the information received across age, gender, and disability. Only one statistically significant difference was found between social media and age in the usefulness of social media sources. Further analysis of social media use and age did not reveal further insight. More research is needed to understand the use of information sources by those living with disabilities in different types of disaster contexts.

4.4 The Effectiveness of “Beast from the East” Risk Communication and Intention to Act

To ultimately assess public perception of risk communication effectiveness in preparation for and response to the BfE disruption, we identified 10 variables of effective risk communication between authorities and the public—following examples assessed by Breakwell (2000), Covello (2003), Covello et al. (2012), and Williams et al. (2018) among others. These included consistency of messages, simplicity of language used, and the usefulness of the Internet and social media. Other variables are trusted information provider, trust in communication channels, live and regular risk information updates, completeness of the information received, timeliness of information received, two-way communication, and burning questions answered. Respondents were asked to rate the extent to which they agreed with these 10 variables on a scale of 0 to 5. A score of 0 means not applicable, 1 means strongly disagree, and 5 means strongly agree. Eight of the 10 variables scored a median score of 4, which suggests that risk communication during the BfE to a large extent was deemed effective as respondents agreed that there was the consistency of information shared between the public and

Table 4 Reliability, clarity, and usefulness of risk information received (0 = n/a, 1 lowest score, 5 = highest score)

Information sources	Reliability of Sources Median	Clarity of Information Median	Usefulness of Information Median
MET Office	5	4	4
Online and web	4	4	4
Transport Scotland	4	5	4
Social media e.g. Facebook	4	4	3
Friends, family, and neighbors	3	4	3
Emergency services e.g. police, fire	4	4	3
Local newspaper	0	4	1
Others	0	4	1
Local council officials	0	3	2
Community forum/center	0	3	1
Member of community council	0	2	1

Table 5 Advice received during the “Beast from the East” from official sources

Advice received	Frequency	Steps taken	Frequency
Do not travel	157	Did not travel or leave home during the red and amber warning	116
Things to consider before traveling	102	I ensured I had enough fuel in case of supply disruption	95
Keeping warm	71		
How to drive safely	48	I drove slowly in icy conditions (during and after the red and amber warning)	112
Information about relevant resources, e.g. emergency number	30	I identified all potentially useful information sources	34
Information about organizations to get help from	15		
Did not receive any advice	11	I did nothing for other reasons	4
Other	5	I did nothing because I did not trust the information sources	1

authorities, the languages used were simple to understand, and Internet and social media sources were useful. Trust in the information provider and communication channel, regular updates from authorities, and timely and complete information rated highly too. The lowest median scores (2) were one-to-one communication with authorities and relevant questions being answered.

We further compared the effectiveness of the risk communication during the BfE across age, gender, and disability. Our analysis shows no statistically significant differences except, again, for age and social media use. Further analysis of age and social media use did not reveal further insight. To shed further insight into the nature of the relationship between risk communication, risk perception, and intention to act, our analysis compared the data on the risk advice received and steps taken as a consequence during the BfE event. Participants were asked to select all responses that applied.

Data in Table 5 suggest that most of the respondents received advice not to travel (157) and information on what to consider before traveling (102) if they must do so; 71 respondents indicated that they had information on keeping warm and a further 48 reviewed how to drive safely in snowy conditions; an additional 30 respondents noted that they received information about relevant emergency resources; 15 participants received information about organizations that offer help; and 11 respondents acknowledged that they had received no prior advice. Our analysis also shows that most of the respondents (116) did not travel during the red and amber warning; 112 of the respondents who travelled during and in the immediate period after the warning period took precautionary measures by driving slowly in icy conditions, and 95 of the respondents bought enough fuel to deal with potential disruptions to fuel supply. Four of the respondents did nothing and one respondent did nothing due to trust issues. This shows that the majority of the respondents in this

study adhered to the risk advice received by taking precautionary measures similar to Wachinger et al. (2013) and Yang et al. (2020). Yu et al. (2020) noted that self-efficacy plays an enabling or inhibiting role in adhering to risk advice. Of the respondents, 85% were very likely or likely to follow future guidance, 7.8% were somewhat likely, and another 2.3% were not sure or not likely to follow future advice.

We sought further insight from the qualitative data collected in the semistructured survey to understand potential barriers to the uptake of official advice. Employer’s expectations, financial commitment, and work obligations were identified as the key barriers to taking up official risk advice. Quotes in the survey say: “Work obligation means that you must attempt to travel to work unless the road is closed by snow or several feet deep.” “[We were] advised not to travel by police/media. Yet employer XXX does not pay staff who can’t get to work.” “Employer expectations.”

A key lesson here is that taking up formal risk advice is not only a function of the effectiveness of the risk communication process per se, but other intervening variables determine if people adhere to official risk advice. This shows a nonlinear relationship between risk communication and intention behave as illustrated in Fig. 1.

5 Conclusion

Understanding how to communicate risk and safety information effectively with different public groups is vital to building community resilience to environmental hazards. Therefore, policymakers and resilience practitioners charged with communicating risk must understand the most effective medium to communicate risk to targeted groups and the whole population. Our analysis suggests that the most commonly used source of information for

heavy snow disaster preparedness were public authority sources such as the MET Office and Transport Scotland. Online and web sources were also highly rated and may be used by public authorities and unofficial sources. Grein et al. (2000) suggested that unofficial sources tend to be the initial source of information providers compared to formal information providers and is especially so where there is an information gap or lack of information from formal authorities. As there is a high reliance on official sources through traditional and web media in environmental hazards and emergencies, as evidenced in this study, timely information from formal sources is crucial to avoid misinformation or fake news from informal sources, which are often the first information provider. An interesting finding in our study is that despite the over-representation of 60+ years old individuals in our study, online sources as providers of risk information rated highly, suggesting a considerable proportion of Internet use among the elderly.

When we compared across age, gender, and ability groups, our analysis found statistically significant differences in the use of information sources between age and gender, but no statistically significant difference in the use of information sources between non-disabled and disabled groups. Women scored a higher mean rank value for the use of social media than the male groups, similar to other studies such as Shaw and Gant (2002) and Booker (2018). But further studies that draw on a larger data set should substantiate how males and females use social media for disaster risk preparedness. We found that while age was a critical factor in the use of the Internet and social media sources, our study found a good level of use among the elderly population. Younger groups between 18 to 24 and 25 to 40 scored highest in their social media source use, which shows this channel should actively be used in communicating environmental disaster risk when communicating with the younger groups.

The data suggest that there is generally a good understanding among the general public of potential harm from heavy snow and self-confidence in their ability to respond. Knowledge on how to protect self and properties ranked slightly lower. The comparison between disabled and nondisabled groups showed no significant difference in the knowledge and understanding of heavy snow risk. Nevertheless, there is a need for people living with disabilities to be included in resilience planning; hence, encouraging a bottom-up approach to resilience planning is desirable (Wolbring 2009).

Our data also reveal a relationship between risk communication, risk perception, and willingness to mitigate disaster risk, similar to Wachinger et al. (2013). Still, other intervening variables determine if people adhere to official risk advice or not, and this may include the employer's expectations, financial commitments, and work obligations.

We argue that where full adherence to official risk advice is required, politicians and community resilience practitioners should carefully consider work obligations and stakeholder expectations.

Like previous risk communication literature, we conclude that an effective risk communication strategy targeted at the entire population should consider the heterogeneity of the different public groups in society as to how they use information sources to inform their risk perception and disaster preparedness. This is essential to effectively communicate risk with the entire population or public groups deemed to be specifically at-risk. An area for further research is to see how the indicative findings in this study on the information seeking behaviors of individuals in snow disaster preparedness compare with information seeking behaviors in other types of hazards or disaster scenarios and also across communities, countries, or regional context (for example, urban communities, developing countries).

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