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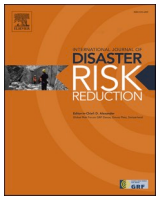

Enhancing tourists' safety in volcanic areas: An investigation of risk communication initiatives in Iceland

Deanne K. Bird [a,*], Guðrún Gísladóttir [a,b]

[a] Faculty of Life and Environmental Sciences, University of Iceland, Iceland
[b] Nordvulk, Institute of Earth Sciences, University of Iceland, Iceland

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ABSTRACT

Providing accurate and timely hazard warnings to residents in Iceland is a difficult task despite authorities being familiar with the at-risk population. A more challenging task is communicating that same information with a transient population i.e., the increasing number of tourists who visit Iceland and engage in activities on and around Iceland's volcanoes. Increased tourism results in greater numbers of tourists exposed to potentially harmful and life-threatening situations. To enhance awareness of these potential situations, authorities rely on risk communication initiatives. This paper examines people's perceptions and beliefs with respect to risk communication initiatives and, behaviour in volcanic environments. Data informing this research was captured through focus group discussions, interviews and questionnaire surveys in a longitudinal study conducted from 2009 to 2017 and involved a range of stakeholders: tourists, tour guides and operators, local police, government officials, rescue team members, local residents and, disaster risk reduction academics, practitioners and professionals. The aims of interrogating these datasets are to: 1) identify whether risk communication initiatives are enhancing or have the potential to enhance tourists' safety and 2) provide evidence-based recommendations to inform the continual improvement of risk communication strategies within the tourism sector. This work is critical given the economic significance of tourism in Iceland and the frequency of volcanic eruptions and other natural hazard events. The results suggest that while these initiatives are reaching some people, they are not accessible to the majority and are therefore ineffective, in their current form, at enhancing tourists' safety. The results also show that tourists are generally not risk averse, highlighting the considerable challenges communicators face. In light of these challenges, we must continually strive to ensure that tourists are well equipped to make informed decisions to prevent injury and fatality. It is imperative that the sector as a whole is actively involved in risk reduction strategies. This includes long-term and ongoing commitment to regularly distributing consistent hazard, risk and response information through all available channels so that when a warning is issued it does not come as a surprise; and, ensuring risk communication information and tools meet the needs of the intended audience. The importance of this research extends beyond Iceland's volcanic environment, given the occurence of death and injury associated with nature-based tourism worldwide. To enhance tourists' safety, governments and the tourism sector as a whole, must invest greater resources and commitment to ensure tourists have access to accurate and up-to-date information so they can make informed decisions about their travel choices.

1. Introduction

Tourism is a fast growing industry in Iceland, from 651,324 visitors in 2009 to over 2 million in 2016 [1], contributing 8.4% to the GDP in 2016 [2]. Iceland's wilderness landscapes of glaciers, volcanoes and black sandy beaches are key attractions, particularly in South Iceland [3–5]. The natural processes that shape these landscapes, however, expose tourists to potentially harmful and life-threatening situations. It is questionable whether tourists are familiar with these natural processes and associated hazards and, more importantly, the recommended actions to ensure personal safety within these environments.

Underlying the Mýrdalsjökull icecap, situated in the heart of South Iceland, is the Katla volcano. Katla is renowned as one of the country's most dangerous volcanoes due to its potential to produce catastrophic

* Corresponding author.
E-mail address: dkb@hi.is (D.K. Bird).

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jökulhlaup (>100,000 m^3s^{-1}) within 1½ to 2 h [6,7]. Jökulhlaup are a sudden burst of meltwater emanating from a glacier, often caused by a subglacial eruption and warranting the need for an immediate response to evacuation orders. In addition to jökulhlaup, other volcanogenic hazards of concern are tephra fallout, lightning, earthquakes, lava flows, poisonous gases, pyroclastic density currents and tsunami [8]. Together with Katla, the Hekla, Grímsvötn and Bárðarbunga volcanoes (Fig. 1), and their associated fissure systems, have the highest eruption frequency in Iceland [9]. Of more recent concern is the Öræfajökull volcano where unrest has warranted the development of additional emergency response plans for this region [10,11]. All these systems are located in South Iceland.

While fatalities are not commonly associated with volcanic hazards in Iceland, there is an increasing likelihood that fatalities will occur in the future with the increasing number of tourists frequenting active regions [8]. In some areas, tourists ignore warning signs [12–14] placing themselves and first responders at risk. This risk-taking behaviour, however, is not isolated to international visitors; domestic tourists are also vulnerable, as evidenced by two fatalities during the 2010 Eyjafjallajökull eruptions. These fatalities were not the result of volcanogenic hazards but rather hypothermia as a result of thrill-seeking behaviour in order to access a better view of the eruption [15].

Internationally, Brown, Jenkins [16] note a large proportion of tourist fatalities at particular volcanoes (e.g., Yellowstone and Kilauea in the United States and Rotorua in New Zealand). The unique challenges of ensuring safety in volcanic environments is the particularly large and diverse array of volcanic hazards that have the potential to cause death or injury. Multiple hazards often occur at the same time with each requiring 'bespoke decisions, actions, and warnings' [17; p.751]. Excluding local residents, Brown, Jenkins [16] show that tourism-related fatalities far exceeded those among scientists, miners, emergency response personnel and the media. The majority of these fatalities occurred during an eruption (480 fatalities during 69 fatal incidents) and were the result of ballistics.[1] The majority of fatalities that occurred during times of quiescence (81 fatalities during 44 fatal incidents), when volcanic hazards are less obvious, were the result of dangerous levels of toxic volcanic and geothermal gases with the vast majority of deaths documented in New Zealand and Japan. These numbers do not include the most recent tragic event at Whakaari/White Island, New Zealand where 21 tourists and tour guides died during an eruption in December 2019.

Tourists, however, are not just vulnerable to injury or death in volcanic regions. Gstaettner, Kobryn [18] report a large number of fatalities worldwide among visitors involved in nature-based recreation and tourism on lands and waters managed by public authorities. These fatalities resulted from a range of activities including walking along or climbing cliff faces, hiking during extreme heat and while snorkelling and swimming. Bentley and Page [19] note that inexperience and unfamiliarity with the local environment, as well as a propensity to ignore instructions, as contributing factors to death and injury to tourists involved in marine, mountain and wilderness-based activities. Other studies have noted fatalities resulting from: illegal cliff jumping into natural swimming holes; disobeying warning signs around ocean cliffs; risky selfie behaviour; and, dangerous rock fishing [20].

The aforementioned fatalities highlight the fact that more needs to be done globally, to ensure tourists' safety in hazardous areas. While ignorance of warning signs, lack of skills and local knowledge and, thrill-seeking behaviours among those visiting hazardous areas will still occur, we must continually strive to ensure that tourists are well equipped to make informed decisions about their own safety.

Brown, Jenkins [16] suggest that fatalities among tourists may be reduced through restricting access to hazard zones, along with warnings and education. Restricting access to hazard zones in Iceland, however, is beset with significant challenges given the extent of the geothermal, glacial and volcanic landscapes that span the country – the very landscapes that tourists seek to experience. Authorities therefore rely on risk communication initiatives to promote personal safety within these environments.

Risk communication is undertaken to: 1) inform at-risk populations about the probability of a natural hazard occurring and its likely consequences and, 2) encourage the sustained adoption of measures to reduce risk and enhance safety [21]. In a broad context, risk communication aims to prompt people to redefine the environment they are in, from one that is safe to one that contains an imminent (disaster warning) or possible threat (hazard education) [22]. Mileti, Nathe [23] assert that warnings and education are not the same – education serves to enhance awareness independent of an imminent threat whereas warnings communicate information regarding imminent threats. While a volcanic landscape may seem innocuous, potentially lethal hazards can occur without warning and during times of quiescence. Therefore, both education and warnings are critical to inform tourists of imminent and potential threats and the actions they can implement to reduce their risk.

In this paper, we focus on risk communication initiatives that serve to educate and warn tourists of potential and imminent threats along with recommended actions to ensure personal safety in relation to Katla, the tourist region of Þórsmörk and Iceland more broadly. The primary initiatives were the 'Eruption Emergency Guidelines' brochures and the 'Katla-Mýrdalsjökull' signs for mountain huts and along hiking trails. These brochures and signs describe the volcano Katla, its associated hazards and actions people can take to reduce their risk. Also described in the brochures and on the signs was the original warning system that consisted of flares to be released by hut wardens if a Katla eruption is imminent or has commenced. In response to improved mobile telephone service coverage across South Iceland, tourists in the region will now receive warnings via an SMS to their mobile telephone. The original Eruption Emergency Guidelines brochures and Katla—Mýrdalsjökull signs, however, were still in use at the time of writing.

More recent government initiatives include the Safe Travel website and 112 app. The Safe Travel website provides detailed information on how to travel safely in Iceland, including current alerts in addition to weather and road conditions. It also allows people to upload their travel plans so that search and rescue teams have locational details to act on if needed. Linked to this website is the 112 app with two functions: a red 'Emergency' button that when pressed alerts the response centre of the phone's location and, a green 'Check In' button that records and stores the phone's location (storing the last five locations) again, providing search and rescue teams with locational detail to act on if needed. In an effort to promote personal responsibility for safety while travelling in Iceland, the 'Inspired by Iceland' campaign asks tourists to agree in writing to respect nature and avoid certain risk-taking behaviours (Fig. 2).

All of these initiatives have been implemented since 2006, which corresponds with longitudinal research the authors have conducted in South Iceland [4,5,15,25,26]. This paper draws on that data to examine people's perceptions and beliefs with respect to risk communication initiatives and, behaviour in volcanic environments. The aims of this paper are to: 1) identify whether these initiatives are enhancing or have the potential to enhance tourists' safety and 2) provide evidence-based recommendations to inform the continual improvement of risk communication strategies within the tourism sector. While the first aim is focused on risk communication initiatives in Iceland, the second aim examines the key issues, challenges and successes of these initiatives to make recommendations that can be used more broadly to enhance tourist safety in other hazardous areas in Iceland and around the world.

[1] Ballistics are fragments of lava or rock ranging in size from a few centimetres to a few metres that are ejected from a volcano during an eruption.

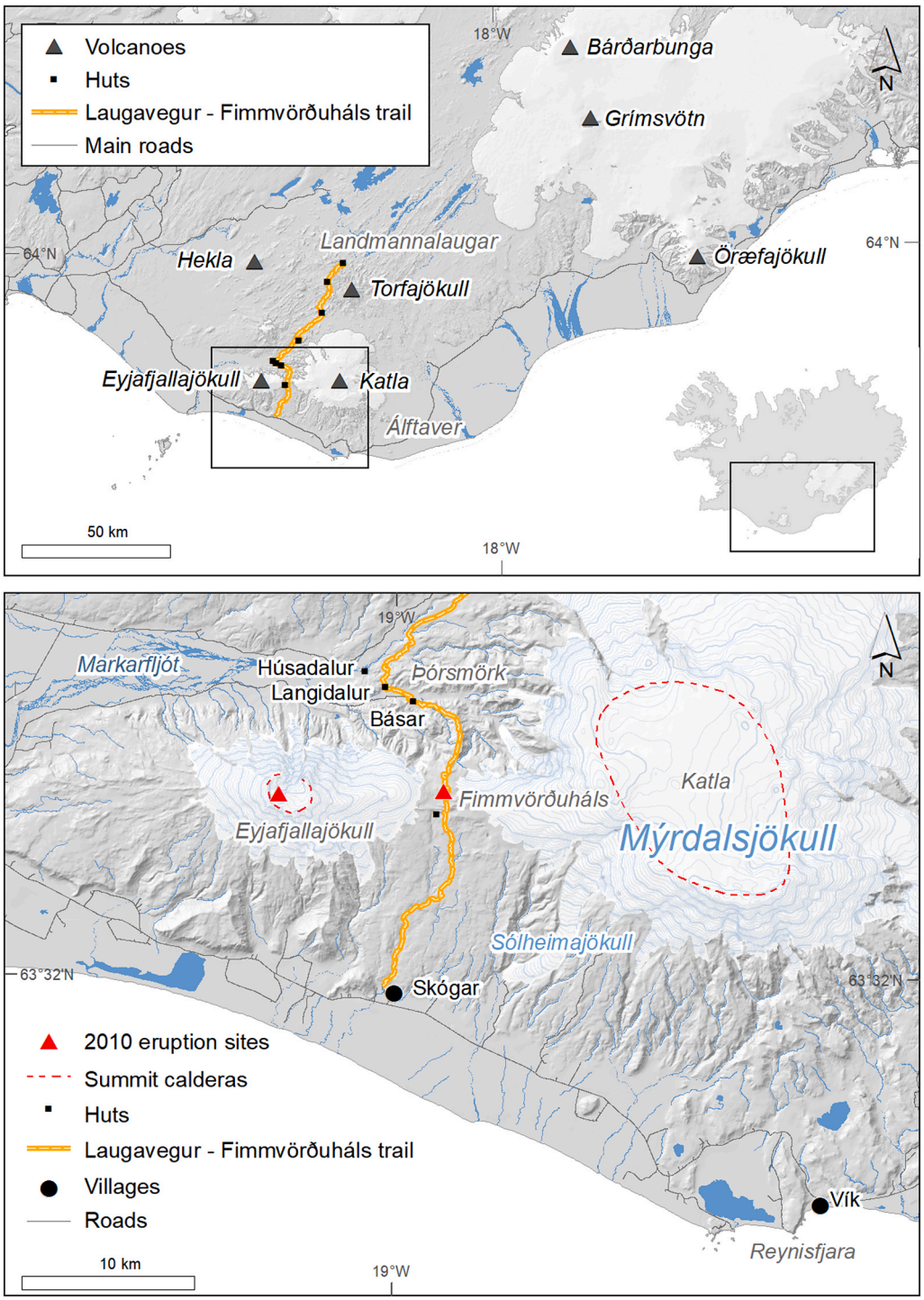

Fig. 1. The top image depicts the volcanoes of South Iceland. The bottom image is an enlargement of the tourist area of Þórsmörk, showing the mountain hut areas, hiking trail and 2010 eruption sites. Map produced by Emmanuel Pagneux.

Given the significance of tourism [27] and the frequency of natural hazard events in South Iceland,[2] it is critical to examine people's perceptions and beliefs with respect to risk communication initiatives and, behaviour in volcanic environments to identify opportunities to improve current practices. Furthermore, with the occurence of death and injury associated with nature-based tourism worldwide, this research is of international importance. Until recently, few studies have explored tourists' perceptions and beliefs with respect to risk communication and warnings or, interrelationships between tourist behaviour and natural hazard environments.

The following section describes the multiple forms of inquiry applied during the longitudinal study and the components of that research that are of import to this paper.

[2] In addition to volcanic eruptions, South Iceland experiences earthquakes, flooding, sneaker waves (or king waves) and extreme weather including wind and snowstorms.

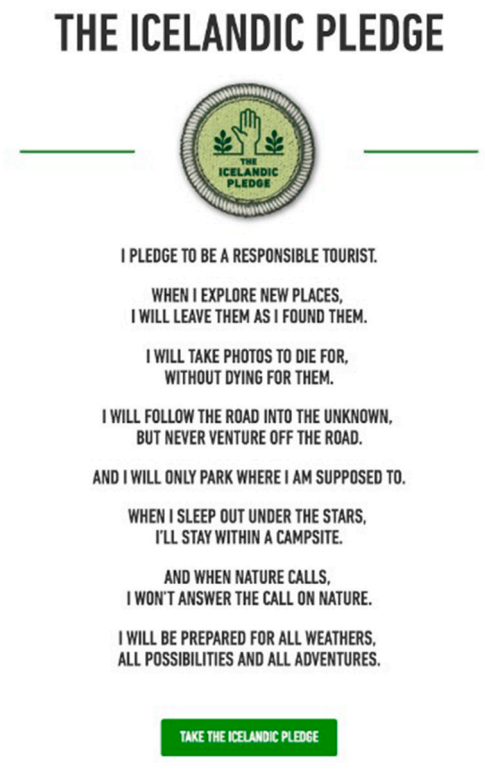

Fig. 2. An 'Inspired by Iceland' initiative asking tourists to take an 'oath' to respect nature and always travel responsibly [24].

2. Methods

Following a pilot survey in 2006 [26], face-to-face questionnaire interviews were conducted in the tourist region of Þórsmörk, South Iceland from July to September 2007 and 2009 to investigate tourists' and tourism employees' hazard knowledge, risk perceptions, adoption of personal preparedness measures and, predicted behaviour if faced with a Katla eruption. Results of the 2007 dataset have been published by Bird, Gísladóttir [4] and some combined 2007 and 2009 data is published by Bird and Gísladóttir [5]. Semi-structured interviews and a questionnaire were used in August 2010 to identify lessons learnt during the 2010 Eyjafjallajökull eruptions. Much of that research has been published elsewhere [15,25,28]. Further interviews were carried out in 2016 to examine advancements in emergency response strategies and explore regional economic, demographic and political changes. While some of that data is also published [see 29], this paper explores the unpublished data from 2016, 2010 and 2009 specifically relating to peoples' perceptions and beliefs with respect to risk communication initiatives and, behaviour in volcanic environments. This data includes views from tourism operators, tourism guides and emergency management officials.

A detailed description of the methods applied in each of these studies is given in the associated published literature, as outlined above. However, in addition to the 2009 face-to-face questionnaire interviews with tourists (n = 105) and tourism employees[3] (n = 19)[4] from July to September 2009, the authors conducted an hour-long focus group discussion with five hut wardens in the Þórsmörk region in July 2009. This focus group followed a semi-structured format in line with the key topics of the questionnaire and was convened, mediated and recorded by the two authors, with the lead author facilitating the discussion. The purpose of this focus group was to initiate an in-depth discussion on risk communication, hazard warnings and emergency response training. Furthermore, two interviews were undertaken with officials from the local police and the Department of Civil Protection and Emergency Management (DCPEM). These interviews also focused on risk communication, hazard warnings and emergency response training in addition to observed behaviour among tourists in South Iceland.

The Eyjafjallajökull eruption began on 20 March 2010 when very few tourists were in the region. Survey research carried out post-eruption, in August 2010, therefore focused on the residents' and officials' experience in relation to their preparedness and response. Nevertheless, the authors captured various perspectives relating to the tourism sector. This was achieved through open interviews with hut wardens in Húsadalur, Þórsmörk, in addition to residents, officials and rescue teams members as described by Bird and Gísladóttir [29].

Based on the results of the 2009, 2010 and 2016 studies, an opportunistic questionnaire was administered at the 8th Conference of the International Society for Integrated Disaster Risk Management (IDRiM), which was held in Reykjavík, Iceland in August 2017. The purpose of this research was to assess the conference participants' knowledge of Icelandic risk communication initiatives and identify possible risk-taking behaviours. Furthermore, the authors believed it would be pertinent to determine whether risk reduction campaigns were proactively explored by disaster risk reduction academics, practitioners and professionals prior to or during their visit to Iceland. The premise behind this belief was the question, 'if current strategies do not attract the attention of those visitors already interested in disaster preparedness and response, how are we to engage the disinterested'?

A hardcopy questionnaire in English was given to participants as they entered the conference during the morning of the first day i.e., 23 August 2017 and collected at the morning break. The questionnaire contained five closed questions relating to Icelandic risk communication initiatives and risk-taking behaviour (see Table 2 in Section 3.4) and three closed demographic questions. The option of 'other, please specify' was provided where necessary to accommodate answers outside of the predesignated options. Prior to dissemination, the questionnaire was pretested with members of NORDRESS (Nordic Centre of Excellence on Resilience and Societal Security) who attended their annual meeting the day before the conference commenced. The IDRiM conference attracted 216 participants from 28 countries. A total of 85 completed the questionnaire representing 19 of these countries.

Questionnaire data was entered in SurveyMonkey and exported to IBM® SPSS® Statistics Version 25 for analysis. As cloud-based software, SurveyMonkey ensures greater access across our research team to the questionnaire and its data for use in future projects, reduces the risk of errors during data entry (when compared, for example, to manually entering code into Excel) and allows easy visualisation of data for crosschecking each entry to ensure accuracy. The authors chose hard-copy administration over online to enhance completion rates through personal interactions during the delivery and collection of questionnaires and also to avoid respondents reactively researching questionnaire items while already on their devices. As per Human Research Ethics protocols, conference participants were informed that participation was voluntary and that they could withdraw from participating without consequence. The human research component of the studies presented here received ethical approval from Macquarie University (2006–2009) and the University of Iceland.

In order to address the aims of this paper, the next section details the results of our interrogation of the following datasets:

[3] Tourism employees consisted of hut wardens (n = 8), guides (n = 7) and drivers (n = 4).

[4] Only 12 tourists declined to participate giving a response rate of 90% and 100% for each the tourist and employee groups, respectively. Five tourists declined due to language barriers, a further five declined due to lack of time, one tourist stated they were too tired, and the other tourist declined due to lack of interest.

- **2009 interviews with government officials** to highlight how risk communication initiatives were developed and their opinions of this development process (see Section 3.1.1)
- **2009 hut wardens/tour guide questionnaire interviews and focus group discussion** to reveal their knowledge and opinions of risk communication initiatives and training; knowledge and perception of emergency response procedures; and, actions taken to enhance personal awareness (see Section 3.1.2)
- **2009 tourist questionnaire interviews** to determine their knowledge and perception of volcanic risk, warnings and emergency response procedures; actions taken to enhance personal awareness and safety; knowledge and opinions of risk communication initiatives; and, perceived levels of preparedness (see Section 3.1.3)
- **2010 interviews with hut wardens, rescue team members, local officials and residents** to explore risk taking behaviour during an eruption and public response to evacuation orders (see Section 3.2)
- **2016 interviews with South Iceland police and tour operators** to investigate their views of tourists' and tour guides' knowledge and perceptions of volcanic risk and emergency response procedures; perceived levels of preparedness; and, current strategies to reduce risk-taking behaviour (see Section 3.3)
- **2017 questionnaire with disaster risk reduction academics, practitioners and professionals** to assess their knowledge of Icelandic risk communication initiatives and identify possible risk-taking behaviours (see Section 3.3)

3. Results

3.1. Enhancing knowledge of hazards and recommended actions to ensure personal safety

3.1.1. Government official perspectives – the development of risk communication initiatives

Government officials described the top-down approach used to develop risk communication initiatives specific for Katla and the tourist region of Þórsmörk (i.e. the 'Eruption Emergency Guidelines' brochures and 'Katla-Mýrdalsjökull' signs). This process involved national and local officials, including some key tourism operator executives and local police who then passed the finalised information down to the rescue teams. Hut wardens were the last to receive this information and be told of their responsibilities.

Despite being collaboratively developed by DCPEM and South Iceland police, involving multiple iterations of the brochure in an effort to make it less alarming for tourists, officials recognised that they should have engaged more broadly with local rescue teams and tourism operators. For example, it was reported that some accommodation operators would not accept the 'Eruption Emergency Guidelines' brochure as they were not involved in its development. Government officials also reported that they had been asked by some accommodation operators to not distribute the brochures in the region as the operators believed the brochure would scare tourists from booking overnight stays. Despite this request, the brochures were distributed locally and were made available for download from the DCPEM website (www.almannavarnir.is).

3.1.2. Tourism industry reflections – turning initiatives to practice

Management at the mountain hut, where the focus group discussion meeting was held, closed the hut office and shop to enable all staff to participate as they believed it was a very important opportunity for them to share their views and concerns. The management noted that they had been calling for information and training in regard to their responsibilities to prepare for and respond to a Katla eruption.

> *I have been waiting to have a meeting with staff but since I thought someone [from DCPEM, police, rescue teams] was coming I put it off. I wanted to get somebody in to give us the information. I have information on how it could affect us but not how to react.*

Much of the concern stemmed from a lack of local knowledge and the high level of responsibility they feel for ensuring the safety of the many tourists that visit the region.

> *The farmers know by heart what to do, they have this knowledge but people living here in Þórsmörk don't have this knowledge, we're not from here. We are different to the residents. We need different information. We are responsible for the tourists.*

Tour guides also called for better education and training to ensure they are well informed of the actions they need to take if an eruption is imminent. Overall, only 21% of respondents indicated that they had received training in relation to a Katla eruption, just over half (53%) definitively knew of the regions' warning system and 58% were aware of the actions to take if a warning was issued.

The wardens discussed wanting to be involved in the development of response plans, which to them, needed to be responsive to the unique conditions of the day, the remoteness of the region and the possibility of losing communication networks due to lightning and tephra fall out.

> *We can have a meeting with the* [Chief of Police] *and the rescue team to discuss where is the best place to go. Then, in the event of an eruption, the rangers can talk to each other and they should be informed how big it's going to be and then we will know where the best and safest place to go is.*

The head wardens confirmed involvement in earlier discussions with the Chief of Police, key tourism executives and a leading volcanologist, as well as attending a more recent meeting held in Reykjavik. However, the wardens expressed a need for further discussion and action on developing localized response plans for each of the mountain hut areas.

> *So we are not shocked when this happens for example if we see the flood coming with massive ice blocks* [broken off from the glacier by the flood water] *in it, we need to know what to expect and know the plan for us … so we are not stressed out and panic.*

Additionally, all respondents (hut wardens, drivers and guides) recognised the need to practice the evacuation plan with the majority (83%) calling for evacuation exercises to be conducted annually, at the start of the summer season.

> *The first information and action is very important if there is an eruption and therefore it is very wise to practice evacuation exercises. Then we will know how to correctly respond.*

When asked how they would respond if an eruption warning is issued, many (69%) stated they would relocate to the highest point (to avoid jökulhlaup)/follow procedures while 21% would simply 'escape' the region. Some guides noted that they would check with the wardens or that their actions would depend on the situation at-hand. Again, all employees regarded their responsibility for ensuring tourists' safety as highly important.

> *I would take care of the tourists like my babies, I would group them together and go uphill where it would be safe considering the situation and I would pray. I would be like the captain and would not leave the ship – I would leave last.*

> *We attended several meetings at the DCPEM offices in Reykjavik. We have the box of flares and we know how to release them. We know what to do. We need to release the flares … We need to get all the people together and tell them to take food and water. We will then take everyone up higher. There may be no possibility to evacuate.*

> *It is very wise to have evacuation exercises. We will learn and see what to do better. It was our initiative to go to these training sessions. They should've forced every hut warden to go to the meetings. They should give the wardens a license after they have had training on how to release the flares.*

To proactively enhance their own awareness, many had accessed Katla-related information via the DCPEM (21%) and Icelandic Meteorological Office[5] (IMO; 79%) websites. In contrast, 53% had followed discussions on Katla in the media (television, radio, newspapers, internet). In regard to usage of the IMO website, one hut warden noted:

> *I have used it frequently since in the last 7–8 days because I noticed a sulphur smell in* [the local rivers] *and there was an increase in the frequency of earthquakes in Eyjafjallajökull.*

The 'Eruption Emergency Guidelines' brochure and 'Katla-Mýrdalsjökull' signs had been seen by 63% and 58% of tourism employees, respectively. Only three respondents hadn't seen either. Tourism employees noted that the 'Eruption Emergency Guidelines' brochure needs to be amended because it currently '*blends in with the postcards and other tourist brochures about Iceland*'. In terms of the content, everyone that had seen the brochure and signs rated the information as moderately to extremely informative. Many, however, made suggestions for improvement, which included:

> *It was not very easy to read as it was quite detailed. I'd prefer it to be more simplified, with pictures making* [the necessary information] *really obvious without having to read it.*

> *Tourists should be given the brochure on the bus with an outstanding title: 'PLEASE READ'.*

> *What is needed is to tell people what they need to take with them … a wet rag to protect their airways and water, food and blanket.*

> *They should have shading of different risk zone areas. There are many people that hike* [Laugavegur] *from Landmannalaugar to Þórsmörk who are not mountain people. The escape routes should be more defined and areas to avoid and safe areas also need to be more defined – there are just arrows and they are not clear.*

There were also calls for '*more science information for the tourists*', and many commented on how unprepared many tourists are for travelling in this region. In an effort to enhance tourists' knowledge, 53% of tourism employee respondents stated that they inform tourists of natural hazard risks related to Katla and the glacier, Mýrdalsjökull.

> *During the big weekends everyone gets a brochure which informs them about Katla. The rescue team comes in and helps us on the big weekends. They stop all the cars at the small hut as they are entering Básar and they give them the brochure that tells them about Katla and what to do. But generally, people aren't thinking of this.*

3.1.3. Tourist perspectives – key concerns for visitors

All tourist respondents stated that they knew Iceland is volcanically active, 91% stated that they were aware of the natural hazards that occur in Iceland and 73% had heard of the Katla volcano. Yet, 68% of respondents that had heard of Katla were not aware of the emergency procedures if an eruption warning is issued. Furthermore, 70% of all respondents had not actively searched for online[6] information regarding possible natural hazards that could affect the region. In addition to online information, some respondents had read about Katla in travel guidebooks (e.g. the Lonely Planet) and had received information from other people (e.g. guides from other regions).

> *Worst volcano, it can make the worst damage and floods. We heard about Katla from a German tourist only 2 hrs ago.*

> *Our taxi driver from the airport told us about Katla. He gave us a lot of information about Iceland, what to do, which restaurant to eat at, and he told us that Katla was due to erupt. He was very informative.*

In terms of general safety, 62% of respondents noted that they had taken some precautionary measures to ensure their own safety while travelling in this region. These included having adequate clothing for bad weather and carrying a map, GPS device and/or mobile phone and first aid kit. The main motivation cited for taking these measures was simply that it's something they always do.

One respondent noted that '*all information is advertising for people to come to Iceland*' and that they had come to Iceland to see the volcanic landscape. This tourist was aware that an eruption occurs about every 5 years. However, they also stated:

> *I don't think volcanic eruptions are a hazard as people will not be affected. There should be plenty of warning and therefore people will not be in the vicinity of the eruption … I don't think of eruptions as a natural hazard. Just because it's volcanic it doesn't stop you from coming here.*

Despite the distribution of the 'Eruption Emergency Guidelines' brochures and the installation of the 'Katla-Mýrdalsjökull' hazard information signs along hiking trails and within mountain huts, many 2009 respondents had not seen or read either. As reported by Bird and Gísladóttir [5], 74% of respondents had not seen the brochure and 56% had not seen the sign. Of those that had seen them, few had taken the time to read the information. The visual appeal, or rather the lack of, was raised by several respondents with respect to drawing people's attention to the signs and brochures.

> *The warning signs should be closer to other information signs and should stand vertical and it should be marked 'BE AWARE'! Not 'Katla-Mýrdalsjökull'.*

> *I was looking for a brochure on volcanic activity but couldn't see any. It would need to be in Landmannalaugar or here in Þórsmörk for it to be effective. I like to read these things. Everywhere we were signing in, but we didn't see a brochure. The wardens should ask if we have seen it.*

Other respondents, however, noted that the hut wardens had informed them about Katla and associated volcanic response plans on their arrival in the area. After one respondent declared that they had not seen the brochure, it was handed to them, at which point they stated:

> *I have seen this. I thought I had to pay for the brochure because it was in the same stand as the postcards, so I didn't look at it.*

Of those that had read the sign and brochure, 70% and 78% rated the information as moderately to extremely informative, respectively. One respondent noted that although they had only read about half of the information presented in the sign they '*rate this information extremely informative as I remember that there is a 40 km radius of trouble – this stuck in my head*' highlighting the significance of visualisations, such as hazard maps, for communicating hazard information. Other positive comments included:

> *I was very happy with the sign. I thought it was very informative and that it contained all information needed. I thought to myself how well people had worked through the information. The information was very clear.*

> *The map was quite clear, but it was for the whole region … The risk areas are detailed and in many languages which is very good. We have an interest in maps and geology and that is why we paid attention to it.*

However, many respondents felt that the information was lacking in specific details.

[5] IMO has government responsibilities for enhancing public safety by monitoring, analysing and informing on natural processes, including natural hazards (e.g. volcanic eruptions, earthquakes, extreme weather and flooding) and issuing associated alerts and warnings (https://en.vedur.is/).

[6] The question specifically asked about online sources as it is the most accurate source for near real time hazard information, which is critical when dealing with natural processes. However, as questionnaires were administered face-to-face, respondents had the opportunity to share offline activities as well.

Bit hard to know what to do if it happened. They said about a hazard but not what to do … it was not detailed enough for the specific place and difficult to know where to go.

It was … not that good, it was not very clear what we should do. We talked about it while we were hiking – what would we do? I am not informed well enough to know. They need to make the signs bigger and more important. The little map does not draw so much attention. The blue and red arrows show the flood path and where to go, but it was confusing. It said to look at the landscape to identify where paths of former flows were but how? I am not an expert on these things. This information came too late and it assumed a high level of knowledge.

The safe places were marked, and you would know where to go as long as you're reasonable at navigation.

I don't link flooding to volcanoes so when I look at this [the brochure] *I don't see that this map is showing flooding. They overestimate the knowledge of tourists.* [When I read the map title], *I only see volcanic eruption not 'subglacial'. And when I read 'volcanic eruption' I think of Etna. Therefore, I don't comprehend the flood hazard. The language is very casual: 'Mt. Katla generally erupts only once or twice every hundred years, and always gives some warning before the eruption takes place, so the risk should not discourage visitors enjoying the beauty of the region.' This is saying to me that I shouldn't read the brochure anymore 'the risk should not discourage visitors' so why should I read on? My attention goes after reading this. 'Mt. Katla see map' – WHERE? I looked and looked but … Mt. Katla is not marked on the map.*

Other respondents called for additional strategies to enhance awareness:

They should educate people to the minimal level. Just a short 20-min introduction session – an introduction to the area makes it more interesting to travel in and it is a real bonus to get more information.

You never know where you are – whether you are 5 km or 10 km from the next hut. It is hard to see where you are from the map. And when the weather is bad, and you need to make a decision whether to go back this sort of information is important. They should place markers along the track. Not everywhere but just a few, so you know how far it is to the next hut.

Interestingly, several respondents discussed their experience of visiting other volcanic regions and how that experience had shaped their perceptions.

We have been in Mexico and you see the signs about evacuations and volcanic eruptions everywhere – in churches, on the streets, in government buildings etc. We haven't seen any signs here. It wouldn't scare us from coming here if we were previously informed.

Several years ago, we hiked up to Stromboli on our own but now it is impossible without a guide to ensure the tourists' safety. I found that very positive and necessary. After the eruption in 2002 in Stromboli that caused the tsunami and the whole island was evacuated, they installed signs and an evacuation system. It described all areas which are defined as safe and the evacuation centres. The system they used was very simple and clear for tourists.

The signs did not scare us. In the tourist information centre in Reykjavík we asked for information, or anything we needed to know before hiking and she told us to bring walking sticks. We feel that she should have told us about blizzards, volcanic hazard information etc. When we were hiking in New Zealand the people at the tourist information centre told us about the possible hazards that can occur in the area and we still went hiking.

Over three quarters of respondents (76%) rated themselves as 'not at all' to 'a little' prepared for an eruption in Katla despite 61% believing that a Katla eruption is 50/50[7] to extremely likely to occur within the next 10 years and 81% believing that the region of Þórsmörk is 50/50 to extremely likely to be adversely affected.

3.2. Lessons learnt from the 2010 Eyjafjallajökull eruption

Dubbed by some as the '*tourist eruption*', the initial phase of the 2010 eruption at Fimmvörðuháls, on the flank of Eyjafjallajökull attracted the attention of many domestic and international tourists, with people '*risking their lives trying to get to a good vantage point.*'

There were so many people looking at the eruption. It was like they were looking at a fountain in the garden. I went up … and it was crazy. You couldn't hear people talking because there was so much noise from helicopters, cars, 4WDs, planes, snowmobiles, quad bikes etc. I felt almost ashamed of being there. It was like a joke.

There were 3,000 cars in the area. It was really unbelievable … Everyone taking a picture. But you know, the eruption in Fimmvörðuháls was so picturesque, it was so beautiful, it was really amazing. It was really nice to just walk up there and sit down there and just watch.

For the rescue teams, however, this was the most stressful stage of the 2010 eruption. While some onlookers were well equipped for the weather conditions, many were not, and the rescue teams were continually working to assist exhausted and ill-prepared tourists hiking to and from the eruption site.

This is the biggest rescue project I've ever been involved in, and I found it amazing that we would be there with a full number of [rescue team members] *and that costs a lot of money just to save people that wouldn't prepare themselves.*

Not only was the eruption site located in difficult terrain, the weather at that time of year can rapidly deteriorate and the volume of traffic to the site was immense. Because of this, one of the rescue team members expected to be '*searching for dead people*'. Despite the two fatalities, he noted that they were fortunate because the '*weather gods helped a lot*'.

During the last days of the *tourist eruption*, officials prohibited tourists hiking to the eruption site if they were not fully prepared for the conditions. The rescue team member commented that they '*should have done that in the very beginning*' but also clarified '*of course it was very beautiful … I am not surprised people wanted to see this; I went five times up to see it*'.

In general, the rescue team members felt that the communication and cooperation between them, the police, DCPEM and the Chief of Police was very clear during the eruption. Good communication was critical, given the fact that so many people were accessing the area, particularly from Skógar in the south but also from Þórsmörk in the north.

Very few tourists were in the region when the initial eruption began in Eyjafjallajökull (e.g. wardens had recently arrived in Þórsmörk to get Húsadalur ready to reopen for the summer season) and both eruptions commenced in the middle of the night. This timing aided the emergency response – there was no concern for people out hiking or camping in the wilderness. Nevertheless, there were many more people that required evacuation during the second phase of the eruption, due to the large crowds that had gathered to view the first phase.

They needed to get a lot of people out [of Þórsmörk] … *there were 50 people from Norway and from all over and they needed to rescue them and get them over Markarfljót so they had to go on the top of the truck …*

[7] Equally likely to occur as unlikely.

all sitting on the back of the truck holding on to a rope. They actually thought it was fun.

Overall, officials were pleased with the public response to evacuation orders. Management of the area during the second phase was aided by road closures throughout the region due to jökulhlaup hazards. As the second phase of the eruption progressed, people '*realised that this was something much bigger and wasn't really a site to visit*'. Consequently, the tourism sector suffered great losses '*because international tourists were advised to travel elsewhere*'. For those that still chose to visit this region, car rental companies threatened fines for possible damage caused by wind-blown ash if their vehicles were driven into the area.

3.3. Fallout from the Eyjafjallajökull eruption – changing risk awareness and tolerance levels

Despite the devastating impact the second phase of the Eyjafjallajökull eruption had in South Iceland and on international air travel, or possibly because of it, tour guides in 2016 reported that many tourists were excited by the possibility of visiting an active volcanic area. It was noted that some tourists were very keen to visit areas of high activity so they could report back to friends (verbally or via social media posts and photo shares) about their real-life experience of '*walking on a volcano that's about to erupt*'.

> [Tourists'] *main interest is in volcanoes in general … They really want to see it, feel it. They don't realise how much danger it is. They don't know they're in a volcanic area but the whole island is one big volcanic area … They don't really know much about glaciers. And nothing about volcanoes under ice. Maybe some people find it unbelievable. Because they are used to just volcanoes where the top comes off or the side blows away. It is something very different in Iceland.*

> *Sometimes I take tourists up to the mountains … The people come here to see the volcanoes, they come here to see the landscape, see the lava. They know about everything that has been going on here in Iceland, many of them were trapped in 2010 somewhere in Europe. But no one is aware if there is any risk now.*

While it was recognised that many tour guides are knowledgeable about volcanic hazards and risks there is concern that they are unable to accurately answer questions regarding warnings and response strategies. It was noted that tour guides promote the infamous Eyjafjallajökull volcano with a focus on the 2010 eruption while neglecting to mention the more destructive volcanoes of Bárðarbunga, Katla and particularly Hekla, where many tourists still walk to its summit in spite of the warning signs advising otherwise. As noted by the local police:

> *Hekla is* [due]. *2 years ago, we put up signs on the roads that have information about the risks, the short warning and so on and that you might get an SMS if something will happen. And there is the 112 app … you can take that with you so if you phone then we can see where you are.*

> *Hekla is not closed for hiking, but we wouldn't go hiking there. It's at your own risk. We try to inform you, tell you about the danger but you need to decide for yourself. I think we can't close it. But Hekla can erupt in an hour. Or after a hundred years, who knows? I don't think we could close it because that would not be popular or realistic. But we must inform people as well as we can.*

In regard to Þórsmörk, police acknowledged that Húsadalur and the northern part of Þórsmörk is a high-risk area in terms of a Katla eruption. It was also noted that there were 200–300 people walking the Laugavegur track from Landmannalaugar to Þórsmörk every day during the 2016 summer season and a similar amount of people walking the Fimmvörðuháls track. Many of these hikers are just as ill-prepared as tourists were in the 2009 and 2010 interviews. The police discussed a recent rescue of distressed hikers on Eyjafjallajökull; they had no compass, no hardcopy maps, no GPS devices. They were relying solely on Google Maps on their mobile telephone.

The police discussed work undertaken to improve the eruption warning system for the Þórsmörk region. Due to concerns regarding the effectiveness of flares to alert hikers of an eruption, the warning system will now rely on an emergency text message disseminated to all mobile phones in the area. The police confirmed that there's '*pretty good coverage in Þórsmörk area, it has improved a lot*' and they were in the process of updating the 'Eruption Emergency Guidelines' brochure and the 'Katla-Mýrdalsjökull' signs. However, informing tourists about risk in an effort to change their behaviour has been an ongoing challenge for South Iceland police.

> *We are not only worried because of the eruptions. We have earthquakes and floods. You name it, it's here. We are worried about travellers every day. The amount of people in* [car] *accidents is rising and the amount of tourists are also growing.*

In an effort to reduce speeding accidents among tourists, the police developed, in cooperation with car rental and insurance companies, a one-page brochure with information and visual images to highlight Iceland's speed limits. The brochure was attached in a prominent position on the dashboard of rental cars. However, the police noted:

> *The strange thing, it was published for three years, in every car rental and so on, it made no difference. Around 60% of speeding fines were tourists. And it was the same through the years. And we asked them, if we pulled over a car and stopped them on the side of the road, "have you seen the sign?" "Yeah, yeah, its here." It didn't work.*

> *We know what information we want to talk to* [tourists] *about, the problem is, how to do it. How can we reach the people? That is the main problem for us. How to inform people? Where would* [tourists] *read it? Do they know the risk? Do they know how to behave? People don't read the signs; they only see the pictures.*

The police officials recognised the need to have more people on the ground '*to be closer to the people*' but were challenged by a lack of resources for such an undertaking.

> *We are not worried about the people living here because they know what do to, but the tourists, there's a lot of them and we're afraid … we* [the police] *are so few … our job is getting more and more but we are always the same amount of policemen in the area.*

On a positive note, the police highlighted the support they were now receiving from various tour operators in the area.

> *I think* [the tour operators] *have learned a lot since the eruption in 2010. They knew that all the planning and all the information that we were gathering and putting out to the people* [was] *more help than damaging* [to tourism]. *So, I think, they are more willing to prepare. We can sell the idea, we can sell it we are living in a high risk area, you can stay in a hotel underneath the volcano but we can also assure you that everything is safe, we have plans to evacuate, we have plans to respond to it.*

3.4. What tools, resources and approaches work?

In the 2017 study, a little over half (52%) the respondents indicated that they had not familiarised themselves with Iceland's natural hazards and/or emergency management procedures prior to or during their current trip to Iceland (Table 1). Of the 48% that had, the Icelandic Meteorological Office's website was the most popular, followed by the Safe Travel website. A further ten responses for 'Other (please specify)', four for 'Almannavarnir/Department of Civil Protection and Emergency Management', three for 'Icelandic Road Association' and one for 'Red Cross Iceland' were received. Other responses included the 'conference website', 'general knowledge and internet searches', 'Flybus/hostel

Table 1
Results of the 2017 survey by gender and age. All data is given as a percentage unless otherwise indicated. Some sections do not equal 100% due to rounding/ multiple responses to a question.

Question	Gender		Age (years)			
	Female	Male	18–29	30–44	45–59	60+
Prior to, or during this trip to Iceland, have you used any of the following websites to familiarise yourself with Iceland's natural hazards and/or emergency response procedures? *n = 75						
• Safe Travel website (safetravel.is) (25%)	47	53	16	32	42	11
• Icelandic Meteorological Office (www.vedur.is) (32%)	54	46	13	54	21	13
• No (52%)	61	40	18	41	36	5
If you had the opportunity during your stay in Iceland, would you hike up Hekla? n = 81						
• Yes (20%)	69	31	13	56	25	6
• No (22%)	47	53	6	39	33	22
• Maybe (31%)	60	40	24	36	40	0
• I don't know about Hekla (27%)	32	68	27	41	27	5
Have you logged your detailed daily travel plans for Iceland with any of the following? *n = 72						
• Family/friends (53%)	61	40	32	37	26	5
• Work institute (29%)	52	48	19	33	43	5
• No (25%)	53	47	0	56	33	11
Have you downloaded the 112 app on your smart phone? n = 84						
• Yes (4%)	100	0	33	67	0	0
• No (60%)	53	47	8	52	28	12
• I don't know the 112 app (37%)	48	52	32	23	42	3
Have you taken the "Icelandic Pledge to be a responsible tourist" while in Iceland? n = 83						
• Yes (11%)	56	44	0	67	33	0
• No (89%)	53	47	20	39	31	10

* Additional responses were provided on these two questions. However, this data is not presented in the table due to the very low responses. They are, however, described in the text.

bookers' and two respondents simply noted that they are from Iceland.

Only 22% of respondents gave a decisive 'no' when questioned, if given the opportunity would they hike up Hekla, while 75% of respondents stated that they had logged their daily travel plans with someone. Family/friends (53%) and work institute (29%) were the favoured source for the logging of daily travel plans. A further three responses for 'Safe Travel Iceland' and four for 'Government organisation of your home country' were received. The majority of respondents (60%) had not downloaded the 112 app to their smartphone while a further 37% indicated that they did not know about the app. And, an overwhelming majority (89%) had not taken the "Icelandic Pledge to be a responsible tourist" while in Iceland.

4. Discussion and conclusion

This paper set out to ascertain whether risk communication initiatives are enhancing or have the potential to enhance tourists' safety. To achieve this, we have drawn on data, which were captured during research undertaken in 2009, 2010, 2016 and 2017. This data suggests that while these initiatives are reaching some tourists, they are not reaching the majority of them and are therefore ineffective, in their current form, at enhancing tourists' safety (Table 2).

Officials, however, are faced with an exceedingly difficult task. Tourists are generally not risk averse, as suggested by the results presented in this paper. Despite knowledge of risk, tourists have not actively informed themselves about potential hazards or emergency response procedures, even when the information is readily available (e.g. on the signs and in the brochures).

These findings are not new. For example, Heggie and Heggie [30] found that many visitors hiking the wilderness areas of Hawaii Volcanoes National Park were inexperienced, unfamiliar with the area they were hiking and disregarded warning signs to gain entry into high-risk areas. Furthermore, only a small proportion of visitors read the warning signs before entering high-risk areas.

Table 2
Summary of the longitudinal findings.

Government official perspectives – the development of risk communication initiatives
- Officials identified the top down approach taken to develop risk communication initiatives
- Officials addressed request by accommodation operators to make risk communication less alarming
- Officials recognised need to engage more broadly in the development of risk communication initiatives

Tourism industry reflections – turning strategies to practice
- Tourism employees recognised their responsibility for tourists' safety
- Tourism employees want to be involved in the development of risk communication initiatives
- Tourism employees want to be informed and trained in response procedures
- Just over 50% of tourism employee respondents had knowledge of the Katla volcano warning system and actions they must take to ensure their own and tourists' safety
- Tourism employees called for localised response plans and annual evacuation exercises
- The IMO website was the most commonly used source for Katla- related information
- Tourism employees viewed tourists' as ill-prepared for travelling in the region
- Tourism employees called for brochures and signs to be located in more prominent positions and that each contained more action-orientated information

Tourist perspectives – key concerns for visitors
- 100% of tourists knew Iceland is volcanically active, 73% knew of Katla but only 68% of those people were aware of emergency response procedures
- Few tourists proactively searched for information regarding natural hazards in the area
- 76% of tourists considered themselves as 'not at all' to 'a little' prepared for a Katla eruption
- 61% of tourists believe an eruption is 50/50 to extremely likely to occur in the next 10 years
- 81% of tourists believe the region is 50/50 to extremely likely to be adversely affected
- Tourists called for brochures and signs to be located in more prominent positions and that both contained more action-orientated and location specific information as well as improved visual representations such as hazard maps to enhance awareness and understanding
- Tourists described learning about volcanic hazard and risk from others, showing that peer-to-peer learning extends beyond tour guides and hut wardens

Lessons learnt from the 2010 Eyjafjallajökull eruption
- The first phase of the Eyjafjallajökull eruption attracted thousands of on-lookers with many ill-prepared for the conditions
- The emergency response to the second phase of the eruption was aided by a lack of international tourists in the region
- Road closures and the threat of fines reduced risk-taking behaviours during the second phase of the eruption

Fallout from the Eyjafjallajökull eruption – changing risk awareness and tolerance levels
- Police and tour operators reported that tourists are excited by the possibility of visiting an active volcano and areas of high activity
- Police and tour operators reported an apparent lack of volcanic risk awareness and preparedness among tourists
- Tour operators called for better education and training of tour guides in regard to volcanic risk, warnings and response procedures
- Police and tour operators reported concern for hikers in high risk areas
- Police and tour operators recognised that tourists do not read risk information and called for answers on how to reach tourists and inform them about risk and appropriate behaviours
- Police described updates to the warning system noting that warnings will be issued via SMS to mobile telephones in the region, highlighting a greater reliance on technology

What tools, resources and approaches work?
- About half of the disaster risk reduction academics, practitioners and professionals surveyed had proactively searched for information on Iceland's natural hazards and/or emergency management procedures prior to or during their trip to Iceland
- The majority of the disaster risk reduction academics, practitioners and professionals surveyed were not aware of national risk communication campaigns aimed at enhancing awareness of natural hazard risks
- 69% of the disaster risk reduction academics, practitioners and professionals surveyed would potentially hike up Hekla if they had the opportunity during their stay in Iceland

While visitors to Iceland are not proactively informing themselves in an effort to reduce their personal risk, many adopted general precautionary measures to ensure their own safety, as evidenced by the 2009 survey. Despite their own efforts, and those of the hut wardens, guides and officials, few tourists felt prepared to respond to an eruption.

Current initiatives are not without issues, as evidenced by the 2017 data that showed a lack of knowledge of volcanic risk (i.e. the Hekla volcano) and engagement with risk communication initiatives among visitors already interested in disaster preparedness and response.

Given the 2010 Eyjafjallajökull eruptions occurred outside of the high season for tourism, we suggest that the majority of people accessing the eruption site during the initial phase were domestic tourists, photographers/local and international media personnel and volcano chasers. That is, they were not your average tourist. Those working to ensure tourists' safety during the eruption, however, were shocked at how ill-prepared people were. It appears that it was not only the *weather gods* that were on their side. If these eruptions occurred during the tourist high season, we expect the death toll would have been much greater.

4.1. Study limitations

We recognise that there are some limitations of our 2009 survey because we were only able to survey people who were proficient in English or Icelandic. Nevertheless, only five tourists declined participation due to language barriers. Also, due to resourcing, we were unable to interview tourists during the 2010 Eyjafjallajökull eruption or repeat the 2009 survey in Þórsmörk post the 2010 Eyjafjallajökull eruption, which would have enabled us to investigate how that event influenced, if at all, knowledge, perceptions and behaviour. As noted earlier, the 'Eruption Emergency Guidelines' brochure and the 'Katla-Mýrdalsjökull' sign had not, at the time of writing, been updated since those developed and installed in 2008. We therefore believe it is safe to assume that many of the issues highlighted during our 2009 survey are still relevant today. Furthermore, the 2010 and 2016 interviews provide an insight, as viewed by officials and tourism operators, of tourists' perception of volcanic risk and their risk-taking behaviours.

4.2. Societal changes over the study period

It is also pertinent to consider societal changes since the 2009 data collection period. Tourism has grown exponentially and the 2010 Eyjafjallajökull eruption has attracted thrill seeking tourists. Alongside this, the world has become more connected through social media. We have become more reliant on technology and more confident in our own abilities because of it, as evidenced by the police report of distressed hikers on top of Eyjafjallajökull who were relying solely on Google Maps to navigate this difficult terrain. Our findings suggest that tourists feel more capable and they take risks, believing no harm will come to them. As Heimisdóttir, Sæþórsdóttir [31] show, tourists feel a positive attraction to the volcanic risks posed by the Icelandic landscape and in doing so, 'underestimate the imagined risk they are seeking and overestimate their own abilities' [31p.272]. In many instances, tourists are less physically and emotionally prepared to deal with nature than they expect.

Despite these challenges, or because of them, we must continually strive to find better ways of communicating hazard information and recommended actions to reduce risk and enhance personal safety so that tourists are well equipped to make informed decisions before and during their travels. This leads us to consider the second aim of this paper – to provide evidence-based recommendations to inform the continual improvement of risk communication strategies within the tourism sector.

4.3. Recommendations

Our results highlight the strong sense of responsibility tourism employees feel for ensuring tourists' safety and their willingness to be involved in risk reduction efforts. These results are backed by seminal work of Drabek [32] on emergent behaviour patterns of tourists and other transients in response to hurricane and earthquake disasters. Drabek [32] concludes: 'investments in community disaster planning through active participation in and support of public-private partnerships in emergency management can reduce catastrophic vulnerabilities that are worsening daily' [32; p.301]. Faulkner [33] highlights this coordinated, integrated approach as a prerequisite for effective tourism disaster management planning while Becken and Hughey [34] postulate that a coordinated and integrated approach must occur at all stages, from preparedness through to response and recovery.

We also consider it imperative that the sector as a whole (e.g. tour guides, mountain hut wardens, tourism operators and travel agents) is actively involved in risk reduction strategies including the development and dissemination of risk communication initiatives and warnings.

This must extended to the dissemination and sharing of risk information by travel agents and tour guides, prior to booking and taking tourists into potentially hazardous environments. Survivors of the Whakaari/White Island eruption that claimed the lives of 21 people in December 2019 report that they received no information regarding the risk and were therefore unable to make informed decisions about their safety [54]. People actively engaging in high risk activities (such as hiking in active volcanic areas) aren't risk seeking *per se*; it is the rush of an experience that motivates them rather than the risk itself [35]. While Buckley [35] asserts that the rush/risk are interconnected, the experienced tourist seeking adventure is likely to undertake precautionary measures to minimise the risk.

Not all tourists, however, have a high level of experience. The underlying premise to successful tourism that incorporates hazardous elements is conceived from risk reduction and the knowledge of inherent safety while still effectively servicing that thrill seeking need [36]. It is therefore critical that all tour guides and hut wardens are trained in emergency response procedures (e.g. on an annual or bi-annual basis). This training should result in certification that tour companies can use for marketing purposes to show the safety standards to which their organisations abide. Once trained and certified, during every trip, tour guides and hut wardens should educate tourists on hazards and the actions they can take to ensure their own safety. This education should provide tourists with an even more thrilling and holistic experience of visiting a hazardous area. On the other hand, knowing how to respond to hazards in that landscape may possibly reduce known (i.e. thrill seeking) or unknown risk-taking behaviours during an imminent threat.

This peer-to-peer learning must extend beyond tour guides and hut wardens. Our findings show that visitors to Iceland are not proactively informing themselves about hazard, risk and response actions. We must therefore find other ways to reach them. Travel agents, accommodation, bar and restaurant managers and staff, alongside taxi, bus and rideshare drivers should all be viewed as spokespeople for ensuring tourists' safety. Furthermore, rather than simply asking tourists to take a Pledge to respect nature and avoid certain risk-taking behaviours, prepared tourists should be encouraged to share their experiences of proactively informing themselves and taking actions to reduce their travel risks. Wood, Mileti [37] report that the most effective motivator for action was when a prepared member of the public (not from government departments or non-government organisations) shared their knowledge and actions with their peers. While the Icelandic Pledge webpage notes 'Encourage your friends to do the same', greater effort is required to instigate action among other tourists. For example, officials might consider incentivising commitment to entice compliance.

Officials must ensure a long-term and ongoing commitment to risk communication initiatives. For warnings to be effective, risk communication must be ongoing and integrated into everyday practices and

actions so that no warning comes as a surprise [38]. This means regularly distributing consistent information through all available channels e.g., brochures, signs, dedicated webpages, social media channels, blogs, documentaries and short films. Repeated information through multiple channels is essentially 'the only way to help people "tune in" [37; p.612]'. The distribution of dense information is critical because of the transient nature of tourists; it is also critical in capturing the attention of the many possible spokespeople (e.g. travel agents; accommodation, bar and restaurant staff; taxi, bus and rideshare drivers) that may have an opportunity to enhance tourists' safety through peer-to-peer learning.

Based on our results and in line with decades of research [e.g., 23, 39–45], risk communications and warnings must be clear and concise with consistent use of terminology and place names. It is essential that location-specific information is provided that includes actions people can implement to reduce their risk for specific hazards during an imminent eruption or during times of quiescence. For example, in times of quiescence, poisonous volcanic and geothermal gases can accumulate in the landscape. Known as a silent killer [46], these poisonous gases often have fatal consequences for those initially exposed and first responders (who are usually family, friends or other tourists) attempting a rescue effort. Knowledge of such hazards and the conditions under which they occur, as well as the specific actions required to reduce risk are essential to ensure personal safety [46–48].

Furthermore, risk communication efforts must be bold and attention-seeking. That is, they need to stand out in the crowded space of tourism advertising. This includes careful consideration of the placement of signs and brochures to ensure they are placed prominently in as many locations as possible.

Our findings indicate that visual representations, i.e. hazard maps, had different impacts in terms of attracting people's attention and enhancing the understanding, acceptance and retention of hazard information. Alongside written information, risk communication initiatives should therefore include a variety of visual representations ensuring that the designs meet the needs of the intended audiences. Thompson, Lindsay [49; p.636] note, "visual representation of hazard information on a map can influence the way that people engage with the information, as well as the messages that people take away, and decisions they make". For example, Haynes, Barclay [50] reveal that perspective photographs of the landscape (rather than a contour map that had been typically used by risk communicators) enabled non-experts to more accurately identify risk through association with personally significant locations. Incorporating the needs of the intended audience when designing hazard maps ensure that they are accessible, relevant and clear to those people who need them [49].

This approach, however, must extend beyond hazard maps. That is, officials must ensure that the broad range of risk communication and warning information and tools meet the needs of the intended audiences. Faulkner and Ball [51; p.75] highlight 'the challenge of converting scientific formulations of risk into effective decision support communication tools must be met, not least because recipients of risk communications have, from the perspective of social justice, the right to expect more mature, dynamic and improved approaches to the communication process'. The challenge is to ensure consistent messaging while reaching the broad diversity of tourists, from the experienced hiker to the retirees travelling in a motorhome.

It is therefore critical to view risk communication as a 'continual process of exchanging and understanding environmental and societal characteristics' so as to generate understanding of how information is 'received, enhancing successful pathways, filling in gaps, paying attention to changes in the locations and the people, and being flexible and dynamic' [38; p.6]. This requires evidenced-based risk communication to ensure information is accurately and easily understood and interpreted so that informed decisions can be made [52]. To achieve this, we must continually engage tourists in discussions around what works, what doesn't, and how information and tools can be improved. Drabek [53] postulates, there is a lot we can learn from tourists if we take the time to observe, listen and act on what we learn.

To achieve all of this, government officials must invest greater resources to ensure visitors have access to accurate and up-to-date information so they can make informed decisions about their travel choices.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] Statistics Iceland International Arrivals by Modes of Transport 2009-2016, 2018. Accessed 24 May 2018, http://px.hagstofa.is/pxen/pxweb/en/Atvinnuvegir/Atvinnuvegir_ferdathjonusta_ferdaidnadur_ferdaidnadur/SAM08006.px/?rxid=d4001cbc-e8af-4f46-9c95-b282c6e35460.
[2] Statistics Iceland *Tourism Satellite Accounts*, 2018. Accessed 24 May 2018, https://www.statice.is/statistics/business-sectors/tourism/tourism-satellite-accounts/.
[3] D. Bird, et al., Climate change and settlement level impacts, in: A. Taylor, et al. (Eds.), Settlements at the Edge: Remote Human Settlements in Developed Nations, Edward Elgar, UK, 2016, pp. 293–319.
[4] D.K. Bird, G. Gísladóttir, D. Dominey-Howes, Volcanic risk and tourism in southern Iceland: implications for hazard, risk and emergency response education and training, J. Volcanol. Geoth. Res. 189 (1–2) (2010) 33–48.
[5] D. Bird, G. Gísladóttir, Southern Iceland – volcanoes, tourism and volcanic risk reduction, in: P. Erfurt-Cooper (Ed.), Volcanic Tourist Destinations. Geoheritage, Geoparks and Geotourism, Springer, 2014, pp. 35–46.
[6] M.T. Guðmundsson, et al., Geothermal activity in the subglacial Katla caldera, Iceland, 1999-2005, studied with radar altimetry, Ann. Glaciol. 45 (1) (2007) 66–72.
[7] M.T. Guðmundsson, Á.G. Gylfason, Hættumat Vegna Eldgosa Og Hlaupa Frá Vestanverðum Mýrdalsjökli Og Eyjafjallajökli, Ríkislögreglustjórinn and Háskólaútgáfan, Reykjavík, 2005, p. 210.
[8] M.T. Guðmundsson, et al., Volcanic hazards in Iceland, Jokull 58 (2008) 251–268.
[9] T. Thordarson, G. Larsen, Volcanism in Iceland in historical time: volcano types, eruption styles and eruptive history, J. Geodyn. 43 (1) (2007) 118–152.
[10] Á. Höskuldsson, Öræfajökull, in: E. lyinskaya, G. Larsen, M.T. Gudmundsson (Eds.), Catalogue of Icelandic Volcanoes, 2015 (IMO, UI, CPD-NCIP: Reykjavík).
[11] Almannavarnadeild Ríkislögreglustjórinn. "Emergency Evacuation – Öræfajökull. 23.11.2017 – Version 1.0." (2017). Accessed 9 April 2018. http://www.almannavarnir.is/utgefid-efni/?wpdmc=articles-in-english.
[12] Morgunblaðið. Possible Dangers of the Ever-Changing Icelandic Nature, 2016. Accessed 15 June 2018, https://icelandmonitor.mbl.is/news/nature_and_travel/2016/08/08/possible_dangers_of_the_ever_changing_icelandic_nat/.
[13] Morgunblaðið, Just Days after the Reynisfjara Beach Death Tourists Still Disregard Warning Signs, 2017. Accessed 15 June 2018, https://icelandmonitor.mbl.is/news/nature_and_travel/2017/01/13/photos_just_days_after_the_reynisfjara_beach_death_/.
[14] Morgunblaðið, ""Terrible Situation" at Iceland's Reynisfjara Beach - Security to Be Improved.", 2017. Accessed 15 June 2018, https://icelandmonitor.mbl.is/news/nature_and_travel/2017/01/12/terrible_situation_at_iceland_s_reynisfjara_beach_s/.
[15] D.K. Bird, et al., Crisis coordination and communication during the 2010 Eyjafjallajökull eruption, in: C.J. Fearnley, et al. (Eds.), Observing the Volcano World: Volcano Crisis Communication, Springer International Publishing, Cham, 2018, pp. 271–288.
[16] S.K. Brown, et al., Volcanic fatalities database: analysis of volcanic threat with distance and victim classification, J. Appl. Volcanol. 6 (1) (2017) 15.
[17] C.J. Fearnley, et al., Volcanic crisis communication: where do we go from here? in: C.J. Fearnley, et al. (Eds.), Observing the Volcano World: Volcano Crisis Communication Springer International Publishing, Cham, 2018, pp. 751–754.
[18] A.M. Gstaettner, et al., Monitoring visitor injury in protected areas - analysis of incident reporting in two Western Australian parks, J. Outdoor Recreation Tourism 25 (2019) 143–157.

[19] T.A. Bentley, S.J. Page, A decade of injury monitoring in the New Zealand adventure tourism sector: a summary risk analysis, Tourism Manag. 29 (5) (2008) 857–869.
[20] A.M. Gstaettner, D. Lee, B. Weiler, Responsibility and preparedness for risk in national parks: results of a visitor survey, Tour. Recreat. Res. (2020) 1–15.
[21] D. Paton, Promoting Household and Community Preparedness for Bushfires: A Review of Issues that Inform the Development and Delivery of Risk Communication Strategies, Bushfire CRC, Melbourne, 2006.
[22] M.K. Lindell, R.W. Perry, Communicating Environmental Risk in Multiethnic Communities, Sage, Thousand Oaks, 2004, p. 246.
[23] D. Mileti, et al., Public Hazards Communication and Education: the State of the Art, vol. 2, Natural Hazards Informer, Boulder, 2004, p. 13.
[24] Inspired by Iceland, "The Icelandic Pledge.", 2019. Accessed 1 December 2019, https://www.inspiredbyiceland.com/icelandicpledge.
[25] D. Bird, G. Gísladóttir, Residents' attitudes and behaviour before and after the 2010 Eyjafjallajökull eruptions – a case study from southern Iceland, Bull. Volcanol. 74 (6) (2012) 1263–1279.
[26] D.K. Bird, The use of questionnaires for acquiring information on public perception of natural hazards and risk mitigation - a review of current knowledge and practice, Nat. Hazards Earth Syst. Sci. 9 (4) (2009) 1307–1325.
[27] A.D. Sæþórsdóttir, Preserving wilderness at an emerging tourist destination, J. Manag. Sustain. 4 (3) (2014) 65–78.
[28] D. Bird, G. Gísladóttir, How the children coped with the April 2010 Eyjafjallajökull eruption in Iceland, Aust. J. Emerg. Manag. 29 (1) (2014) 50–55.
[29] D.K. Bird, G. Gísladóttir, Responding to volcanic eruptions in Iceland: from the small to the catastrophic, Palgrave Commun. 4 (1) (2018) 151.
[30] T.W. Heggie, T.M. Heggie, Viewing lava safely: an epidemiology of hiker injury and illness in Hawaii volcanoes national Park, Wilderness Environ. Med. 15 (2) (2004) 77–81.
[31] Þ. Heimisdóttir, A.D. Sæþórsdóttir, G. Gísladóttir, The sublime attraction of active volcanoes: an exploration of tourists' experiences during a long-distance hiking route in Iceland, Tour. Stud. (2019), 0(0): p. 1468797619832306.
[32] T.E. Drabek, Disaster Evacuation Behavior. Tourists and Other Transients, University of Colorado, Boulder, Colorado, 1996.
[33] B. Faulkner, Towards a framework for tourism disaster management, Tourism Manag. 22 (2) (2001) 135–147.
[34] S. Becken, K.F.D. Hughey, Linking tourism into emergency management structures to enhance disaster risk reduction, Tourism Manag. 36 (2013) 77–85.
[35] R. Buckley, Rush as a key motivation in skilled adventure tourism: resolving the risk recreation paradox, Tourism Manag. 33 (4) (2012) 961–970.
[36] C.I. Cater, Playing with risk? participant perceptions of risk and management implications in adventure tourism, Tourism Manag. 27 (2) (2006) 317–325.
[37] M.M. Wood, et al., Communicating actionable risk for terrorism and other Hazards, Risk Anal. 32 (4) (2012) 601–615.
[38] I. Kelman, et al., Warning systems as social processes for Bangladesh cyclones, Disaster Prev. Manag.: Int. J. 27 (4) (2018) 370–379.
[39] D.S. Mileti, J.H. Sorensen, Communication of Emergency Public Warnings: A Social Science Perspective and State-Of-The-Art Assessment, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, TN, 1990, p. 128.
[40] D.S. Mileti, J.H. Sorensen, A Guide to Public Alerts and Warnings for Dam and Levee Emergencies, U.S. Army Corps of Engineers. Institute for Water Resources, Risk Management Center, Davis, CA, 2015, p. 24.
[41] T.E. Drabek, Understanding disaster warning responses, Soc. Sci. J. 36 (3) (1999) 515–523.
[42] J.H. Sorensen, Hazard warning systems: review of 20 Years of progress, Nat. Hazards Rev. 1 (2) (2000) 119–125.
[43] J.H. Sorensen, B.V. Sorensen, Community processes: warning and evacuation, in: H. Rodríguez, E.L. Quarantelli, R.R. Dynes (Eds.), Handbook of Disaster Research, Springer, New York, 2007, pp. 183–199.
[44] C. García, Designing and implementing more effective Integrated Early Warning Systems in mountain areas: a case study from Northern Italy, J. Alp. Res. 100 (1) (2012), https://doi.org/10.4000/rga.1679.
[45] C. Garcia, C.J. Fearnley, Evaluating critical links in early warning systems for natural hazards, Environ. Hazards 11 (2) (2012) 123–137.
[46] M. Edmonds, J. Grattan, S. Michnowicz, Volcanic gases: silent killers, in: C. J. Fearnley, et al. (Eds.), Observing the Volcano World: Volcano Crisis Communication, Springer International Publishing, Cham, 2018, pp. 65–83.
[47] L. Cantrell, M. Young, Fatal fall into a volcanic fumarole, Wilderness Environ. Med. 20 (1) (2009) 77–79.
[48] A. Carfora, et al., Fatal inhalation of volcanic gases in three tourists of a geothermal area, Forensic Sci. Int. 297 (2019) e1–e7.
[49] M.A. Thompson, J.M. Lindsay, G.S. Leonard, More than meets the eye: volcanic hazard map design and visual communication, in: C.J. Fearnley, et al. (Eds.), Observing the Volcano World: Volcano Crisis Communication, Springer International Publishing, Cham, 2018, pp. 621–640.
[50] K. Haynes, J. Barclay, N. Pidgeon, Volcanic hazard communication using maps: an evaluation of their effectiveness, Bull. Volcanol. 70 (2) (2007) 123–138.
[51] H. Faulkner, D. Ball, Environmental hazards and risk communication, Environ. Hazards 7 (2) (2007) 71–78.
[52] M. Siegrist, More questions than answers: a response to 'Four questions for risk communication' by Roger Kasperson (2014), J. Risk Res. (2014) 1–3.
[53] T.E. Drabek, Disaster evacuation responses by tourists and other types of transients, Int. J. Publ. Adm. 22 (5) (1999) 655–677.
[54] ABC, Relatives to Sue Royal Caribbean Cruise Line over New Zealand Volcano Tragedy, 2020. https://www.abc.net.au/news/2020-04-27/new-zealand-white-island-volcano-disaster-four-corners/12150706?nw=0. (Accessed 29 September 2020).