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VOLCANIC CRISIS MANAGEMENT IN ICELAND: LESSONS FROM THE NOVEMBER 10, 2023, EVACUATION OF GRINDAVÍK

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ABSTRACT

This study examines the rapid-onset evacuation of Grindavík, Iceland (10 November 2023), to understand how environmental cues, institutional communication, and community networks shape evacuation decisions and outcomes. We use a mixed-methods design combining a survey (n = 338) with six in-depth interviews to triangulate behavioural, organisational, and emotional dimensions across individual, institutional, and community levels. Findings reveal that 71% of residents left before the official order, primarily in response to seismic shaking and visible road damage. However, inconsistent or conflicting information reduced trust in authorities and exposed a gap between documented plans and operational readiness due to limited full-scale drills. Theoretically, we frame evacuation as a complex adaptive system, introducing collective trust dynamics that connect risk signals, communication flows, and social cohesion to protective action. Practically, we recommend unified, authoritative communication channels, regular scenario-based drills, targeted support for vulnerable groups, and long-term psychosocial care. Although grounded in Iceland, the framework and results generalise to small, hazard-exposed communities, such as island settlements and coastal towns, that face sudden threats and constrained evacuation routes. The case enriches crisis management, risk communication, and resilience research while offering actionable guidance for hazard-prone settings worldwide.

KEYWORDS

crisis management, evacuation, risk communication, volcanic hazards, community resilience

CLASSIFICATION

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INTRODUCTION

Volcanic hazards pose complex challenges for communities located in tectonically active regions, as illustrated by global case studies of sudden seismic or eruptive signals that necessitate rapid evacuations [1-3]. Research on crisis management has examined evacuation modelling [4], risk perception [5], and multi-level coordination [6]. However, relatively few studies have explored how small communities adapt to abrupt, large-scale evacuation orders triggered by potential magma intrusion beneath residential areas.

Although Iceland has experienced major eruptions, such as Eyjafjallajökull (2010) and others on the Reykjanes Peninsula (2021-2023), these occurred mostly in uninhabited regions or led to short-term evacuations. The November 10, 2023, evacuation in Grindavík – prompted by intensifying seismic activity that indicated a possible eruption beneath the town – offers an unprecedented case to examine community-level responses and the efficacy of crisis planning under extreme uncertainty.

Previous studies highlight how conflicting information sources and limited lead time can increase stress and hinder decision-making during volcanic emergencies [1, 2, 7, 8]. However, few investigations have examined the social, emotional, and managerial aspects of a rapidly evolving evacuation in a tightly knit Icelandic community. This paper aims to address that knowledge gap by analyzing Grindavík residents' perceptions and responses to the sudden evacuation order, contributing new insights to the broad literature on crisis management, risk communication, and collective resilience in volcanic emergencies.

A mixed-methods approach was utilised, combining a quantitative survey (n = 338) with in-depth qualitative interviews (n = 6) to capture both broad behavioural patterns and nuanced personal experiences. Our theoretical framework draws on research underscoring the significance of risk perception, information overload, and social cohesion [9, 10]. Specifically, we investigate whether pre-existing evacuation plans, timely official guidance, and strong community networks can mitigate the uncertainties associated with rapid-onset volcanic threats.

Following this introduction, we review relevant literature on crisis management, risk communication, preparedness, and resilience (Section 2). Section 3 outlines the mixed-methods design, including survey and interview data collection and analysis. Section 4 presents the main results, highlighting residents' evacuation timing, information use, and emotional responses. It, along with Section 5, discusses the Grindavík case from a systems perspective, situating findings within broader theoretical frameworks. Section 6 elaborates on the broader relevance of the framework for other hazard-prone communities and provide implications for practice and theory, finally concluding with limitations and directions for future research.

Building on this, the study addresses the following research questions:

RQ_1: How did residents perceive and respond to the sudden evacuation order?
RQ_2: What role did institutional communication and community networks play in shaping decisions?
RQ_3: What lessons does this case provide for improving volcanic crisis management in small, hazard-exposed communities?

LITERATURE REVIEW

The literature on volcanic crisis management highlights how natural hazards evolve into disasters when they intersect with human settlements and when institutional capacity is insufficient to manage uncertainty. This review's subsections cover: 1) crisis management in volcanic emergencies; 2) risk communication and public response; 3) evacuation preparedness and behaviour; and 4) the psychological and social dimensions of resilience.

CRISIS MANAGEMENT IN VOLCANIC EMERGENCIES

Volcanic crises illustrate how natural hazards become disasters when they intersect with human settlements, particularly in small, hazard-prone communities such as fishing villages in Japan, island settlements in the Caribbean, or coastal towns in New Zealand [11, 12]. These cases demonstrate that preparedness and collective resilience are decisive in shaping outcomes when evacuation must occur with little warning. To analyse these dynamics, this study draws on interconnected strands of literature on crisis management, risk communication and evacuation behaviour, and the psychological and social dimensions of resilience.

Natural events such as eruptions or earthquakes escalate into disasters only when societal structures fail to absorb their impact [13]. Research consistently indicates that crises are most disruptive where preparedness is limited [14]. Crisis management, therefore, involves not only documented plans but also the adaptive capacity of institutions and communities to respond under uncertainty [1, 10].

Within this perspective, the complex adaptive systems (CAS) theory is a valuable analytical lens. CAS emphasises that systemic outcomes emerge from nonlinear interactions between subsystems rather than from centralised command [15-17]. Applied to evacuation contexts, this means that responses are shaped dynamically by feedback loops among natural signals, institutional communication, and social networks. Understanding evacuation as a CAS helps explain why communities sometimes respond effectively even in the absence of clear official orders, and why contradictions between signals and directives can destabilise response systems.

RISK COMMUNICATION AND PUBLIC RESPONSE

Communication plays a decisive role in evacuation behaviour. Studies reveal that residents' decisions are shaped by a combination of environmental cues, such as visible ground damage and tremors, and official messages from authorities [5]. When these two align, compliance and trust increase; when they diverge, residents often prioritise personal observation and peer communication [7, 18].

This pattern is well captured by the social amplification of risk framework (SARF) [19, 20]. According to SARF, risk signals are not transmitted neutrally but are amplified or attenuated through formal institutions, media, and community narratives. In volcanic contexts, peer-to-peer exchanges and social media posts can magnify local perceptions of danger more rapidly than official announcements, leading to early evacuations. Conversely, inconsistent or delayed communication from authorities can attenuate trust and delay compliance. Understanding these amplification dynamics is essential for designing coherent, multi-channel risk communication strategies.

EVACUATION PREPAREDNESS AND BEHAVIOUR

Preparedness determines how effectively communities can act on warnings. Research indicates that regular, scenario-based drills improve recognition of evacuation routes, foster a culture of readiness, and reduce chaos during real events [21]. Studies also highlight that community-based participation, such as school-led or neighbourhood drills, creates stronger preparedness than passive, top-down dissemination of information [22, 23].

At the same time, preparedness is uneven across demographic and social groups. Women often act more proactively in seeking and sharing risk information, while men are more likely to focus on logistical measures such as securing supplies [24]. Older adults may bring valuable experience but also face mobility challenges, while individuals with disabilities are often underprepared due to lack of tailored planning [25, 26]. Recognising these differences is critical for inclusive evacuation strategies.

PSYCHOLOGICAL AND SOCIAL DIMENSIONS OF RESILIENCE

Finally, research demonstrates that volcanic crises are not only logistical challenges but also psychological and social events. Prolonged displacement without clear timelines increases stress and anxiety among evacuees [4]. Trust plays a central role in shaping both immediate safety and long-term recovery: Communities with high social trust are more likely to support each other, share resources, and recover more quickly [27, 28].

This dual dimension of resilience – structural (infrastructure, plans) and relational (social cohesion, mutual aid) – is increasingly recognised in resilience theory [29-31]. For small communities in particular, relational resilience can be decisive: Improvisation, solidarity, and peer support often bridge the gaps left by limited institutional capacity. In other words, resilience depends not only on strong systems and plans but also on the strength of social ties and collective improvisation, especially in small communities.

VOLCANIC CRISIS MANAGEMENT IN ICELAND: A CASE STUDY OF GRINDAVÍK

Iceland's unique geological setting places it under constant threat from seismic and volcanic activity. Over the past decade, eruptions such as Eyjafjallajökull (2010) and repeated events since 2021 on the Reykjanes Peninsula have provided critical lessons for volcanic crisis management. National authorities rely on continuous seismic monitoring, hazard assessments, and predefined contingency plans to mitigate risks. This infrastructure is supported by a centralised civil protection system capable of issuing rapid alerts and coordinating evacuation procedures at the national and local levels [32].

Grindavík, a fishing town of approximately 3 600 residents located on the Reykjanes Peninsula, became the focus of such measures during the November 10, 2023, evacuation. Multilingual evacuation guidance, maps of safe routes, and designated shelters had been developed in advance, reflecting Iceland's emphasis on inclusivity and clarity in risk communication. Public updates were delivered through official channels, including direct notifications, media briefings, and community meetings, in an effort to ensure accuracy and reduce uncertainty.

Nevertheless, the evacuation revealed critical gaps. Although written procedures were in place, few institutions, such as schools and care facilities, had conducted full-scale evacuation drills. As a result, operational challenges arose, particularly for vulnerable groups. Residents also reported confusion when institutional messages did not fully align with their own observations of seismic activity and ground deformation. These tensions underscored the fragile balance between institutional authority and community-based interpretation of risk signals.

SUMMARY

The Grindavík case illustrates both the strengths and vulnerabilities of Iceland's volcanic crisis management. Continuous monitoring and multilingual communication supported timely action, but the lack of full-scale rehearsal exposed operational weaknesses. Aligning institutional guidance with residents' lived observations proved decisive for maintaining trust, while strong community cohesion provided redundancy when official capacity was stretched. These lessons are not only relevant for Iceland but also transferable to other small, hazard-exposed communities, such as island settlements in the Caribbean or coastal towns in Japan, where limited evacuation routes and tight social networks make the balance between formal planning and lived practice decisive for resilience – as summarised in Table 1.

Table 1. Strengths, gaps, and transferable lessons from the Grindavík evacuation (November 10, 2023).

Strengths	Gaps	Transferable Lessons
Continuous seismic monitoring and hazard assessments	Limited full-scale evacuation drills in schools and care facilities	Early warning systems must align with local observations to maintain trust
Multilingual evacuation guidance and route maps	Operational challenges for vulnerable groups	Multilingual communication ensures inclusivity and reduces uncertainty
Centralized coordination by civil protection authorities	Confusion when official communication did not align with lived observations	Regular scenario-based drills strengthen preparedness
Strong community cohesion and mutual aid	Overreliance on documentation without practical rehearsal	Community solidarity provides redundancy when official capacity is stretched

The case illustrates how continuous monitoring and multilingual communication supported timely action, while limited drills and operational gaps highlight challenges that are relevant for other small, hazard-prone communities worldwide.

RESEARCH METHODOLOGY

DATA

To explore how Grindavík residents perceived and responded to the large-scale evacuation order on November 10, 2023, this study employed a mixed-methods design [33]. Data collection combined a quantitative survey with qualitative interviews. The survey, completed by 338 residents, was distributed online through closed Facebook groups popular among Grindavík inhabitants. Although this convenience sampling was non-random, it provided rapid access to a substantial segment of the local population. Respondents gave informed consent, were assured anonymity, and could exit at any time. Basic demographic information such as age, gender, and household composition was gathered to enable subgroup analysis without compromising confidentiality.

In addition to the survey, six residents were interviewed in depth using purposive and snowball sampling [34]. This approach ensured representation from different age groups, household types, and professional backgrounds, including health and emergency services. Each interview lasted approximately 60 minutes and was conducted in person whenever possible, or otherwise via telephone or video call. An interview guide was followed, and all interviews were audio-recorded with consent and transcribed verbatim.

RESEARCH INSTRUMENT

A structured questionnaire was developed using established literature on crisis management [10], evacuation decision-making [5], and risk communication [7]. The survey contained 21 questions, primarily closed-ended using Likert scales and multiple-choice formats, supplemented by a few open-ended items for more nuanced feedback. Participants (n = 338) were recruited

via closed Facebook groups popular among Grindavík residents. Although this convenience sampling was non-random, it provided rapid access to a substantial segment of the local population. The questionnaire was hosted on a secure online platform for two weeks. Respondents provided informed consent, were assured anonymity, and could exit at any time. Basic demographic data – age range, gender, and household composition – were collected to enable subgroup analysis without compromising confidentiality.

In addition to the survey, six residents were selected for semi-structured, in-depth interviews using purposive and snowball sampling [34]. This approach ensured representation from different age groups, household types (such as families with children and single residents), and professions, including health and emergency services. Each interview lasted approximately 60 minutes and was conducted in person whenever possible, or otherwise via telephone or video conferencing. The interview guide focused on four main topics: initial awareness of the potential volcanic activity, information sources influencing evacuation decisions, emotional and practical challenges encountered during and after evacuation, and reflections on official directives, infrastructure preparedness, and lessons learned. All interviews were audio-recorded with participant consent and transcribed verbatim.

ANALYSIS

Survey responses were transferred to a statistical software package (e.g., SPSS or R) for descriptive and inferential analysis. Frequency distributions, cross-tabulations, and basic statistical tests, such as χ^2, were performed to identify associations between demographic factors (e.g., age, presence of children) and reported behaviours.

For the qualitative data, transcripts underwent thematic analysis [35]. An initial open-coding phase identified recurring ideas (e.g., “uncertainty”, “fear”, “information overload”), followed by focused coding to group related concepts into broader categories (e.g., “social influence on decision-making”, “emotional stressors”, “conflicting information”). Finally, overarching themes emerged that captured core experiences, and a validity check was completed by two researchers who independently reviewed and coded a subset of transcripts. Discrepancies were resolved through discussion, ensuring reliability of the qualitative findings.

By combining quantitative and qualitative data, this study employs triangulation to strengthen the credibility of its conclusions [34]. Statistical patterns – such as the proportion of residents who evacuated early – were enriched by interview narratives that explained why certain individuals left immediately while others hesitated. This integration provided a comprehensive view of how official directives, social networks, and personal risk assessments interact in rapidly unfolding crises.

ETHICAL CONSIDERATIONS

All participants received information about the study’s objectives and their right to withdraw at any point. No personally identifying data were collected in the survey, and interviewees were assigned coded identifiers (e.g., Participant A, B, C). Audio recordings were securely stored, and transcripts were fully anonymised. The research protocol was reviewed and approved by the relevant ethics committee at the University of Iceland’s Faculty of Business Administration.

LIMITATIONS OF THE METHODOLOGY

While social media outreach effectively reached a broad audience, residents lacking internet access or strong digital literacy may be underrepresented, potentially introducing sampling bias. Additionally, data collection took place relatively soon after the evacuation, potentially amplifying emotional responses or memory distortions. Finally, the tight-knit nature of Grindavík may limit the generalisability of these results to larger or more diverse communities.

RESULTS

This section presents the findings of the study in direct relation to the three research questions introduced in the introduction. Each subsection integrates quantitative survey results and qualitative interview insights, offering both statistical patterns and the lived experiences of Grindavík residents during the November 10, 2023, evacuation.

RQ_1: HOW DID RESIDENTS PERCEIVE AND RESPOND TO THE SUDDEN EVACUATION ORDER?

Survey data show that 71% of respondents evacuated before the official announcement, citing strong and unpredictable tremors as their primary trigger [5]. The sample consisted of 338 participants, with a slight majority (53%) aged 45-64 and over 80% identifying as female. Participation in the evacuation was high across all demographic groups, with no significant differences by age or gender. While 45% of respondents reported high levels of fear, many also described methodical responses, such as packing essentials and helping neighbours. One participant explained, "*I had a plan in mind – pack extra clothes, gather the children, and head out, but I was shaking the entire time*".

Interview data reinforce these survey findings. Four of the six interviewees described leaving before the official order, highlighting heightened risk perception due to seismic activity and visible ground damage. One explained, "*We heard rumours the ground might be shifting. I didn't wait; I grabbed my daughter and left that evening*". These findings illustrate that immediate environmental cues were decisive in shaping behaviour and that many residents demonstrated proactive and adaptive responses despite experiencing significant emotional stress.

RQ_2: WHAT ROLE DID INSTITUTIONAL COMMUNICATION AND COMMUNITY NETWORKS PLAY IN SHAPING DECISIONS?

Trust in institutional communication was mixed. Approximately 33% of survey respondents reported high trust in official instructions, while 27% indicated low or mixed trust, relying instead on personal observations and neighbourhood cues [7]. More than one-quarter found official updates confusing in the hours prior to evacuation. In the week leading up to November 10, over half of respondents (56%) reported checking information sources multiple times per day, reflecting widespread anxiety and the importance of timely guidance [4].

Interviews further reveal the tension between institutional communication and peer networks. Residents described relying on multiple sources – such as social media, local radio, and meteorological reports – which sometimes created confusion. As one participant stated, "*Everyone was posting pictures of cracks in the roads, but I kept hearing on the news we had time. I felt stuck between what I saw and what officials said*".

Despite gaps in institutional readiness – few schools and care facilities had conducted full-scale evacuation drills – community networks played a decisive role. Neighbours supported each other by coordinating evacuations, for example by placing "evacuated" signs in friends' windows to signal to rescue teams. These findings highlight that while inconsistent institutional communication undermined trust, strong community solidarity provided essential redundancy during the crisis [5, 21].

RQ_3: WHAT LESSONS DOES THIS CASE PROVIDE FOR IMPROVING VOLCANIC CRISIS MANAGEMENT IN SMALL, HAZARD-EXPOSED COMMUNITIES?

Survey findings indicate that 18% of respondents encountered constraints during evacuation, such as caring for elderly relatives or navigating damaged roads. One resident explained, "*We*

saw cracks in the main road and couldn't get through easily; my elderly mother was terrified". These findings underscore the importance of planning for vulnerable groups.

Across both quantitative and qualitative data, three lessons stand out. First, timely and consistent warnings are crucial. Delayed or conflicting messages eroded trust in authorities and prompted uneven responses [7]. Second, preparedness gaps were evident. Although institutions had documented evacuation plans, few had conducted scenario-based drills, which created operational challenges during the evacuation [21]. Third, the emotional toll of prolonged displacement was significant. Many residents expected to return within days but instead faced extended restrictions, which heightened stress and uncertainty. As Marrero et al. [4] emphasise, extended displacement without clear updates increases psychological strain.

Taken together, these results point to key lessons for crisis management: the need for unified and authoritative communication platforms, mandatory scenario-based drills across schools and care facilities, targeted support for vulnerable groups, and long-term psychosocial care supported by transparent re-entry timelines.

DISCUSSION

This study investigated how Grindavík residents experienced the November 10, 2023, evacuation in response to escalating seismic activity, with a focus on how environmental cues, information sources, and preparedness measures influenced evacuation behaviour. The findings demonstrate that many residents self-evacuated early in response to observable seismic hazards, including tremors and visible cracks in infrastructure, while confusion arose from conflicting information channels such as social media, local radio, and official statements. These patterns emphasise that immediate environmental indicators often outweighed formal advisories in shaping decisions, underscoring the importance of timely, coherent warnings that align with lived observations [5, 7]. Delays or discrepancies in communication weakened trust and contributed to uneven or disorganised responses, while strong community solidarity partially compensated for institutional shortcomings. Moreover, the research reveals a gap between documented evacuation plans and operational readiness: although schools and care facilities had basic plans, few had conducted full-scale drills, which contributed to confusion during the evacuation [18]. Finally, the emotional toll of prolonged displacement emerged as a critical concern, consistent with findings by Marrero et al. [4] that extended uncertainty without clear updates heightens psychological strain. Transparent, continuous communication and psychosocial support are therefore essential to mitigate such impacts.

From a theoretical perspective, the Grindavík case provides empirical support for conceptualising evacuation as a complex adaptive system (CAS), where outcomes emerge from dynamic interactions between natural signals, institutional communication, and community networks [15-17]. Figure 1 illustrates this conceptual framework, highlighting trust as a central mediator: when official communication aligned with residents' lived experience, trust was reinforced and facilitated coordination; when communication diverged from observation, trust eroded, prompting reliance on peer networks. This finding advances CAS theory by showing how collective trust dynamics can accelerate or fragment adaptive responses in small communities facing acute uncertainty.

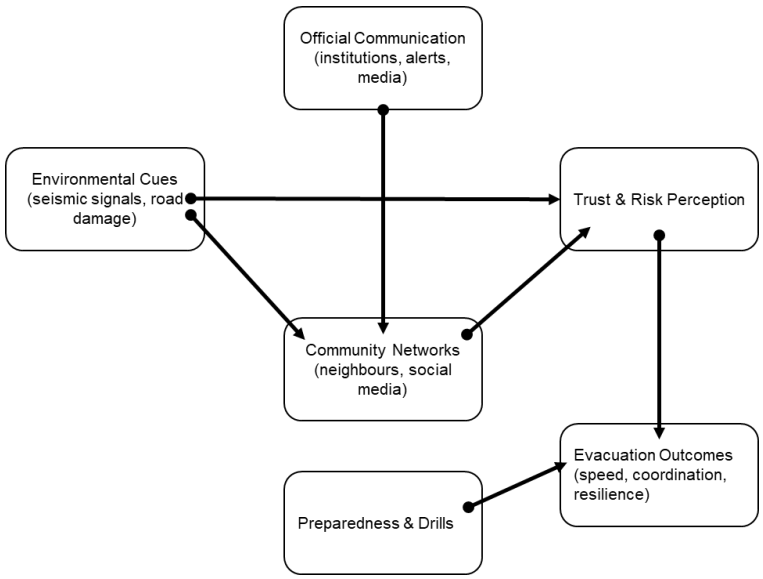

Figure 1. Conceptual framework of the Grindavík evacuation as a CAS.

The findings also extend the SARF [19] by demonstrating how peer-to-peer communication can amplify risk perceptions in real time, sometimes overtaking institutional channels. This reflects the relational and fluid nature of trust, echoing recent research that emphasises how contradictions between institutional and community narratives shape behavioural outcomes. Furthermore, the study contributes to resilience theory [29-31] by underlining both structural preparedness (infrastructure, formal plans) and relational resilience (cohesion, solidarity, improvisation). The Grindavík case illustrates how relational resilience often compensates for institutional gaps, suggesting that resilience should be reconceptualised not only as robustness but also as the emergent capacity of social networks in hazard-prone communities.

The findings have broader relevance beyond Iceland. Many small, tightly knit communities worldwide face comparable challenges of sudden-onset hazards, constrained evacuation routes, and reliance on social cohesion. Fishing villages in Japan, for instance, have developed single-person tsunami drills to foster bottom-up risk communication and enhance self-efficacy among elderly residents [22]. Similarly, households across Caribbean island states demonstrate resilience rooted in community cohesion, though they face difficulties in engaging consistently with formal institutions during crises [23]. By distinguishing between localised features – such as Iceland's centralised civil protection system and advanced seismic monitoring – and generalisable dynamics such as feedback loops, peer communication, and trust, the Grindavík framework contributes both context-sensitive insights and comparative lessons for disaster management globally.

In practical terms, several implications arise. A unified and authoritative communication platform is needed to minimise confusion created by multiple or contradictory sources. Verified SMS alerts, dedicated emergency websites, or mobile applications could serve this purpose. Regular scenario-based drills should be mandatory in schools, care facilities, and workplaces to transform written plans into operational readiness [18]. Support for vulnerable groups must be prioritised, as households with elderly or dependent members faced significant obstacles, underscoring the importance of community-based coordination and volunteer mobilisation. Authorities should also integrate local observations into official communication, explicitly linking scientific data with observable phenomena such as tremors or ground cracks, to enhance credibility and compliance. Finally, the experience highlights the necessity of long-term psychosocial care and transparent re-entry planning, since prolonged displacement created sustained stress and uncertainty [4].

Theoretically, this study refines several established frameworks. It strengthens CAS theory by illustrating how decentralised, emergent responses in small communities reflect adaptive co-evolution across subsystems. It expands SARF by showing that trust is not static but relationally negotiated, co-produced through institutional and peer networks during crises [2, 3]. It broadens resilience theory by demonstrating that resilience is both structural and relational: infrastructural robustness is important, but improvisation, mutual aid, and social cohesion proved equally decisive. By highlighting the role of trust as a mediating dynamic, the Grindavík case bridges insights from complexity theory, risk communication, and resilience research.

At the same time, the study has limitations. The reliance on an online survey may introduce sampling bias by under-representing residents with limited digital access or literacy. Data were collected shortly after the evacuation, which may have heightened emotional responses and limited reflection. Moreover, the tightly knit nature of Grindavík may restrict the generalisability of findings to larger or more diverse contexts. Future research should pursue longitudinal studies to assess how experiences and psychosocial impacts evolve over time, and comparative research across diverse hazard-prone communities could evaluate the transferability of the Grindavík framework. Further studies might also examine the long-term consequences of displacement on trust, mental health, and social resilience, extending the contributions of this work.

Taken together, the Grindavík evacuation illustrates both vulnerabilities and strengths in crisis management. While inconsistent institutional communication and insufficient preparedness exercises hindered efficiency, strong community cohesion and adaptive decision-making enabled many residents to protect themselves effectively. The study contributes to theory by advancing CAS, SARF, and resilience frameworks, and to practice by highlighting the importance of unified communication, realistic drills, targeted support for vulnerable groups, and psychosocial care. Ultimately, the case underscores that resilience in volcanic crises depends not only on scientific monitoring and institutional planning, but also on the adaptive capacity of communities themselves.

SUGGESTED ADDITION AT THE END OF DISCUSSION

In summary, the Grindavík case makes several key contributions. Theoretically, it advances crisis management research by situating evacuation behaviour within the CAS framework, extending SARF through an emphasis on relational trust, and broadening resilience theory by highlighting its structural and relational dimensions. Practically, it provides concrete lessons for policymakers and practitioners, emphasising the need for unified communication, scenario-based drills, targeted support for vulnerable groups, and long-term psychosocial care. Together, these contributions demonstrate how insights from a small, hazard-exposed community can inform both academic debates and real-world crisis management strategies.

CONCLUDING REMARKS

This study examined the November 10, 2023, evacuation of Grindavík residents in response to escalating seismic activity, illustrating how environmental cues, community solidarity, and official communication influenced evacuation behaviours. Although many residents acted proactively, overlapping and sometimes contradictory information sources caused confusion. The lack of full-scale drills also revealed gaps in practical readiness. Meanwhile, sustained stress due to delayed access to their homes heightened the emotional toll of prolonged displacement among the evacuees.

To strengthen future response efforts, emergency managers should issue timely and authoritative communication; conduct regular, realistic evacuation exercises; and provide clear re-entry timelines alongside psychosocial support. While this research reflects primarily

short-term perspectives and may be subject to sampling and recall biases, it offers a basis for more extensive longitudinal studies. Bridging the gap between theoretical preparedness and practical implementation will help communities in seismic and volcanic regions better protect public well-being in times of crisis.

Therefore, this study offers contributions on both theoretical and practical levels. Theoretically, it advances crisis management literature by framing evacuation as a CAS in which environmental signals, communication flows, and social trust interact dynamically. Practically, it highlights the need for integrated communication platforms, regular scenario-based drills, community support for vulnerable groups, and continuous psychosocial care. Together, these insights underline that resilience in volcanic crises depends not only on scientific monitoring and institutional planning but also on the capacity of communities and systems to adapt collectively under uncertainty.

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