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Contributions in the Research section of the *Australian Journal of Emergency Management* are peer reviewed to appropriate academic standards by independent, qualified reviewers.

Foreword

Associate Professor Michelle Villeneuve

Deputy Director, Centre for Disability Research and Policy, University of Sydney

It was an honour to join my team on stage to receive the 2023 Resilient Australia National Award at the National Award Ceremony in Perth on 22 November for our Person-Centred Emergency Preparedness Certificate Course. With me were representatives from each of the groups who are advancing inclusive approaches to disaster risk reduction in their communities.

At the Centre for Disability Research and Policy at the University of Sydney, we have been working in partnership to co-design new ways of working that ensure people with disability and their support needs are at the centre of disaster preparation and planning. Together, we are advancing disability-inclusive disaster risk reduction through shared learning, local collaborative actions and the co-production of tools that everyone can use. For nearly a decade, this sustained partnership research involved meaningful and active participation of people with disability, their supporting services, government, non-government, and emergency services personnel working together to develop tools and training as well as programmatic guidance on person-centred and capability-focused approaches to policy and practices that leave nobody behind.

The course is a major outcome of this partnership effort and is a co-designed, nationally consistent education that has bridged the gap on how to enable responsibility-sharing between emergency services, people with disability and the services that support them. The self-paced, activity-based online modules bring learners together to develop the knowledge and skills to prepare ourselves and others to anticipate, plan and respond effectively to disaster risks through tailored preparedness planning and cross-sector collaborative action.

The course is a foundation for other initiatives to advance risk reduction at the local level. Last year, we partnered with the Australian Institute for Disaster Resilience (AIDR) to host the Leave Nobody Behind webinar series. Over 3 events, the series explored tangible actions that people can take to ensure disability inclusion in emergency management practices and policy decision-making.

Following on from the Leave Nobody Behind webinar series, Australia's first National Disability Inclusive Disaster Risk Reduction Forum was hosted in June 2023. In partnership with the NSW Government and AIDR, the University of Sydney showcased research gathered through the Leave Nobody Behind project and worked with forum participants on how learnings can be applied to the translation and scaling of risk reduction tools at a national level. The seeds we have planted are germinating across Australia and we are thrilled that the Certificate Course has supported a nationally consistent approach to disability-inclusive disaster risk reduction.

A key element of reducing disaster risk is making it inclusive. We have made significant progress by working to co-design actions for risk reduction. There has been significant progress made on developing the evidence base for these actions as a result of the Australian Research Council Linkage Project to advance and scale disability-inclusive disaster risk reduction initiatives. I am so proud to see the work of the Leave Nobody Behind project shared nationally and the Certificate Course recognised at the 2023 Resilient Australia Awards for its contribution to increasing emergency preparedness and facilitating cross-sector collaboration to make sure that nobody is left behind when disasters strike.

For each of the winners and finalists across the 6 award categories, the awards have provided an important platform to share knowledge and advance disaster resilience and risk reduction at a national scale.

I encourage you to learn more about the winning and highly commended projects on page 62 in this edition of the *Australian Journal of Emergency Management*, and hope you find inspiration in what they have achieved and contributed to resilience building in Australia.

Vale Associate Professor Kevin Tolhurst AM

Dr Kevin Tolhurst AM was an Honorary Associate Professor in Fire Ecology and Management at the School of Agriculture, Food and Ecosystem Sciences, University of Melbourne. Based in Creswick, north of Ballarat, Kevin's death was a shock to friends and colleagues. His loss will be deeply felt by many in our community.

Kevin died suddenly of a heart attack after presenting on fire management to the community in Mallacoota, Eastern Victoria. Assisting fire-prone communities was a task Kevin enjoyed and one which those communities highly valued.

For decades Kevin was a pillar of the fire science community, both nationally and internationally. His knowledge and insights were highly regarded as was his remarkable ability to explain complex science in accessible and comprehensible language. Kevin helped numerous communities to better appreciate the landscapes they chose to call home by assisting residents and authorities to understand the importance and the dangers of fire.

Relatively few of us in the 'fire' business competently straddle the design and implementation of complex research and also be able to convey the real-world application of research findings. It was in this sense that Kevin was held in such high esteem by his colleagues and by the wider community.

Over recent decades, Kevin assisted many local and regional communities, and his fire-management knowledge and insights were in high demand during major bushfires as well as during subsequent reviews, inquiries and royal commissions.

His career spanned half a century and involved all aspects of fire management; from fire ecology, fire behaviour and the role of fuels; to suppression and recovery.

During his career, Kevin authored more than 200 scientific papers, and, every fire season, offered his scientific knowledge and insights to incident management teams and regional and state co-ordination and control centres during fire emergencies. In southeast Australia in particular, chief fire officers routinely sought Kevin's advice and counsel, both during and after major fire events. For decades, Kevin had a major influence on the region's fire management strategies.

Another component of Kevin's career was his determination to understand the longer-term effects of fire, and of the absence of fire, in the natural environment. Kevin led a 30-year, multi-disciplinary study into the effects of repeated low-intensity fires in dry eucalypt forests in central Victoria. This research revolutionised how ecological values are incorporated into fire management, how fuels are assessed and how bushfire risk is calculated. This research led him, together with Derek Chong, to develop the PHOENIX RapidFire bushfire spread model. The computer program simulates bushfire behaviour, aiding real-time bushfire control operations by predicting how bushfires will move in real-time. The program has proved invaluable in bushfire risk analysis and for ecological and land-use planning. It is now used widely across Australia.

Kevin also initiated the Overall Fuel Hazard assessment process that is widely used across Australia. Part of this initiative was the development of the Wiltronics T-H Fine Fuel Moisture Meter that is used in prescribed fire operations. Kevin was a pioneer in the use of fauna and flora life history attributes in developing sustainable fire regimes.

Beyond his research Kevin, for decades, delivered lectures and led field studies for under- and post-graduate students. This was another role Kevin delighted in. Students valued these interactions and Kevin's enthusiasm in helping them appreciate the science of fire and ecosystem management. His ability to convey complex science in an accessible way was greatly appreciated by student ecologists and land and fire managers, many who went on to careers across Australia and beyond.

In 2015, Kevin was made a Member of the Order of Australia and, in 2016, he was also honoured with the International Association of Wildland Fire's Ember Award for excellence in wildland fire science. Kevin was to be in Coolangatta in November 2023 to receive the N. W. Jolly Medal from Forestry Australia. This award is Forestry Australia's highest and most prestigious honour for outstanding service to forestry in Australia. It recognises contributions from across the full scope of forestry and reflects the diversity of significant contributions being made across a wide range of disciplines and forest management activities.

Kevin Tolhurst's career spanned most aspects of forest and fire management in one of the most fire-prone regions on Earth. He was widely valued for his contributions to research and development, his published works, university teaching, professional training and for his decades-long involvement in public forums, formal inquiries and his assistance to the media. His efforts have inspired generations of park, forest and fire managers, planners and field staff to manage our precious natural areas sustainably. His legacy will be enduring.

Kevin – forester, ecologist, environmentalist – will remain long in the memories of his family and all those he assisted to better understand the landscapes we call home.

Gary Morgan AM AFSM and Mike Leonard

Natural hazards: the future of learning is already here

Dr Margaret Cook

Griffith University

When floods occur, humans have a habit of looking for someone to blame. Rather than examine the underlying human-induced causes behind the disaster, it is easier and palatable to blame others and this avoids awkward issues of culpability. But in doing so, it can remove the opportunity to reduce the effects of future hazard events.

Floods are natural events, caused by heavy or intense rain over an extended period and, without humans, they are not disasters. It is the decision by humans to live and build on the floodplain that can have calamitous consequences that become a disaster. In Brisbane, after every major flood, society has reverted to a blame game, finding a scapegoat each time, rather than interrogating the human factors behind the disaster. My concern is that if society continues to find external sources to blame and not address the root problems, we lose opportunities for climate adaptation that will make communities safer.

Submerged houses in South Brisbane after 1893 flood.

Source: University of Queensland.

In February 1893, a rain depression dumped 1,026mm of rain in the Brisbane area that resulted in flood heights at the then Port Office Gauge of 8.5m on 5 February and 9m on 19 February. Many viewed the floods as an 'Act of God'. Others blamed 'freaks of the weather God' or the actions of 'Dame Nature'.[1] By calling floods an Act of God or 'natural disaster', those in authority are cleared of responsibility. With divine intervention and accidents of nature beyond their control, they could not be held accountable. The event could be dismissed as an aberration or rare calamity and urban growth on the floodplain continued unabated.

Whole portions of Brisbane's suburbs were flooded in 1974.

Source: Brisbane City Council Archives.

On the Australia Day weekend in January 1974, a deep low-pressure system oscillated above the Brisbane River catchment and floodwaters reached 5.5m at the Port Office Gauge on 29 January. The community blamed Somerset Dam for not delivering the perceived (unrealistic) promise of flood immunity via water storage. By diverting blame to the dam, again society could avoid uncomfortable questions about floodplain development, poor planning laws and inadequate building codes. With the opening of Wivenhoe Dam in 1985 many people thought Brisbane was flood proof and urban growth expanded in flood-hazard areas.

Major Brisbane highways were cut by flood waters in 2011.

Source: Brisbane City Council Archives.

In January 2011, after intense rain, a flood peaked at 4.5m at the Port Office Gauge. People again looked for a scapegoat. Why had Wivenhoe Dam not prevented the flood? Fuelled by media stories, many called the flood a 'great avoidable catastrophe' or a 'dam release flood' caused by mismanagement by the operating engineers.[2] For many, the Queensland Floods Commission of Inquiry[3], a Crime and Misconduct Commission investigation[4] and a class action that followed the floods reaffirmed a faith in dams, if only they were operated differently. This approach avoided questioning the region's dependence on the dam for flood mitigation and diverted discussions away from culpability by governments and land-use management; a debate many wished to avoid. Rather than challenge the reliance on engineering to control floods, the public debate shifted to blaming individuals.

Brisbane experienced major flooding again in February 2022, peaking at 3.85m at the Brisbane Gauge. Much of the rain fell downstream of Wivenhoe Dam in the unregulated portion of the river system and poured into Brisbane's complex network of creeks. Flooding was inevitable and largely unpreventable. Political leaders, the public and the media largely focused on Nature and the unrelenting rain that pummelled the city, describing it as an unrelenting and unpredictable 'rain bomb'.[5] Without a dam or operators to blame, it seems that criticism largely reverted to Nature and, once again, the opportunity to question human behaviour was lost.

While the timing, temporal and spatial characteristics of the next flood are unknown, its arrival is certain. Climate change brings an increased chance of intense rain and flooding because every additional degree in atmospheric temperature means it can hold around 7% more moisture.[6] With a warming climate, most scientists predict that future floods will be greater than the largest recorded floods.

I am concerned that climate change will be used by those with authority as another factor that can be blamed for floods and other hazards of nature. It won't be the fault of those who fail to address floodplain development or climate adaptation. If we don't accept that anthropogenic factors have caused or exacerbated climate change then it will provide a convenient scapegoat for those who govern, work or live in Brisbane and for populations in high-risk hazard areas. Climate change will be added to Nature, God, dams and dam operators in the human arsenal of factors that can be blamed for damage and loss from floods.

Until people who live in high-flood-risk areas (most of the populated east coast of Australia) accept that the flood hazard has anthropogenic causes—primarily the human encroachment on the floodplain—our towns and cities will repeat the mistakes of the past. Instead, particularly for Brisbane, we must recognise these factors and adapt to the realities of living in a city beside a sub-tropical river that is prone to flooding. Only then can we stop diverting blame and find the courage to make the systemic changes needed to reduce future flood disasters.

About the author

Dr Margaret Cook is a Research Fellow at the Australian Rivers Institute, Griffith University and a Researcher at La Trobe University.

Endnotes

1. *Week*, 24 February 1893, 16; *Telegraph,* 22 February 1893, 4; *Brisbane Courier,* 20 February 1893, 4.

2. Hedley Thomas, 'The Great Avoidable Flood', *The Australian,* 22–23 January 2011.

3. Queensland Floods Commission of Inquiry, at *www.floodcommission.qld.gov.au/.*

4. Queensland Floods Commission of Inquiry, at *http://www.floodcommission.qld.gov.au/publications/final-report/.*

5. Conal Hanna, 'Brisbane homes flooded as "rain bomb" continues to threaten lives in south-east Queensland', *The Guardian*, 27 February 2023.

6. Climate Council (2022) *Everything you need to know about floods and climate change, 2 March 2022, at www.climatecouncil.org.au/resources/climate-change-floods/.*

Abstract

Climate change is having a significant effect on disasters worldwide. In response, societies have attempted to mitigate the consequences by developing standardised arrangements, known as incident command systems. Many of these systems have a military heritage using hierarchical command-and-control principles that are authoritative by nature and fit well within bureaucratic organisations. While emergency services agencies have embraced these incident command systems, other agencies have not, thereby making the multi-agency response to disasters challenging. This research investigated current incident command systems to develop an improved framework that includes all agencies and improves the multi-agency response to emergencies and disasters. A multi-modal qualitative research approach was undertaken using a literature review, semi-structured interviews with informants and a policy analysis of recent disaster reviews and inquires. This combined data informed the development of 4 options for improvements to the multi-agency response and consolidated the issues into 5 domains. These domains and options for improvement were presented to a panel of experts at the strategic level of emergency and disaster management by way of a 2-round modified Delphi study. This paper reports on the final phase of the research; the policy analysis and modified Delphi study. The most significant outcome of this research was a new level of understanding of strengths and weakness of the incident command system. This contributed to the development of a new conceptual framework based on modifications to the incident command system principles.

Improving the response to disasters by enhancing the incident command system

Peer reviewed

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Introduction

There is growing evidence that the changing climate is influencing the frequency and severity of hazard events worldwide (Hallegatte, Vogt-Schilb and Rozenberg 2020; Ripple *et al.* 2022; Pörtner *et al.* 2022; Mishra, Bruno and Zilberman 2021). The Intergovernmental Panel on Climate Change (IPCC 2021) found the Earth's temperature has already increased by one degree Celsius and is expected to exceed 1.5 degrees within the coming 2 decades. During 2022, the Asia-Pacific was the world's most disaster-prone region with floods in Afghanistan, Australia, Bangladesh, India, Pakistan and Thailand, droughts in China, Kiribati and Tuvalu, typhoons in the Philippines, heatwaves in India, Japan and Pakistan and severe earthquakes in Afghanistan, Fiji and Indonesia (United Nations 2023). Despite mitigation efforts and up-to-date preparation initiatives, millions of people continue to be negatively affected by these extreme weather events. As a consequence, how we respond remains a significant aspect of disaster management and will become more important in the future (De Smet, Schreurs and Leysen 2015).

Emergencies and disasters are complex, dynamic and often fast-paced. Successful resolution is reliant on effective teamwork and the ability of emergency services agencies to interact and integrate with other disaster management agencies (Power 2018; Kelman 2017). Emergency and disaster management requires multiple agencies to work together and crucial information needs to change rapidly and accurately as the event evolves. This interoperability is pivotal to enable collaboration among all agencies involved and to reduce the effects of emergencies and disasters on communities and the environment (Kapucu and Garayev 2011). Large and complex declared disasters such as Tropical Cyclone Debbie in 2017 and the subsequent flooding in South East Queensland involved multiple hazards over a long period of time and required a significant inter-agency coordinated response (Eburn 2013; IGEM 2017). Since that time, it is uncommon for these large events to be managed independently by a single agency or jurisdiction without assistance from other emergency services or government and non-government organisations such as local councils (Owen *et al.* 2013; Yates 1999). However, the capacity

to carry out collaborative and coordinated responses can be challenging due to political, cultural, economic and other motives and reasons. Achieving the required level of collaboration between agencies can be problematic as each agency has its own operating procedures, legislation, protocols and requirements for managing response (Coppola 2015; Hayes 2012; Yates 1999).

Regardless of the type of hazard, the response requires elements of an incident command system. This system can vary between countries, the types of agencies involved, the legislative requirements and the local emergency management policies and procedures (Paton and Owen 2013; Comfort and Kapucu 2007). The incident command system was developed in California, USA in the 1970s after a series of catastrophic wildfires highlighted the need for an effective system to manage response operations (Stambler and Barbera 2011). It was designed to alleviate issues commonly observed in responding to emergency incidents, such as ineffective coordination, varied terminology, conflicting priorities and poor communication (Williams and Treadaway 1992; Townsend 2006; Dynes 2003; Pitt 2008). The incident command system is based on principles that govern and standardise the organisational structure as well as the management of decisions, resources and personnel during a response (Bigley and Roberts 2001; Comfort and Kapucu 2007; Moynihan 2009). These principles include command, which incorporates unity of command, unified command structures and transfer of command. It also includes a manageable span of control and coordination or joint planning of operational activities while conducting integrated operations (FEMA 2008).

This paper includes findings from the final phase (Phase 3) of a policy analysis and modified Delphi study that was part of a broader study (Bradley, Tippett and Fitzgerald 2023). This broader study applied a 3-phase multi modal approach (see Figure 1) that highlighted issues regarding the practicability of incident command systems when applied to multi-agency emergency management. Problems such as the ineffectiveness of the incident control system for large scale, complex disaster situations and the unwillingness of some response agencies to adopt incident control system principles (Farcas *et al.* 2020; Drakek 1985; Dynes 1983; Quarantelli 2002 as cited in Bradley, Tippett and Fitzgerald 2023). Other reported barriers included difficulties around the coordination of stakeholders, including volunteers; conflicting agency priorities; poor communication and the lack of information sharing between agencies. These and the other reported challenges associated with disaster and emergency management in general have motivated this research to focus on the application of the incident command system to a multi-agency disaster.

For context, each state or territory in Australia is responsible for its own disaster and emergency arrangements. Disaster and emergency planning is premised on the concept of shared responsibilities, partnerships and collaboration between government and non-government sectors (Arklay 2012). The incident control system is known as the Australasian Interservice Incident Management System (AIIMS). This system has synergies with other incident management systems around the world, such as the New Zealand Coordinated Incident Management System and the U.S. National Incident Management System.

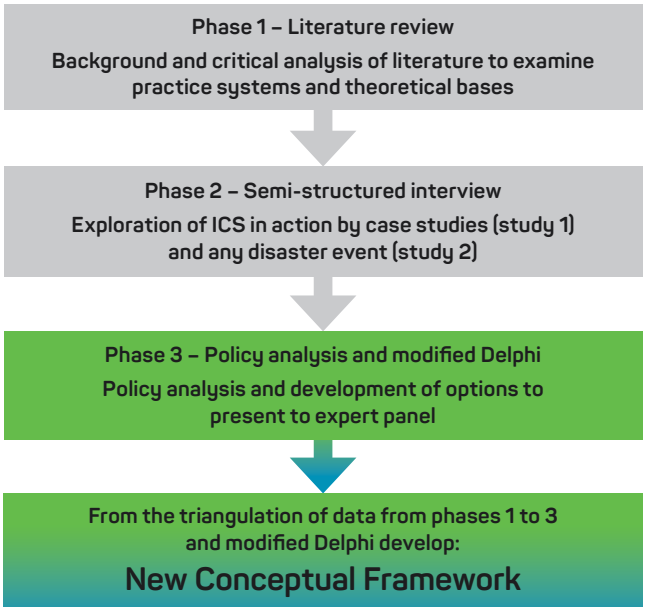

Figure 1: The data collection process encompassing all phases of the research study. Phases 1 and 2 are indicated in grey. Phase 3, depicted in green, is the focus of this paper.

Method

A 2-round modified Delphi study sought the input of an expert panel made up of senior leaders and decision-makers from across the Australian emergency management sector regarding the relevance and applicability of the current incident command system. The research by Bradley, Tippet and Fitzgerald (2023) identified the barriers of the system by employing a critical analysis of the literature followed by semi-structured interviews with informants who had been involved in the 2018 Central Queensland bushfires and the 2019 North and Far North Queensland monsoon trough floods (*n*=15). These events were chosen as they represent major and complex multi-agency events with different agencies taking the lead in the response. They were also chosen because they both occurred around the same time within a single jurisdiction. This enabled issues of jurisdictional variation in policy and practice and other variations over time to be minimised so that core issues could be exposed. The research objectives were then investigated by interviewing participants who had been involved in any type of disaster after 2017 (*n*=22).

Thematic analysis identified themes and patterns in the data collected based on the barriers, facilitators and suggested improvements to the use of incident control systems for multi-agency response. Building on these results, Phase 3 involved a policy analysis of recent disaster reviews and inquires in Australia. The established barriers (from the broader study) and the issues identified in the policy analysis were consolidated into 5 domains, shown in Table 1. Table 1 informed the development of 4 potential options (see Table 2) for improving the multi-agency response to emergencies and disasters. The domains and options were presented to an expert panel by way of a 2-round modified Delphi study; round one (*n*=15) and round 2 (*n*=11) via an online platform. The options were ranked from 1. *Most likely to succeed* to 4.

Table 1: The domains of core issues.

Domain	Description
Doctrine	Refers to the conceptual, legal and organisational frameworks within which an incident control system operates. Issues identified are the ambiguity and disconnection between the incident control system principles and the legislative-based roles and responsibilities and, in particular, how those change throughout the Prevention, Preparedness, Response and Recovery (PPRR) continuum of disaster management.
Communication	Despite improved communication being a core aspiration of incident control system, there is a failure of communication between emergency services agencies due to inconsistent terminology, a lack of effective exchange of information and a lack of technological capability required to facilitate communication.
Competency	Identifies the lack of knowledge and understanding of incident control systems, not only by emergency services agencies less familiar with response but also within traditional response agencies* (such as police, fire, ambulance). Efforts to build competency have had limited effectiveness.
Social aspects	Recognises that effective coordination is often reliant on personal relationships and on the psychological and welfare aspects of emergency management and these often conflict with the highly structured approach of an incident control system.
Operational aspects	Includes issues such as fatigue and continuity of operations that influence compliance with any system of governance. These aspects need to be considered in the design of any system.

* For the purpose of this research, traditional agencies include police, fire, ambulance and other organisations that exist for ensuring public safety by addressing different emergencies. Conversely, non-traditional agencies such as councils, non-government organisations and community groups, typically have other non-emergency roles within the community.

Least likely to succeed. An advantage of an expert panel is that results are gained quickly and opinions and views can be used to build on the research (Marshall and Rossman 1999). In this study, 'agreement' was taken to be the true consensus (75% agreeance) of what the panel thought.

Participants

Participants were recruited using the research team's professional contacts and LinkedIn network connections who were operationally involved or experienced in contemporary disaster or emergency management. Participants were able to nominate other potential participants. Suitably qualified participants were contacted by email providing the research information, ethics and consent forms and information on how the study would progress.

Table 2: The options for incident control system future development presented to the expert panel.

Option	Description	Agreeance % (likely to succeed in future) *
1	Enforce compliance of incident control system/AIIMS for all agencies	20%
2	Redesign AIIMS to include new criteria (AIIMS+)	90%
3	Develop a new system (DICS)	80%
4	Maintain status quo – do nothing	40%

* Panel participants were asked to rank each option from 1. *Most likely to succeed* to 4. *Least likely to succeed* and provide additional written feedback.

The modified Delphi was carried out by providing the expert panel participants with 2 rounds of questionnaires and information using an online Qualtrics survey. The panel consisted of senior leaders and strategic decision-makers from across the Australian emergency management sector and included representatives from the health sector, fire, police, Inspector General Emergency Management (IGEM), Australasian Fire and Emergency Services Authorities Council (AFAC) and local government. The definition of 'expert' for this study was:

- participants must have had a designated disaster management response role at a strategic level in multiple (3+) declared disaster events
- participants must have extensive knowledge through practice or education in disaster response.

The first round of the online Qualtrics survey was distributed by email. The email contained an overview of the issues identified in the research, a description of how the Delphi study would progress and the 4 potential options and descriptions (see Table 2). The second round provided the results from round one and asked for feedback on improvements to 2 options (Option 2: AIIMS+ and Option 3: Develop a new system) that were aggregated and agreed as the ones most likely to succeed in the future.

The surveys were conducted until saturation was reached and when it was identified that no new information to address the options was found; round 1 (n=15) and round 2 (n=12). The total panel sample included 2 female and 13 male participants. Ten participants completed both rounds of the survey and 3 participants were unable to complete both rounds due to operational commitments or leave.

Ethics approval was granted by the Queensland University of Technology ethics committee (Ethics Approval Number 2000000061). This included the recruitment email, participant information sheet and consent form.

Results

Overall, the expert panel members agreed that changes were needed to the current incident command system to support the complexities of emergency and disaster management particularly regarding strategic political decision-making and consequence management. Summarised feedback for each:

- Option 1: Enforcing compliance – fails to address the barriers identified and would require a level of compliance among all governments and organisations. Overall, it was ranked as the option very unlikely to succeed.
- Option 2: Redesign the current AIIMS system to include new criteria to address the problems identified (AIIMS+) – requires inclusion of a detailed recovery section to address the emergency management cycle changes to legislation to improve multi-agency interoperability and improvement to strategic-level reporting. Minor changes to terminology, improved training and competency maintenance were also suggested. Overall, it was ranked as the option most likely to succeed but with a few conditions.
- Option 3: Develop a new system (Disaster Interagency Coordination System) – was reported as having merit but would be extremely challenging. Suggested improvements included changing terminology and legislation changes, improved multi-agency training and better reporting systems. Overall, it was ranked as likely to succeed but with the introduction of a new model being acknowledged as extremely difficult to implement.
- Option 4: Maintain the status quo – regarded as a middle ground with most participants ranking this as unlikely to succeed but with others suggesting that natural evolution may support an improved system.

Overall, most participants agreed that building on the current incident control system to include changes that encompass the intricacies of disaster and emergency management was the most advantageous option. AIIMS+ was ranked as the option mostly likely to succeed as it built on a 'well-known and well established' system (Bradley, Tippet and Fitzgerald 2023, p.242). Other changes included a detailed recovery section, changes to legislation, improvements to strategic-level reporting and inclusive training and competency maintenance programs as well as the recognition of good relationships and relevance of the social or psychological aspects of disaster management. The incorporation of successful practices from other states and territories and moving from the C2 (Command, Control) towards a C4I (C2 plus Coordination, Communication, Intelligence) or C6I (C4 plus Consequences, Community connection) model were also suggested by the expert panel.

Discussion

The findings of this research are that the current incident control system used for contemporary emergency and disaster response requires updating. Although useful components remain, reform is required. Emergency services agencies have embraced the incident control system, but other agencies often involved in community-level disaster response, such as non-government organisations and community groups, have not.

The incorporation of an incident control system across traditional and non-traditional response providers is recommended due to the increasing frequency, complexity and severity of high-risk hazard events and man-made disasters, which require wider definitions of response. There is more to emergency and disaster management than technical knowledge and expertise, such as recognition of the adverse effects to the health and wellbeing of individuals and communities. This study confirmed the importance of recognising non-technical skills. Future studies might examine this and focus on incident control systems in relation to new technologies, changes in the threat environment and other threats such as cyber-attacks and pandemics.

Limitations

A limitation of this study was the lack of representation of expert health participants. The availability of strategic-level health participants was difficult to obtain due to leave or work commitments. Another limitation was that research quality is dependent on the skills of the researcher and can be influenced by the researcher's personal biases and idiosyncrasies. To address this the study included steps to present a relatively unbiased analysis, such as involving university supervisors in the validation of initial coding categories during the pilot study.

Conclusion

Climate change has a significant effect on the frequency and severity of disaster events worldwide and increases the importance of good emergency and disaster management systems. Disasters are complex, dynamic and fast-paced environments and involve many emergency services agencies including first-response agencies, non-government organisations, community groups, volunteers and local governments. Successful response relies on effective teamwork and the ability of agencies to interact and integrate. The response to these events often includes components of an incident control system. Although pitched as all-hazard, all-agency systems there has been debate that the incident control system has a number of shortcomings and challenges related to how principles are applied across disaster events.

This research generated a useful evidentiary platform on which to pursue the development of a conceptual framework to reform the incident control system to improve multi-agency coordination during an emergency response. The findings suggest that much can be done in the area of psychological research to understand how people operate during complex events and how best to support the health and wellbeing of communities and emergency management personnel. Similarly, the study found that successful disaster management is about people and relationships. The importance of developing non-technical skills such as social, cognitive, decision-making and emotional intelligence is a useful inclusion in developing a new system.

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Developing an Australian dust early warning system

Abstract

In Australia, the perception of large continental-scale dust storms has traditionally been restricted to aspects of 'inconvenience' or 'novelty'. However, as the climate changes, there is an increased likelihood of dust storm activity that puts communities at increased risk. The aim of this study was to explore the need and possibility of developing a dust early warning system for Australia. Through a scoping review of internationally used sand and dust early warning systems, we found that an array of systems exist or were theoretically tested in the Northern Hemisphere. The sensor networks, one of which was operational, were of particular interest because Australia already has an operational air quality network that could be expanded to a dust early warning system. The need for a trans-boundary system is critical for Australia and, therefore, requires a combined approach of expanded sensor network with satellite-based systems to increase validation of any future modelling approach. This improved understanding could inform the development of a dust warning system for multi-socio-economic factors that account for cumulative exposure to small, localised and large continental-sized dust events.

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Introduction

Significant amounts of dust are emitted and transported across the globe each year, with values ranging from 29.1 Tg/yr (Chappell *et al.* 2023) to 1877 Tg/yr (Tanaka and Chiba 2006). Each year, Australia contributes around 6–20% to the global dust budget[1] and is the biggest dust emitter in the Southern Hemisphere (Tanaka and Chiba 2006; Chappell *et al.* 2023). Dust from Australia's arid and semi-arid interior, such as the Lake Eyre Basin, is transported eastward across the highly populated southeast regions and northward across Queensland (see Figure 1) (McGowan and Clark 2008; O'Loingsigh *et al.* 2017).

The distance that dust is transported is crucial to distant communities due to the size of the dust particles (Tozer and Leys 2013). Dust storms close to the entrainment source are coarser than those thousands of kilometres from the source. In Australia, urban communities have been affected by dust storms dominated by fine PM_{10} and $<PM_{2.5}$[2]

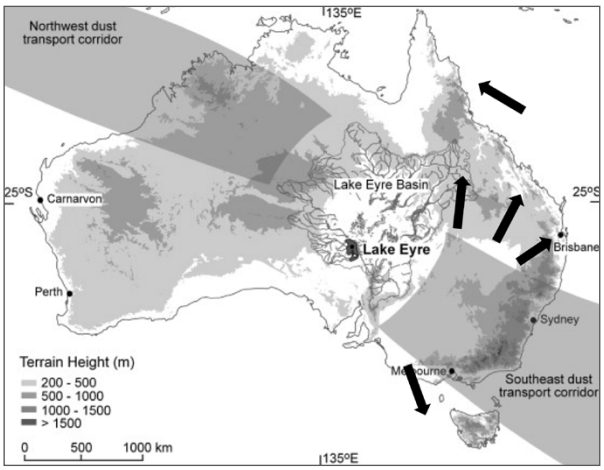

Figure 1: Australian dust transport pathways have traditionally presented dust storms moving across 2 pathways, southeast Australia and northwest Australia.

Source: modified from McGowan and Clark (2008)

1. The global dust budget refers to the amount of dust emitted and deposited across the globe annually. It takes into account dust emission from various dust source regions and where this dust is deposited.
2. PM_x describes the size of particulate matter. In this case, 'x' is either less than 10 microns or less than 2.5 microns.

particles, both of which are known to affect respiratory health. In addition, weather conditions at the coast deposits the sediment and organic material carried in dust storms (Pye 1987). The combination of populations residing on the coastal fringe of large arid/semi-arid regions makes eastern Australian communities exposed to dust storms (Tozer and Leys 2013).

Dust storm effects

Health

Respiratory health is the greatest concern associated with dust storms. Dust from China has been found to cause conjunctivitis outbreaks in Taiwan (Lien *et al.* 2013) and increased hospital admissions due to respiratory illness (Ma *et al.* 2016), leading to respiratory mortality (Díaz *et al.* 2017). Research in Australia by Rutherford *et al.* (1999) examined the effects of dust on human health that found that frequent dust events were associated with increased severe asthma in Brisbane between 1992 and 1994. The health implications of subsequent individual dust events throughout the 2000s (Aragnou *et al.* 2021) supported these early findings. During the large 2009 dust storm, Brisbane Hospital emergency department admissions increased by 39% (Aragnou *et al.* 2021). To date, most studies in Australia exploring the effects of dust on human health have been limited to a single city or a single dust event. Thus, there is limited information on the long-term spatial patterns and trends of dust events with respiratory health.

Economic

The economic context related to dust storms is often studied based on a singular dust storm event. Significant soil loss, commodity and infrastructure destruction, disruption to communities and societal function occur across the dust transport corridor (Tozer and Leys 2013). The September 2009 dust storm in Queensland was estimated to cost nearly $300 million, with the largest costs being reported as cleaning ($254.8 million), transport disruption ($10.8 million), absenteeism ($7.5 million) and fire alarm call outs ($189,000) (Tozer and Leys 2013). Improved monitoring and increased documentation of dust events will provide increased knowledge of the economic consequences of dust storm activity.

Climate and environment

Changes in climate affect dust storm frequency (Sharratt *et al.* 2015). Projected changes in rainfall patterns are expected to result in some regions becoming drier, reducing vegetation cover and increasing the vulnerability to erosion (Huang *et al.* 2020). Land management will need to adapt to avoid accelerating these conditions (Geist and Lambin 2004). Land managers who are unaware or who do not adapt will put vegetation cover under greater pressure and may accelerate low-cover conditions and increase the risk of erosion (Leys *et al.* 2023; McTainsh *et al.* 2011). Spatial and temporal changes in heat waves and droughts requires communities, especially in rural and remote areas, to be alert and adaptive. Vegetation cover must be kept above regional target levels to reduce the exposure of soil to wind erosion (Yang *et al.* 2022). In Australia, these ground cover targets are described as 50% ground cover (Leys 1999). Throughout the arid/semi-arid regions, active decision-making and being responsive to environmental conditions is required to reduce these risks.

Emergency services delivery

The 2009 dust storm grounded a significant number of Queensland air medical retrieval aircraft for 20 hours due to low visibility, high turbulence and risk of damage. Any disruption to emergency services delivery during dust storms could be critical to human life (Holyoak, Aitken and Elcock 2011). Sand and dust storms also affect the signal attenuation of telecommunications systems, which can be avoided by using a dust attenuation parameter and supplying extra power during major dust storms (Harb, Abdillah and Abdul-Jauwad 2014).

Understanding risk

Australia has a long history of dust activity and is a significant global contributor of dust. Climate change forecasts predict future dust activity to increase. This increases risk to human populations and societal functions. Both the *Sendai Framework for Disaster Risk Reduction 2015-2030* and the United Nations Convention to Combat Desertification emphasise the value of having 'the availability of and access to multi-hazard early warning systems' (UNDRR 2015, p.12) and 'sand and dust storm early warning systems' (UNCCD 2022) as a priority to build resilience against dust.

Australia has the Australian Warning System[3], which provides consistency in warning language and cross-boundary coordination. The system is a multi-hazard early warning system but has no specific reference to a dust early warning system (AIDR 2021). Given dust storms often occur with other hazards, for example dust storms and bushfires in 2002 (McTainsh *et al.* 2005) and 2019 (Aragnou *et al.* 2021), there is merit in identifying what parameters are required to include a dust early warning system in Australia.

This research scoping review explored the international literature of sand and dust storm early warning systems globally to understand how achievable it might be for Australia to develop and incorporate a meaningful dust early warning system.

Methodology

A scoping review is a method to quickly investigate, summarise and convey research findings compared to a systematic review (Arksey and O'Malley 2005). This scoping review explored the international literature to identify:

- the early warning sand and dust detection systems that are in operation or have been tested
- the general descriptions of how those systems operate
- if the systems are transboundary
- what risks and hazards effects are considered in the purpose for the system.

3. Australian Warning System, at www.australianwarningsystem.com.au/.

To identify relevant studies, 4 databases (Web of Science, Scopus, JSTOR and Bibliography of Aeolian Research) were searched using the terms: 'warning system' OR 'alert system' OR 'detection system' AND 'dust' OR 'sand' OR 'SDS' OR 'multi-hazard' OR 'particulate matter' OR 'PM'. Only papers published between January 2000 and December 2022 in English were included. The papers were imported into an EndNote referencing system for the next stage of exclusion and analysis (see Figure 2).

The titles and abstracts of compiled papers were screened using exclusion criteria:

- The paper does not describe or test an early warning system.
- The paper does not include a focus on sand and/or dust.
- An early warning system is a suggestion to a problem.
- The early warning system is for aviation, coal mines or indoor only.
- The paper was a systematic review of some form.

It is acknowledged that there might be operational dust early warnings performed by government agencies where publicly accessible content is limited. Searching for government reports (grey literature) was performed using search tools (Google, Elicit, institutional website search tools) with very limited results and those identified provided limited analysable content. International cases, if available, might also be presented in the local language. These considerations limit the breadth of the international results, especially of operational early warnings systems. However, it is expected that results from this review will prove meaningful in the context of evaluating different types of sand and dust storm early warning systems that exist or are being developed.

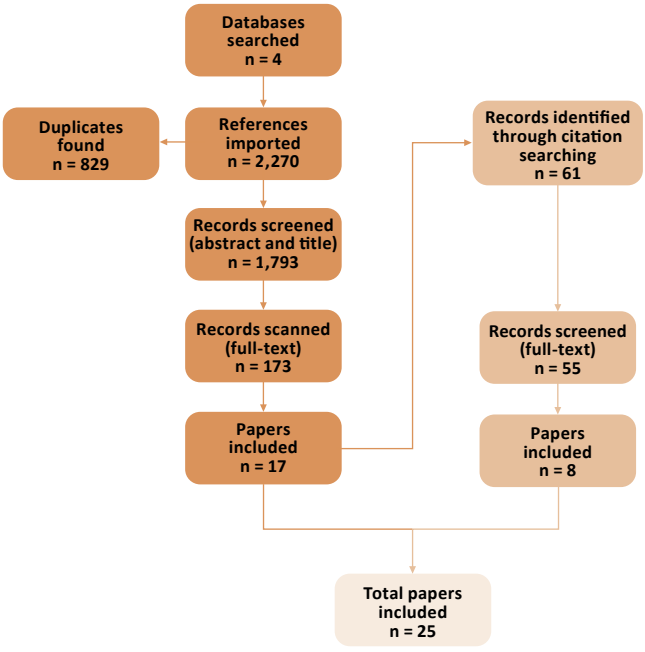

Figure 2: The process to identify papers for the scoping review included searching 4 databases, screening abstracts and titles and screening the full text.

Features of the studies

There were 25 papers between 2000 and 2022 that presented sand and dust early warning systems (Figure 3). Geographically, the majority of these papers existed in China (*n*=7), which aligns with the understanding that China is significantly affected by sand and dust storms that develop from the Taklimakan and Gobi deserts (Tanaka and Chiba 2006). Taiwan (*n*=3) and America (*n*=3) were the next most common case studies (Table 1). Interestingly, all 3 studies from Taiwan were localised to rivers or cities near rivers. All case studies were in the Northern Hemisphere, which aligns with the larger populations affected by these storms compared to the Southern Hemisphere. The majority of papers published in 2022 (the year with most publications (*n*=5)) came from the Middle East perhaps related to the increased dust storm frequency in that area (Rashki, Middleton and Goudie 2021).

Table 1: The regions where sand and dust early warning systems have been tested or operate.

Region	Number	Authors
China	7	Kim *et al.* (2011); Gong and Zhang (2008); Zhou *et al.* (2008); Jin *et al.* (2018); Gao and Han (2010); Zhang *et al.* (2009); Hu *et al.* (2004)
Taiwan	3	Nguyen *et al.* (2021); Lin *et al.* (2016); Chuang *et al.* (2016)
America	3	Sprigg *et al.* (2014); Yin *et al.* (2005); Nickovic *et al.* (2001)
Iran	2	Goudarzi *et al.* (2022); Mirzadeh *et al.* (2022)
South Korea	2	Hahm & Yoon (2021); Zhou *et al.* (2008)
Romania	1	Adam *et al.* (2022)
Italy	1	Chianese *et al.* (2019)
Qatar	1	Fountoukis *et al.* (2022)
India	1	Ghude *et al.* (2020)
Japan	1	Zhou *et al.* (2008)
Saudi Arabia	1	Akhlaq *et al.* (2012)
Middle East and North Africa	1	Rostkier-Edelstein *et al.* (2022)
Europe and Middle East	1	Martínez *et al.* (2009)
Atlantic Ocean	1	Ansmann *et al.* (2017)
Undefined	1	Al Murayzig *et al.* (2016)

Note: Some early warning systems were transboundary so an author may be cited more than once. The early warning system described in Al Murayzig *et al.* (2016) is a hypothetical system and was not operationally nor theoretically tested using data and, therefore, is not constrained geographically.

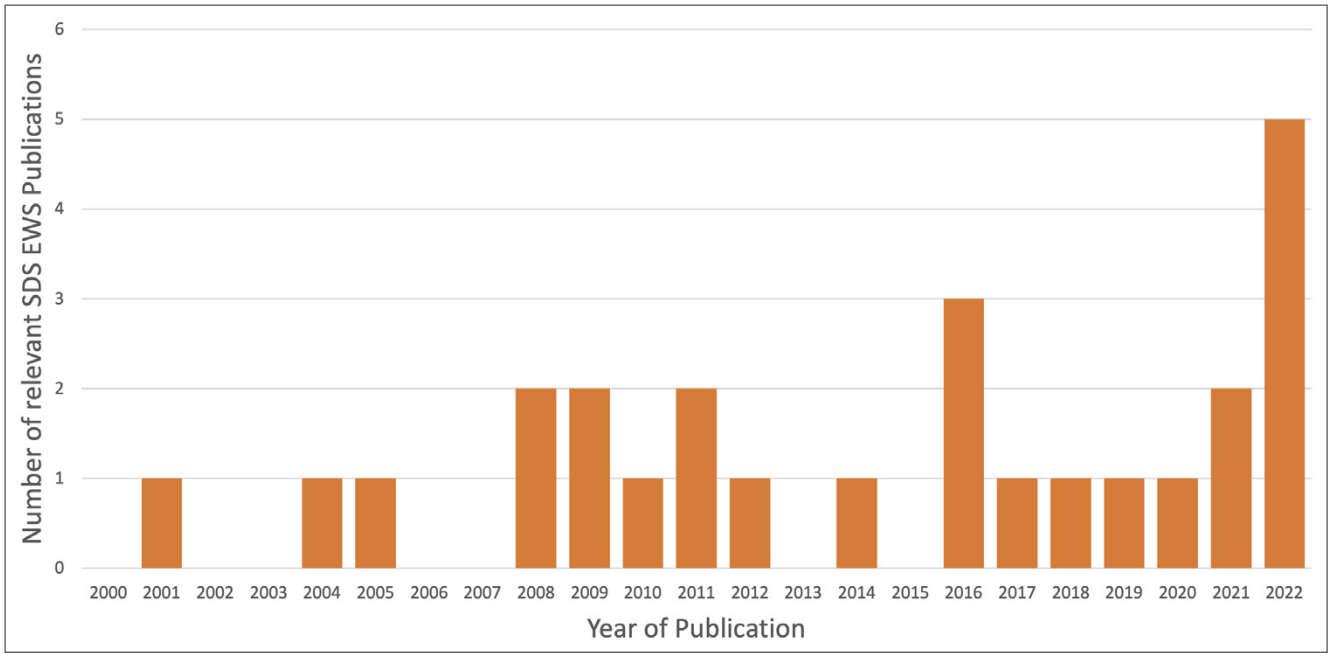

Figure 3: The spread of publications describing sand and dust early warning systems reviewed from 2000 to 2022.

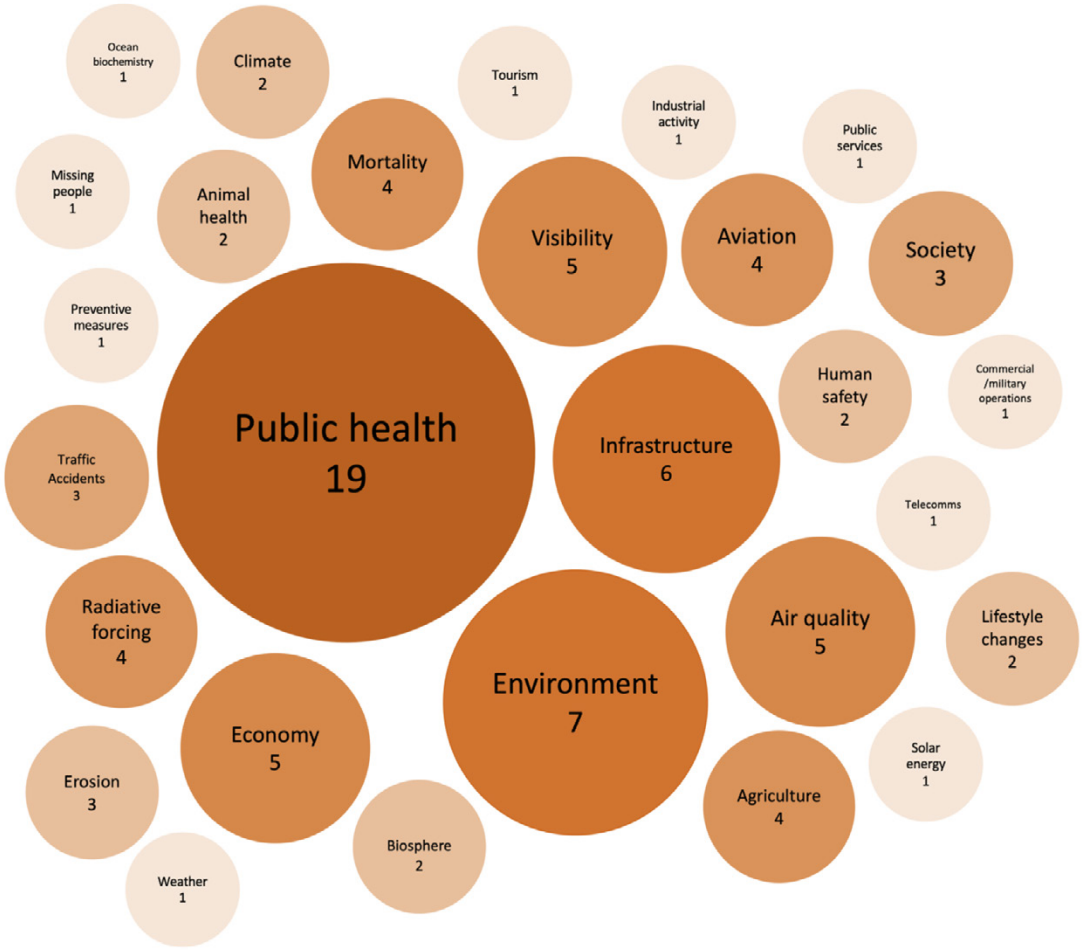

Figure 4: The frequency of sand and dust storms effects considered within the papers analysed.

Overwhelmingly the early warning systems studied aimed to reduce public health effects (*n*=19), with a particular focus on the respiratory and cardiovascular conditions caused by dust particles. Some acknowledgment was given to increases in hospital admissions and medical costs. The next most cited effects (*n*=7) were environmental factors, followed by infrastructure (*n*=6) and the economy (*n*=5) (see Figure. 4). These results were expected as they pose the most immediate threat to large populations exposed to continental-scale sand and dust storms (Goudie 2014). This is mirrored in the Australian context, with the dust storms of 1983, 2009 and 2019 studied through an environment lens (Raupach, McTainsh and Leyset 1994), the economy (Tozer and Leys 2013) and health (Aragnou *et al.* 2021).

A total of 30 sand and dust storm early warning systems were covered in the 25 papers. Of these systems, 8 are/were operational, 19 were theoretically tested and 1 was an untested hypothetical system (see Table 2). Of the operational systems, 6 were models and 2 were sensor networks. The 2 operational sensor networks were published in 2021 (Hahm and Yoon 2021) and 2022 (Adam *et al.* 2022), while operational model systems span from 2008 onwards.

Table 2: The domains of core issues covered in the selected papers.

Type	System	Status	Number	Authors
Sensor Network	Photometer	Operational*	1	Adam *et al.* (2022)
	Sensor Network	Theoretically tested	1	Akhlaq *et al.* (2012)
		Operational	1	Hahm and Yoon (2021)
	Satellite Images	Theoretically tested	1	Martínez *et al.* (2009)
Machine Learning	Artificial Neural Network	Theoretically tested	5	Chianese *et al.* (2019); Goudarzi *et al.* (2022); Nguyen *et al.* (2021); Mirzadeh *et al.* (2022); Chuang *et al.* (2016)
		Not tested	1	Al Murayzig *et al.* (2016)
	Adaptive Neuro Fuzzy Interference System	Theoretically tested	1	Mirzadeh *et al.* (2022)
	Support Vector Regression	Theoretically tested	2	Mirzadeh *et al.* (2022); Zhang *et al.* (2009)
Statistical	Regression Analysis	Theoretically tested	2	Lin *et al.* (2016); Gao and Han (2010)
	Historical Analysis	Theoretically tested	1	Hu *et al.* (2004)
Regional Climate Models	CUACE	Operational	2	Gong and Zhang (2008); Zhou *et al.* (2008)
	DREAM	Theoretically tested	2	Yin *et al.* (2005); Sprigg *et al.* (2014)
		Operational	1	Nickovic *et al.* (2001)
	WRF-Chem	Theoretically tested	2	Fountoukis *et al.* (2022); Rostkeir-Edelstein *et al.* (2022)
		Operational	1	Ghude *et al.* (2020)
	CFORS	Operational	1	Kim *et al.* (2011)
	ADAM	Operational	1	Kim *et al.* (2011)
	SKIRON	Theoretically tested	1	Ansmann *et al.* (2017)
	MACC/CAMS	Theoretically tested	1	Ansmann *et al.* (2017)
	LOTOS-EUROS/Dust	Theoretically tested	1	Jin *et al.* (2018)
	NMMB/BSC-Dust	Theoretically tested	1	Ansmann *et al.* (2017)

* 'Operational' means operational at the time of the study and not necessarily operational at present.

Thematic findings

Sensor networks as early on-ground detectors

Aerosol monitoring networks use a range of instruments, $PM_{2.5}$, PM_{10}, TSP, TEOM, nephelometers, sun photometers and ceilometers to estimate aerosol concentration. Recording and reporting frequency varies depending on the intent of the monitoring network. Regardless of the sensor type, there is a benefit to an early warning system having a sensor network as an on-ground early detector. Hahm and Yoon (2021) describe an advanced sensor network that consists of over 600 aerosol ($PM_{2.5}$) monitoring stations across South Korea. This monitoring network strengthens predictions, both spatially (easier to pinpoint source and movement) and temporally (more likely to signal early detection due to the high density of sensors) with different designations of warning areas. $PM_{2.5}$ concentration thresholds are set for different risk and warning levels and are sent via text message (Hahm and Yoon 2021). The authors found that this system reduced hospital visits and admissions for dust-related issues during dust-heavy days. This indicated an effectiveness as a risk reduction mechanism (Hahm and Yoon 2021).

Akhlaq, Sheltami and Shakshuki (2012) combined satellite derived (METEOSAT) red, green and blue composites to detect dust events with a network of meteorological parameters (e.g. wind speed, temperature, humidity) to forecast dust transport and deposition. This system can alert for 3 types of dust storms (severe, short-term and small-scale, long-term and large-scale) dependent on the spatial/temporal sensitivity of the sensor network and/or satellite. Adam *et al.* (2022) integrated sensor networks consisting of ceilometers, sun photometer and AERONET with HYSPLIT back trajectory modelling and aerosol optical depth data. Ceilometers detect other aerosols such as smoke, fog and anthropogenic particulates that require careful quality control to ensure accuracy in the early warning system. The study identified several negatives of the system including availability of AERONET data, the ceilometer only detecting aerosols up to a certain height, spatial availability of sun photometer data, need of internet access and errors in running the HYSPLIT model (Adam *et al.* 2022).

Artificial neural networks

Use of an Artificial Neural Network (ANN) as an early warning system has occurred since 2016 given their simplicity of use, limited data input requirements and reduced computing power compared to deterministic models (Chianese *et al.* 2019). Despite the popularity of the system as an early warning system, none of the ANN systems included in this review were operational. Two operational challenges exist: network bias occurring from low spatial resolution of the monitoring network and/or an ANN system that is geographically dependent. While monitoring density is considered important to reduce bias, no definition of an adequate density was stated in any of the papers reviewed related to ANNs. For example, despite the low number of stations used in the studies of Goudarzi *et al.* (2022), 4 stations across 530 km^2 and Mirzadeh *et al.* (2022), 3 stations across 2,491 km^2, the accuracy of the forecasting was not considered compromised. The large monitoring area required in Australia makes it difficult to extrapolate these studies from the Northern Hemisphere. Bias associated with geography can be associated with the proximity of monitoring stations to urban areas and industrial emission hot spots (Chianese *et al.* 2019; Goudarzi *et al.* 2022) or simply the need for local geographic area calibration (Zhang, Patuwo and Hu 1998). Routinely, these were described as biases to be aware of and not constraints to operational use. So, while simple in use, the use of such systems would prove complex.

Regional climate model systems

Models make up almost half of the systems analysed in this review (*n*=18) and most operational systems (*n*=6). Given models are usually purposefully built and use historic data, this is not surprising, with many of the models being operational since the mid-2000s. Across the models, data inputs generally consist of vegetation cover, soil moisture, turbulent mixing processes and aerosol interactions. These properties can be mapped back to the process of dust emission and transportation (Opp *et al.* 2021), providing a broader view than a sensor network or ANN that makes predictions based on localised, current data (Zhang, Patuwo and Hu 1998). Regional climate models from the Northern Hemisphere are often transboundary, crossing country borders (e.g. Rostkier-Edelstein *et al.* 2022). Out of the 30 early warning systems analysed, 11 were transboundary. For a dust model to be effective as a transboundary early warning system it largely depends on the model itself (input data) and the study region(s). For example, while Rostkier-Edelstein *et al.* (2022) found that the WRF-Chem/RTFDDA model performed well as a theoretical early warning system that covered the Middle East and North Africa regions, Kim *et al.* (2011) found that their models showed dust relatively well across Japan and South Korea but not China. They conclude that dust emission and meteorological input data might be the likely cause of these results (Kim *et al.* 2011).

Satellites

While satellite data was commonly used as data input or for verification, only one paper used satellite data as the primary operation of the system (Martínez, Ruiz and Cuevas 2009) (some studies used satellites as secondary sources of data to support their operation (Akhlaq, Sheltami and Shakshuki *et al.* 2012). Martínez, Ruiz and Cuevas (2009) recognised the capability of METEOSAT to detect the development of small dust plumes and 'subtle changes', meaning that the development of a dust storm can be identified at its early stages and in near-real time. METEOSAT is a geostationary satellite that scans the Middle East and North Africa regions every 15 minutes (Schmetz *et al.* 2002). While the spatial resolution doesn't compare to satellites such as MODIS or Landsat, it has the capacity to detect and monitor the development and transport of dust plumes (Baddock *et al.* 2021).

Is Australia ready?

A suite of monitoring and forecasting tools are required to be effective. While many of the reviewed sand and dust early warning systems were dominated by one tool (i.e. ANN or satellite), often multiple tools supported the early warning process. For example, Pearson coefficient[4] analysis to find what meteorological parameters were important for dust storm prediction was conducted by Goudarzi *et al.* (2022) despite the ANN forming the core part of the forecasting system.

Australia has ground-based instrumented networks, high-temporal resolution satellite capability and locally developed wind erosion models ready for tuning to forecasting. The Dust Watch Network[5], established in 2002, is a cross-jurisdictional citizen-science project to monitor dust activity in southeast Australia. It hosts over 40 monitoring stations across rural and remote New South Wales, Victoria and South Australia (Leys *et al.* 2008). Riley (2021) also described the New South Wales air quality network that send automatic alerts to registered people via email or SMS, providing information about actions to take. This network is multi-hazard and send alerts for dust, smoke and other pollutants, however, it is region-specific to New South Wales. The rural locations of the instruments make this network highly relevant as an early warning system because early detection of dust before the plumes reach downwind urban centres is advantageous (Opp *et al.* 2021) and the coastal network of air quality monitors extends that capability (Riley 2021).

Akhlaq, Sheltami and Shakshuki (2012) took advantage of both a sensor network and red, green and blue satellite images to form a warning system in Saudi Arabia for different types of sand and dust storms. Similarly, the operational network system in South Korea (Hahm and Yoon 2021) uses over 600 aerosol monitors (covering an area of 100,210 km^2) to feed into regional modelling and creating it's early warning system network. Although the current Australian dust monitoring network is essentially spatially constrained to New South Wales, the rural position acts as an early detection system to trigger use of the high-temporal satellite monitoring. Critically, the rural positioning of current instruments informs an early warning system for large dust storms that commonly affect Australia's eastern cities (Strong *et al.* 2011; Baddock *et al.* 2015).

The Korea Meteorological Administration (KMA) operates a dust early warning system under the Regional Data Assimilation and Prediction System aided by ground observations (KMA n.d.). The KMA issues an 'advisory' warning when PM10 > 400 $\mu g/m^3$ and an 'Asian Dust' warning when PM10 > 800 $\mu g/m^3$ (KMA 2016). The latter warning urges people to stay inside, especially children and those with respiratory issues, as well as the rescheduling of outdoor activities (KMA n.d.). The Japan Meteorological Agency forecasts dust through the Model of Aerosol Species in the Global Atmosphere (MASINGAR), which takes into account the physical processes of dust storm formation and transportation. The KOSA website[6] provides forecasts of dust in advance of 96 hours and alerts are communicated via the website (Mikami, Maki and Tanaka 2009).

Australia is expansive and has dust storm events that occur regionally through to scales that cross multiple states. The sand and dust storm early warning systems analysed in this review that use satellite data have only been tested or operationalised in countries far smaller than Australia. The study by Martínez, Ruiz and Cuevas (2009) demonstrated the capability of satellites to detect early development of dust storms across large areas. While METEOSAT does not operate over Australia, an almost 1:1 comparative satellite does. Himawari-8 (H-8), launched and operated by the Japan Meteorological Agency, scans the Asia-Pacific region every 10 minutes at a spatial resolution of 1–2 km (Bessho *et al.* 2016). The advantage that H-8 offers is the spatial and temporal coverage it can provide to detect the development of dust storms, especially during the night using thermal infrared bands (Bessho *et al.* 2016).

Modelling dust emission and transport across Australia has been conducted using models underpinned by datasets and physical and chemical processes. The Computational Environmental Modelling System relies on climate and vegetation data to estimate dust loss (Shao *et al.* 2007). Chappell *et al.* (2023) used an albedo-based model to estimate surface roughness controls of dust emission and transport globally, including across Australia. The WRF-Chem has been used in Australia to research dust transport (Aragnou *et al.* 2021; Nyugen *et al.* 2019) using global aerosol and saltation schemes. The different approaches used between these 3 models present an opportunity for a transboundary early warning system, particularly if calibrated with monitoring network- and satellite-source detection. Thus, H-8 or model-based early warning systems that have been tested over regions as expansive as Australia would be more suitable for the establishment of a dust early warning system for Australia.

Conclusion

This research makes a case for the development of an Australian dust early warning system through a scoping review of international systems, both theoretical and operational, and the consideration of the applicability of such systems in Australia. Sand and dust early warning systems have been tested and applied primarily in the Northern Hemisphere, with more model systems operationalised compared to non-model systems. The systems analysed use a range of tools to inform the early warning system being ground-based sensor networks, remote sensing aerosol detection, modelling and statistical approaches. Many global examples combine a number of techniques to build locally sensitive systems. Australia has a range of tools relevant to building an early warning system, albeit disparate and built for alternative purposes. The New South Wales air quality network incorporates the rural and remote network of DustWatch. The geographic position of these instruments provides crucial input data to trigger the use of high-temporal resolution satellite monitoring. It is recommended that a transboundary Australian

4. Pearson coefficient analysis examines the relationship between 2 variables.
5. DustWatch, at www.environment.nsw.gov.au/topics/land-and-soil/soil-degradation/wind-erosion/community-dustwatch.
6. KOSA forecasts, at www.data.jma.go.jp/gmd/env/kosa/fcst/en/.

multi-hazard early warning system that accommodates dust detection be established through a combination of rural dust monitors and satellite monitoring. Investment to expand the instrumented networks across state borders, along with cross-boundary data management, would need to occur to build a transboundary dust early warning system. This development could reduce risks to people's health as well as the effects on the economy and communities, especially in a changing environment and climate.

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Descriptive epidemiological study assessing emergency department presentations associated with the Hawkesbury-Nepean flood plain

Abstract

Floods disrupt essential services and infrastructure including food, utilities and dwellings. These disruptions affect health outcomes and access to essential health services. The increasing incidence of severe weather events has been linked to climate change (IPCC 2022) and highlights the importance of a climate-resilient health system to provide timely services. This paper considers the immediate effects that a severe flooding event within Nepean Blue Mountains Local Health District (NBMLHD) had on emergency health utilisation to inform future health planning and facilitate the evaluation of climate responsive interventions.

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Introduction

The Hawkesbury-Nepean Valley of New South Wales has a complex and high flood exposure risk; one of the highest in the state. It is considered particularly vulnerable at choke points along the river that results in upstream flooding (Herron *et al.* 2018). In March 2021, heavy rainfall caused significant water outflow from the Warragamba Dam that resulted in a 1 in 10 to 20 chance per year flood downstream at the urban centres of North Richmond, Windsor and Sackville (Infrastructure NSW 2021). The flood damage caused riverbank erosion, road and bridge closures, it isolated communities north of the river and limited access to essential infrastructure (Infrastructure NSW 2021). It was reported that 65,000 people across Sydney were affected by evacuation warnings and orders during this time (National Recovery and Resilience Agency n.d.). An estimated 1,230 dwellings, commercial buildings and homes in caravan parks were inundated in the Hawkesbury and Penrith regions (Infrastructure NSW 2021).

The direct health effects following a flood event include drowning, injury, hypothermia, carbon monoxide poisoning and infectious diseases, specifically gastroenteritis secondary to contaminated drinking water, skin infections and vector- or rodent-borne diseases (Paterson *et al.* 2018; Ahern *et al.* 2005, Saulnier *et al.* 2017). Other indirect health effects can arise due to treatment interruption due to limited access to services or medications and poor nutrition (Paterson *et al.* 2018; Saulnier *et al.* 2017). Mental health conditions can also occur but are more likely in the longer term (Mulchandani *et al.* 2020).

There is limited evidence available that assesses the effects of floods on health outcomes and, due to the challenges in researching high-risk hazards and disasters, research often relies on observational data (Public Health England 2014). Globally, emergency department (ED) presentation data has been used in various flood and storm events to evaluate health outcomes. Following Hurricane Sandy in New York, Lee *et al.* (2016) demonstrated transient reductions followed by overall increases in presentations to EDs in the 4 days following the event with subsequent analysis by Doran *et al.* (2016) showing that there was a disproportionately higher number of presentations related to social factors such as homelessness and inadequate housing in the weeks following the event. ED presentations for dermatitis (Chen *et al.* 2021), skin infections (Saulnier *et al.* 2018), gastroenteritis (Wade *et al.* 2014, Saulnier *et al.* 2018), injuries (Sahni *et al.* 2016) and drowning (Ogden *et al.* 2001) have also been reported to increase after flood events. While acute cardiovascular and respiratory conditions have been shown to increase during storms, available evidence is limited in the context of floods (Saulnier *et al.* 2018).

An observational study was undertaken to understand health service utilisation for flood-related health issues and, therefore, inform future health planning in a notoriously flood-prone area.

Methods

A retrospective, observational, before-after study was conducted of people who presented to EDs from flood-affected postcodes in NBMLHD between 24 January and 22 May for the years 2015, 2017, 2018, 2019 and 2021 and between 25 January and 22 May for 2016 (due to the leap year).

Data was accessed via the Secure Analytics for Population Health Research and Intelligence platform (NSW Health 2022a) and was extracted from the Emergency Department Records for Epidemiology dataset. This dataset is a compilation of data from almost all EDs in New South Wales (several small rural hospitals and multi-purpose facilities are not covered) (NSW Health 2022b). SAS Enterprise Guide 9 was used to access de-identified data. Further analysis of aggregated data was done with Microsoft Excel and confidence intervals were calculated with a web-based rate ratio calculator, OpenEpi (Sullivan & Dean 2008).

Flood-affected postcodes (2745, 2750, 2753, 2754, 2755, 2756, 2758, 2765 and 2775) were defined as the suburbs within NBMLHD that had greater than 20 inundated dwellings, greater than 10 dwellings isolated by flooding or had flood levels reaching a major flood definition (Infrastructure NSW 2021). The flood dates were characterised by the period of major flooding from measured water levels (Infrastructure NSW 2021). The study periods were subsequently defined as:

- pre-flood reference period (24 January–20 March)
- flood period (21 March–27 March)
- first month post-flood (28 March–24 April)
- second month post-flood (25 April–22 May).

Daily presentation incidence ratios were calculated for flood and post-flood periods relative to the pre-flood reference period for 2021. The same calendar dates were analysed as comparative periods for non-flood years (2015–19). Even though there was no flooding in these years, the same nomenclature was retained for these comparative calendar periods. ED presentations in 2020 were excluded due to that year's minor-to-moderate flooding as well as significant bushfires occurring in the region. There was sub-group analysis by demographic (age and gender), triage groups and diagnostic classification groups of interest defined by ICD-10/SNOMED codes (Public Health England 2014). All SNOMED codes were mapped to ICD-10 (SNOMED International 2022) to facilitate comparison and amalgamation of data.

Ethics approval for this study was obtained from the NBMLHD HREC (2022/ETH01439).

Results

The total population residing in the affected postcodes within NBMLHD local government areas in 2021 was estimated as 163,837 people (51% female and 49% male; 10% were under 5 years of age and 15% were 65 years and over). Population mix was calculated based on Australian Bureau of Statistics 2021 Census data (Australian Bureau of Statistics 2021). The proportion of presentations to EDs by age and gender for pre-flood to post-flood periods were calculated and noted to be similar across the calendar periods (Table 1).

Table 1: Population characteristics during the study periods in flood and pre-flood years.

Age	2021	2015–19
Under 5 years	10%	11%
5 – 64 years	67%	67%
65 years and over	22%	22%
Gender		
Male	50%	51%
Female	50%	49%

The total daily ED presentations were higher in the second month post-flood (rate ratio 1.04 [95%CI 1.02–1.07]) whereas they declined in the comparative non-flood period (rate ratio 0.88 [95% CI 0.87–0.88]) (Table 2). There was a reduction in the daily presentation rates during the flood (rate ratio 0.87 [95% CI 0.83–0.91]) and first post-flood month (rate ratio 0.97 [95% CI 0.95–0.99]), consistent with the comparative non-flood years (rate ratio 0.97 [95% CI 0.96–0.98]). However, the rate ratio reduction for the flood year was more marked.

The rate ratio for high-urgency presentations (triage categories 1, 2, 3) were higher in the second post-flood month (rate ratio 1.06 [95% CI 1.03–1.10]). During the flood period, the reduction in high-urgency presentations (rate ratio 0.86 [95% CI 0.81–0.92]) was more marked compared to non-flood years (rate ratio 1.00 [95% CI 0.98–1.02]). In the non-flood years, low-urgency presentations (triage categories 4, 5) reduced during the second month post-

flood dates. However, there was no difference for the flood year during the same period (rate ratio 1.02 [95% CI 0.99–1.06]), which suggests a relative increase in lower category presentations.

There were no significant changes in the presentation rates for NBMLHD hospitals during the flood and post-flood periods (Table 2). However, there were increased presentations to out-of-area hospitals during the flood (1.15 [95% CI 1.02–1.21]) and during the first post-flood month (1.08 [95%CI 1.01–1.17]) and second post-flood month (1.09 [95%CI 1.01–1.17]).

The diagnostic classification groups of ED presentations showed some difference in the flood and post-flood periods when compared to non-flood years (Table 3). Respiratory and cardiovascular presentation rates increased but no significant trends were seen with gastroenteritis, dermatological conditions, injury and trauma, chemical and poisoning or mental health when compared with the preceding non-flood year trends.

An increase in respiratory presentations in the first (rate ratio 1.42 [95%CI 1.27–1.59]) and second months (rate ratio 1.72 [95%CI 1.55–1.92]) following the flood was noted. In comparison, an increase in respiratory presentations during the corresponding periods in the non-flood years was noted. However, during the flood year the increase in presentations was more marked with the greatest rate ratio increase seen in the second post-flood month (Table 3).

Cardiovascular presentations were higher in the second post-flood month (rate ratio 1.24 [95% CI 1.02–1.50]). In comparison with non-flood years there was no difference seen in the same calendar dates.

There was a reduction in injury and trauma presentations during the flood period (rate ratio 0.79 [95%CI 0.71–0.87]), which was more marked when compared to the corresponding non-flood years (rate ratio 0.96 [95% CI 0.93–0.99]). The reduction in chemical and poisoning presentations in the second month post-flood was comparable with the non-flood years.

Discussion

When compared to non-flood years, the increase in total ED presentations in the post-flood period suggests that the flood may have affected ED presentations patterns in the district. The reduction of ED presentations at the time of the flood is consistent with the findings from Lee *et al.* (2016) that showed there is a transient reduction in presentations at the time of the event followed by an increase in ED utilisation in the most-disaster prone regions. However, in this study, the increases were seen 2 months after the event in contrast to a few days, as reported by Lee *et al.* (2016). This may be explained by the longer duration of the study periods such that a granular variation may not have been identified in the analysis.

In addition to identifying reduced ED presentations during the flood, this study captured the number of people who presented to out-of-area hospitals where there was a significant increase in ED presentations, indicating that there may have been barriers to accessing hospital services. Standing evacuation orders and messages regarding avoiding the area (Pearce and Marsh 2021) may have diverted residents away from NBMLHD hospitals and the isolation of the North Richmond area (Infrastructure NSW 2021) may have re-directed residents to out-of-area

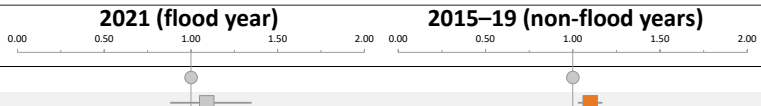
Table 2: Rate ratios for total ED presentations per day by triage category and hospital location for flood year 2021 and non-flood years 2015–19*.

	Calendar period	Presentations per day	Ratio	2021 (flood year)	2015–19 (non-flood years)	Presentations per day	Ratio
				0.50 0.75 1.00 1.25 1.50	0.50 0.75 1.00 1.25 1.50		
All ED presentations							
	Pre-flood period	349.9				607.4	
	Flood period	302.9	0.87			588.9	0.97
	1st Post-flood period	339.2	0.97			581.4	0.96
	2nd Post-flood period	364.9	1.04			532.1	0.88
Triage Category							
Category 1,2,3	Pre-flood period	180.5				262.0	
	Flood period	155.6	0.86			261.6	1.00
	1st Post-flood period	174.0	0.96			254.8	0.97
	2nd Post-flood period	191.5	1.06			242.8	0.93
Category 4,5	Pre-flood period	169.2				345.2	
	Flood period	147.3	0.87			326.8	0.95
	1st Post-flood period	165.2	0.98			330.3	0.96
	2nd Post-flood period	173.2	1.02			289.2	0.84
Hospital							
NBMLHD hospital	Pre-flood period	313.1				549.2	
	Flood period	260.4	0.83			558.3	1.02
	1st Post-flood period	299.3	0.96			524.2	0.95
	2nd Post-flood period	325.0	1.04			480.0	0.87
Out-of-area hospital	Pre-flood period	36.8				58.1	
	Flood period	42.4	1.15			57.5	0.99
	1st Post-flood period	39.9	1.08			61.0	1.05
	2nd Post-flood period	40.0	1.09			52.1	0.90

* Rate ratios for all periods are calculated relative to the pre-flood reference period. Statistically significant increased ratio of presentations (orange), statistically significant decreased ratio of presentations (blue). Pre-flood period: 24 Jan to 20 Mar (25 Jan to 20 Mar for 2016). Flood period: 21 Mar to 27 Mar. First post-flood period: 28 Mar to 24 Apr. Second post-flood period: 25 Apr to 22 May.

Table 3: Rate ratios for ED presentations per day by diagnostic classification groups for flood year 2021 and non-flood years 2015–19*.

Diagnostic Classification	Calendar period	Presentations per day	Ratio	Presentations per day	Ratio
		2021 (flood year)		2015–19 (non-flood years)	
Respiratory	Pre-flood period	12.9		27.6	
	Flood period	14.1	1.09	30.4	1.10
	1st Post-flood period	18.4	1.42	32.6	1.18
	2nd Post-flood period	22.3	1.72	28.8	1.04
Cardiovascular	Pre-flood period	4.8		7.9	
	Flood period	5.6	1.17	6.2	0.79
	1st Post-flood period	4.4	0.91	7.0	0.89
	2nd Post-flood period	5.9	1.24	7.7	0.97
Gastroenteritis	Pre-flood period	2.9		7.9	
	Flood period	3.7	1.30	6.5	0.82
	1st Post-flood period	3.6	1.26	6.7	0.85
	2nd Post-flood period	3.1	1.10	5.2	0.67
Dermatological	Pre-flood period	6.3		11.2	
	Flood period	6.1	0.97	8.1	0.73
	1st Post-flood period	4.6	0.73	9.9	0.88
	2nd Post-flood period	6.7	1.06	7.1	0.63
Injury and Trauma	Pre-flood period	77.2		122.0	
	Flood period	60.9	0.79	116.8	0.96
	1st Post-flood period	75.7	0.98	121.3	0.99
	2nd Post-flood period	74.3	0.96	113.2	0.93
Chemical and Poisoning	Pre-ffood period	1.9		3.2	
	Flood period	1.8	0.95	1.3	0.42
	1st Post-flood period	1.8	0.94	2.3	0.72
	2nd Post-flood period	1.1	0.55	1.6	0.51
Mental Health	Pre-Flood period	1.9		4.1	
	Flood period	0.6	0.30	4.5	1.10
	1st Post-flood period	1.8	0.95	4.0	0.98
	2nd Post-flood period	2.5	1.35	3.4	0.84



* Rate ratios for all periods are calculated relative to the pre-flood reference period. Statistically significant increased ratio of presentations (orange), statistically significant decreased ratio of presentations (blue). Pre-flood period: 24 Jan to 20 Mar (25 Jan to 20 Mar for 2016). Flood period: 21 Mar to 27 Mar. First post-flood period: 28 Mar to 24 Apr. second post-flood period: 25 Apr to 22 May.

hospitals. Further, a temporary medical service was deployed to the isolated North Richmond area to triage critical patients and provide medical support while patients awaited transfer to tertiary care (NBMLHD 2021). The service was not open to walk-in patients and non-critical patients were redirected to their general practitioner or community pharmacies (NBMLHD 2021).

Flood awareness campaigns and messaging promoting preparedness and resilience during 2019 and 2020 (Infrastructure NSW 2021) may have also potentially reduced community reliance on EDs. The introduction of telehealth in primary care in Australia since the COVID-19 pandemic (Australian Department of Health and Aged Care 2022) may have introduced greater capacity in the primary care system, relieving the pressure on tertiary services, such that treatment for minor illnesses or prescriptions were accessible by phone.

While this study identified the effect on some acute presentations, the duration of follow-up may not have been sufficient to identify conditions with longer latency, such as mental health. The results showed mental health presentations reduced during the flood year (Table 3) and there was no difference in the post-flood period. However, Mulchandani *et al.* (2020) demonstrated that the effects of floods on mental health can take years to be identified. It is uncertain what the consequences will be of repeated flooding events on the baseline mental health incidence for the residents living in flood-prone areas (Mental Health Commission of NSW 2022).

There were also consistent reductions in gastroenteritis presentations during the flood and post-flood periods for the non-flood years, but no difference was seen during the flood year (Table 3). This suggests that gastroenteritis may have increased after the flood relative to the comparative non-flood years. However, the interpretation of this finding is uncertain and as daily case rates were low (as was the case for mental health presentations) and there may have been insufficient statistical power to demonstrate a significant difference. In a systematic review by Saulnier *et al.* (2017), there were several studies showing onset dates of gastrointestinal illness up to 7 weeks after the flood with 10–54% of treatment facility presentations being related to gastroenteritis. However, this was based on studies located in low- and middle-income countries and may not be generalisable to the Australian context.

Cardiovascular presentations have been shown to increase after disaster events and are thought to be related to the direct physical and emotional stress and the indirect effects of treatment interruption (Babaie *et al.* 2021). This could explain the increase in cardiovascular presentations noted in the post-flood period in this study.

The marked increase in respiratory presentations, particularly in the second month post-flood period, may have been related to heavy rainfall and flooding causing increased mould exposure triggering allergic rhinitis and asthma as identified by Takaro and Henderson (2015). Despite this study being undertaken during

the pandemic, COVID-19 case numbers were stable with only 9 locally acquired cases and no community transmission identified throughout the study period (NSW Health 2021b).

This study attempted to account for the influence of the pandemic in several ways. Firstly, rate ratios were calculated before and after the flood, when the case rates were stable in New South Wales and COVID-19 was likely to affect pre- and post-flood periods in the same way. Secondly, the study design ensured that the follow-up period did not overlap with the emergence of the Delta variant wave. Finally, 2020 was excluded from the analysis due to bushfires and flooding and also due to the effects of the pandemic restrictions on ED presentations in that year. While these effects returned to pre-COVID ranges by 2021, there were significant decreases in ED presentations in March 2020 at the start of the pandemic (Australian Institute of Health and Welfare 2021) and similar effects were seen for presentations for gastroenteritis and bronchiolitis, which likely decreased due to hand hygiene and social distancing measures (NSW Health 2021a).

The study of disaster events can be challenging when there is such heterogeneity in flooding events, especially when the timing and degree of flooding cannot be predicted. Exposures may vary in the extent of inundation, infrastructure damage, geographic location, promptness of warnings and may occur in conjunction with other weather events, amalgamating into an event that may be unique (Public Health England 2014). Therefore, use of routinely collected data allows for baseline and post-flood evidence and this methodology is better placed to retrospectively evaluate the demand on EDs after a flooding event. The use of routine ED presentation data can be considered reliable because activity-based funding requires administrative data to be collected (National Health Funding Body 2021).

There are limitations with ED presentation data. Emergency department presentation patterns vary seasonally and this study attempted to address this by comparing patterns to years that pre-dated the pandemic and the major flood event. Diagnostic classifications and residential postcodes are limited by potential coding or data collection errors, particularly for people who may have been displaced or evacuated (Public Health England 2014). ED presentation data is skewed towards high-severity disease and is likely to underrepresent low-severity illness and people may present elsewhere for treatment. The use of varied health data sources allows for the identification of different severity disease and, for future studies, such sources could include routinely collected data for mortality, clinical toxicology consultations, laboratory, syndromic surveillance, primary care, prescriptions and community survey data (Public Health England 2014).

The use of postcode boundaries is also unlikely to represent residents who are equally affected by the flood. As such, a study that analyses a cohort of people residing in non-flood affected areas may have allowed for direct comparison to better control for confounders such as the pandemic and weather conditions.

Conclusion

The propensity for flooding in the Hawkesbury-Nepean Valley combined with the increasing frequency of extreme weather events requires future service planning to be responsive to the effects of major flooding events on EDs. This study demonstrated an increase in ED presentations in the second month after the 2021 flood and relative decreases in ED presentations during the flood period. There was an increase in high-triage category presentations in the second month post-flood and a relative increase in out-of-area hospital presentations during and after the flood. Respiratory and cardiovascular presentations were shown to increase in the post-flood period with no meaningful findings for mental health, chemical and poisoning, injury and trauma, dermatological or gastroenteritis presentations. These results suggest that there are likely effects for tertiary healthcare service delivery during and after major flooding. This study highlights the importance of service delivery planning and messaging during the post-event recovery period. Research to understand the effects of floods on primary care and long-term chronic health conditions would be beneficial.

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Preparing for the expected: cyclone threats

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Abstract

The Gold Coast is a bustling region in South East Queensland with a large concentration of people and has dynamic and growing business and tourism activity. The region is subject to thunderstorms and tropical cyclones that can generate damaging winds. The *Severe Wind Hazard Assessment for South East Queensland* evaluates the risk posed by severe winds and has strategies for managing this risk (Edwards *et al.* 2022). Results from the most recent assessment showed that older residential houses were the most damaged by severe winds and that this contributed disproportionately to community risk. However, lessons from recent wind damage caused by Tropical Cyclone Seroja in Western Australia in 2021 indicated that modern house designs have important vulnerabilities. These findings are a concern for any exposed coastal area and, in particular, for South East Queensland. This paper presents a suite of scenarios developed to address this vulnerability. Specifically, we describe how emergency and disaster managers can conduct capability analyses with the goal to enhance intelligence and planning capabilities. An example of the City of Gold Coast was used to show how it has leveraged these capabilities to improve emergency risk-based planning and begin a community resilience transformation with effective places of refuge and evacuation centres for the community.

Background

The *State Natural Hazard Risk Assessment 2017* (Queensland Fire and Emergency Services 2017) identified tropical cyclone risk as the highest priority for Queensland alongside riverine flooding. A similar conclusion was reached in the *Queensland 2021/22 State Disaster Risk Report* (Queensland Fire and Emergency Services 2022) that also identified tropical cyclone risk as the second highest priority after riverine flooding. Given this priority, tropical cyclones require an in-depth follow-on analysis.

In 2018, a collaborative project was formed between Queensland Fire and Emergency Service, Geoscience Australia, Department of Environment and Science and James Cook University Cyclone Testing Station to better understand the potential effects of tropical cyclones on population centres and critical infrastructure across Queensland. The intent of the project was to explore and assess a range of scenarios extending beyond historical analyses of prior severe weather events to inform decision-making for rarer but higher-consequence events. As a result of this work, the Severe Wind Hazard Assessment Queensland (SWHA-Q) was completed in 2020 and released in 2022 (Arthur *et al.* 2020).

In January 2020, 6 coastal local governments in South East Queensland and their stakeholders (emergency response agencies, non-profit organisations, industry and academia) worked to develop the *Severe Wind Hazard Assessment for South East Queensland* (SWHA-SEQ). The project's objectives were to improve understanding of the present wind risks in the region and to develop actions that could feed into future planning to reduce this risk. Over the course of the project, the group expanded to 19 stakeholders. The project was jointly funded (25% local councils, 50% state government and 25% insurance industry) and resulted in an aligned view of wind risk in the region through expertise, data and information-sharing.

The project findings were of particular interest to planners in the Gold Coast region, one of the largest concentrations of population in South East Queensland, with business activity, tourism and infrastructure important to the economies of Queensland and Australia. The region is home to over 630,000 people (City of Gold Coast 2023), which makes it Australia's second largest local government area behind

Brisbane City Council and Australia's sixth largest and fastest growing city. Projected population for the city is expected to reach 1.1 million by 2050 (Queensland Government population projections 2023). The speed and magnitude of this growth, reflected in continued urban development and a rapid increase in the city's geography and town designs, create vulnerabilities for local communities, especially related to cyclone exposure (Queensland Fire and Emergency Services & Geoscience Australia 2022). The city's river catchments, canals and waterways require deliberate and strategic consideration of the severe wind risk (similarly to those witnessed during a tropical cyclone) and consequent mitigation measures.

To support and explore what the project's findings mean for the Gold Coast region, Queensland Fire and Emergency Service conducted *Exercise Averruncus* that explored issues around preparation, response and initial recovery for a tropical cyclone making landfall in the area. The focus of the exercise was on interoperability and interdependencies between local and state governments. It identified exposures for the community, residential buildings and critical infrastructure resulting from severe winds, storm surges and riverine flooding. Participant discussions during the exercise focused on infrastructure resilience, the ability to evacuate large numbers of people and the use of public messaging such as emergency alerts, dashboard information, social media and traditional media. The exercise explored residential properties and not the impacts on commercial or strata title properties.

The exercise was based on Tropical Cyclone Seroja that made landfall in the Western Australian town of Kalbarri in 2021. Kalbarri shares a similar longitude to the City of Gold Coast on the east coast. A similar cyclone event to the one experienced in Kalbarri in the built-up areas of South East Queensland would be catastrophic at many levels due to population, manufacturing, business and tourist activities.

Findings

South East Queensland has experienced tropical cyclones in the past and will remain exposed to storms and cyclones into the future. The area has a significantly increased risk for cyclone and thunderstorm than other parts of the state, predominately due to higher exposure of people (population density) and building vulnerability (design standards).

Findings from the SWHA-SEQ report include a semi-quantitative analysis of climate change effects for severe wind risk indicating that the region is likely to see an increase in the proportion and intensity of very rare severe tropical cyclone events. The realisation of such a risk could cause catastrophic damage for communities, especially given the extent of predicted building damage to the current residential stock. To explore these risks, 5 scenarios were modelled as part of the assessment.

The scenarios followed the Queensland Inspector-General Emergency Management Cyclone Debbie Review, especially recommendation 7.b, that highlighted:

> *Significant effort should be invested to provide disaster decision-makers at every level with a shared understanding of risks, the situation and capability, so that they can agree on the best decisions for the communities they serve* (Office of the Inspector-General Emergency Management 2017, p.23).

The City of Gold Coast selected Scenario 1 (see Table 1) to form the base for future planning actions to address severe wind and its risks. Scenario 1 refers to a 10.

> *[The event] forms near the Solomon Islands in late January, initially moving southwards for the first five days. By 4 February, the cyclone intensifies into a severe tropical cyclone and changes direction to a more southwesterly track, but remains slow moving. By 10 February, the cyclone is around 350 km off the coast of Mackay and turns back to a southerly course. The cyclone remains off the coast and moves slowly southwards, maintaining intensity as a category 4 storm. Early on 13 February, the cyclone turns southwest and moves towards the coast, slowly weakening as it approaches. Through the evening 13th, of the cyclone accelerates and enters Moreton Bay, making landfall towards the southern shores near Wellington Point in the early hours of 14 February. Strongest winds are experienced across Mulgumpin (Moreton Island), and through the Gold Coast, including the hinterland regions. Through 14 February, the cyclone dissipates over northern NSW* (Edwards *et al.* 2022, p.74).

Scenario 1 revealed that 137,115 residential buildings in the Gold Coast would experience moderate to extensive damage from severe winds (see Figure 1).

A further 4 plausible scenarios were analysed and considered to support planning, risk assessments and Gold Coast response plan development. These scenarios were 'selected for the expected swath of maximum winds, consideration of historical events […], and propensity to impact all local government areas in the study region' (see Edwards *et al.* 2022, pp.89–96 for a detailed description of each scenario).

The SWHA-SEQ showed locations and types of houses that were exposed disproportionally to the wind risk. Offering incentives to these house owners to retrofit their properties to reduce risk through a cost-sharing scheme would make a meaningful change to the risk profile. However, for most houses, retrofitting may not be cost effective until other implications of societal disruption are factored in. The majority (79%) of residential houses in the study region are in lower-hazard site conditions[1] where retrofit, even with incentives, would not appear cost-effective (Edwards *et al.* 2022). Residential strata title buildings are also significant contributors to risk and have not been considered in this study. In summary, the findings showed that tropical cyclones and severe winds are posing an increasing risk that would have significant effects on the Gold Coast region and that requires preparation and action plan.

1. A low-hazard site condition refers to a to property that, if exposed to severe wind event, the likelihood and potential impact will be relatively low.

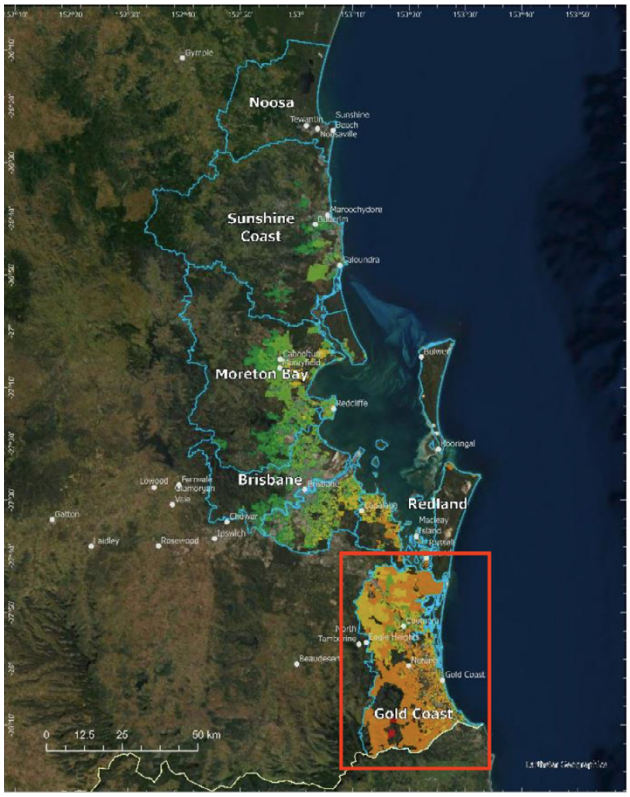

Figure 1: Areas of potential inundation for the Gold Coast area resulting for Scenario 1 modelling.

The City of Gold Coast response

To address the findings in this project, the City of Gold Coast council established a project to 'prepare for the expected'. Project AIR (Advocacy, Information and Resilience) aims to prepare for the effects of severe wind or tropical cyclone and focuses on protecting critical infrastructure and services, increasing community readiness and resilience and safeguarding the Gold Coast way of life. The Project AIR steering committee is chaired by a Local Disaster Coordinator with 3 supporting subcommittees (each focusing on a specific project stream of advocacy, information and resilience) and representatives from across the City of Gold Coast. The 6-year project will be completed in phases to deliver its outcomes:

- Identification and structure assessment of critical infrastructure for the City of Gold Coast.
- Identification of infrastructure improvements required to elevate the standards.
- Infrastructure hardening of existing infrastructure and influencing design of new projects.
- Development of an Advocacy Strategy Plan.
- Development of an Information and Education Strategy Plan.

The project outcomes are that resilience is achieved across the community for the built environment and that the shared understanding of risk of tropical cyclones and severe winds is improved and sustained. This project involves investigating opportunities to mitigate risk exposure to existing infrastructure, particularly in locations that may be used as places of refuge for people without suitable shelter-in-place arrangements. Places of refuge refer to buildings that have been identified as somewhere to stay during the passage of a cyclone (Inspector-General Emergency Management 2019). Places of refuge are not evacuation centres that are established to cater for long-term accommodation of evacuees for a minimum of 2 weeks (Inspector-General Emergency Management 2019).

A stocktake of the places of refuge and evacuation centres will assess the current level of building suitability to withstand a severe wind event and determine if infrastructure improvement is required to provide people with a safe option for shelter during these events. Project AIR's phased approach will contribute to future planning and construction projects for the Gold Coast. In addition, it is anticipated that the project will provide detailed information that can be considered in future land-use planning decisions, coastal hazard adaptation actions and emergency and disaster management.

Table 1: Categorical building damage for current residential stock – Scenario 1.

	Negligible	Slight	Moderate	Extensive	Complete
Noosa	5,500	0	0	0	0
Sunshine Coast	57,900	9,800	1,400	1	0
Moreton Bay	83,600	47,300	15,000	1,900	0
Brisbane	188,100	91,000	39,000	4,200	0
Redland	13,400	6,900	13,000	30,300	365
Gold Coast	28,400	21,000	36,900	99,400	815

Source: Arthur *et al.* (2020, p.81)

Pilot phase (study)

Following the SWHA-SEQ report, the City of Gold Coast engaged the James Cook University Cyclone Testing Station to pilot a critical infrastructure review to understand the suitability of evacuation centres. The pilot also assessed locations identified as a place of refuge and recommended remediation works to protect the community and city operations.

Thirty facilities were identified and a desktop assessment was conducted against the principals of:

- facilities must be accessible in the hours leading up to the extreme winds
- facilities must be safely clear of flood levels under flash flooding, riverine flooding and storm surge as modelled by the City of Gold Coast hazard modelling team and the data provided through SWHA-SEQ
- facilities must have a structure and cladding system that is likely to survive an extreme wind event
- facilities must provide safety against debris impact and injuries sustained because of wind-driven rain.

Nine physical facility inspections were conducted and the Cyclone Testing Station team reported building age, materials used, vulnerabilities, location, design criteria used for construction, potential use as a place of refuge and remediation works required. This concluded the pilot phase of this project.

Project AIR phase 1 substreams

Building on the pilot study conducted in collaboration with the Cyclone Testing Station, Project AIR initiated its first phase that was split into 3 subcommittees.

Advocacy

To help mitigate risk from severe winds and tropical cyclones, the Advocacy Subcommittee will create and deliver a plan for relevant building legislation and codes. This aims to influence design criteria and guidelines to improve resilience in increased wind-load conditions during severe wind events. Wind-load design needs to account for increased wind loads from a breach in the building envelope (e.g. failed window or door) and for wind-driven rain. The building needs to remain intact and provide safe shelter for occupants during a cyclone.

The City of Gold Coast will seek cost-sharing opportunities or grant schemes from the Queensland and Australian governments to determine resilience of built infrastructure along with community education activities during the project. This will include working with stakeholders on a collective plan that can deliver change. Stakeholders scoped for inclusion in this work are:

- Insurance Council of Australia
- University of Queensland
- Local Government Association Queensland
- South East Queensland local government areas
- National Emergency Management Agency
- commercial and private infrastructure asset owners.

Information

Severe wind risk is often underestimated by communities and points to a need to raise community awareness and enhance preparedness. The Information Subcommittee will develop and deliver an information and education campaign about how communities can prepare for increased wind events such as cyclones. The campaign will be integrated into the Queensland 'Get Ready'[2] campaign. A key element of the campaign is to promote stronger personal resilience (self and home) and to provide a variety of tools for people to use to prepare for and respond appropriately during severe wind events.

Through the SWHA-SEQ, Geoscience Australia provided data sets from the 5 modelled tropical cyclone scenarios that identified local wind speed across 20 annual exceedance probabilities. Geoscience Australia also provided risk information that identified areas with greater vulnerability in terms of structural damage to residential housing. The City of Gold Coast will use this data to develop community messaging and identify shelter-in-place and evacuation options.

Resilience

The Resilience Subcommittee will investigate opportunities to mitigate the exposure risks to existing infrastructure, particularly for locations that may be used as places of refuge. This would be for people without suitable shelter-in-place arrangements. The resilience stream is a phased approach and will expand into future construction as part of a implementation strategy of Project AIR outcomes.

During the pilot phase, critical infrastructure was identified and structural assessments completed. Phase 1 includes the initial remediation works to harden this infrastructure so they meet elevated standards for resilience and suitability for use as places of refuge. Phase 2 is a longer-term plan for moderate-to-major works to occur for identified infrastructure. This work leverages the expertise and materials already developed by the Cyclone Testing Station, Queensland Fire and Emergency Service and the Queensland Reconstruction Authority.

Conclusion

The population of the Gold Coast is predicted to almost double over the next 30 years and this will require an expansion of secure infrastructure. This growth is considered with regards to the area's exposure to severe winds and tropical cyclones and so requires a deliberate and planned approach to preparing local communities and infrastructure for these events.

Following in-depth analysis of expert findings, and in response to the increasing risk to the city and its residents, the City of Gold Coast is implementing Project AIR in a phased approach over 5 years. The aim is to improve resilience in the community and for the City of Gold Coast critical infrastructure. Project AIR is a collaboration of local government areas across South East Queensland and will be monitored and evaluated to identify lessons for future activities.

2. Queensland Get Ready campaign, at www.getready.qld.gov.au.

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About the author

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Fannie Couture is an assistant professor of strategy at HEC Montreal. Her research employs practice and process theories to explore strategy in pluralistic contexts to address socio-environmental issues.

Abstract

This study examined the (mis) alignments between multiple disaster cultures, the Indonesia Tsunami Early Warning System (InaTEWS) and local risk profiles as revealed by the 2018 non-tectonic tsunami triggered by the Anak Krakatau Volcanic eruption in Labuan. The research assessed to what extent the tsunami warning system was adapted to local needs and characteristics. Based on qualitative data collection, this study showed that before the 2018 tsunami (and notwithstanding memories of the 1883 Krakatau tsunami) different local groups shared a strikingly homogeneous understanding of tsunamis as exclusively triggered by earthquakes. After the 2018 tsunami, study participants reported increased awareness of different tsunami types and earthquake risks. However, this rarely translated into practical actions and changes at the local level as structural and cultural factors significantly hampered the work of local government and emergency management agencies. This research identified steps to improve alignment, for example by involving community members in warning technology maintenance, tailoring awareness-raising materials to local hazard profiles and connecting awareness-raising with local cultural traditions. However, a reform of the InaTEWS is necessary, including overcoming sectoral silos and incorporating local knowledge and experiences into policymaking. By addressing these (mis)alignments, authorities can better support communities to understand tsunami risks and respond to future event, ultimately enhancing preparedness.

Disaster cultures and the Indonesia Tsunami Early Warning System: (mis) alignments revealed by the 2018 non-tectonic tsunami in Labuan

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Introduction

On Saturday night, 22 December 2018, a series of tsunami waves 'silently' hit the coastal areas of Banten and Lampung provinces surrounding the Sunda Strait of Indonesia. According to the Indonesian National Disaster Management Authority (BNPB) (2018), Labuan district of Pandeglang Regency, Banten (Figure 1), was one of the most affected in relation to casualties, infrastructure and economic consequences. The government initially referred to the event as an 'extreme tidal wave' but later confirmed a tsunami that was likely the result of a partial flank collapse of the Anak Krakatau Volcano situated between the islands of Java and Sumatra (Ye *et al.* 2020; Zengaffinen *et al.* 2020). The local communities of Banten and Lampung provinces did not experience any prior earthquakes nor receive any warnings from authorities. While the Indonesia Tsunami Early Warning System (InaTEWS) has been operational since 2008, it was designed to produce tsunami warnings based on seismic events only (Annunziato, Prasetya and Husrin 2019; Titov 2021).

The 2018 tsunami underlines the need to align tsunami warning systems with local needs and characteristics. This is true in terms of risk profiles as tsunami can be triggered by earthquakes, volcanic eruptions or submarine landslides as researched in Indonesia and Australia (Brune *et al.* 2010; Paris *et al.* 2014; Puga-Bernabéu *et al.* 2017; Clarke *et al.* 2019). That alignment is also necessary in terms of disaster cultures. Cultural beliefs, customs and practices play a significant role in disaster risk reduction (Bankoff *et al.* 2015) and must be incorporated into risk planning, communication and warnings (Bankoff 2004).

Understanding how people perceive, experience and respond to emergencies reveals why they do or do not take action to minimise risks. Within government agencies, they constitute social groups with established customs and practices over time, shaping their approach to managing risks and disasters (Tierney 2007).

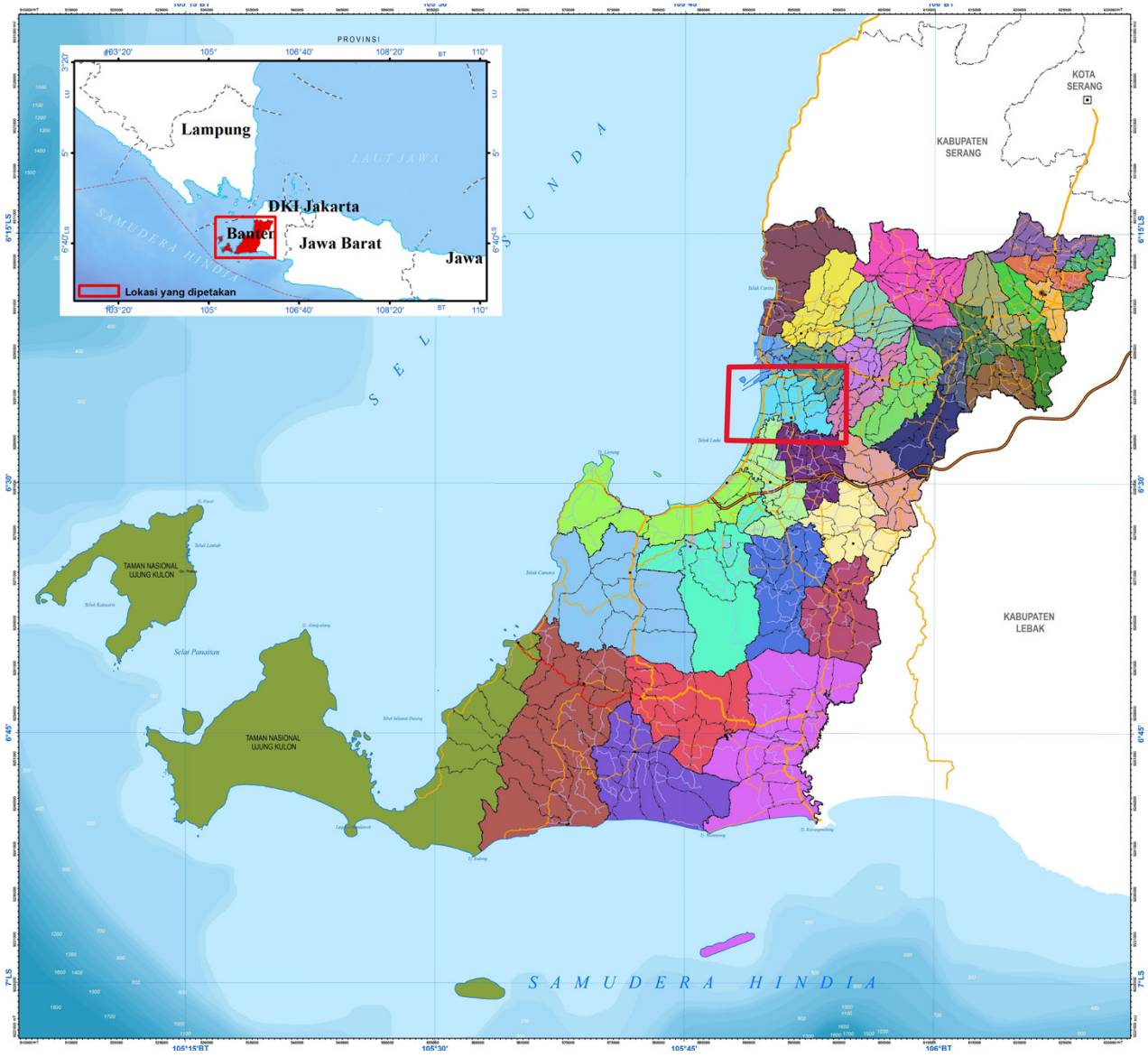

Figure 1: Locus of the study in Labuan district (red square) in an administrative map of Pandeglang Regency.

Source: Kabupaten Pandeglang (2011)

Figure 2 illustrates a triangle approach to analyse the alignment of local hazard profiles, multiple cultures and the InaTEWS instrumentation and procedures in the Labuan district.

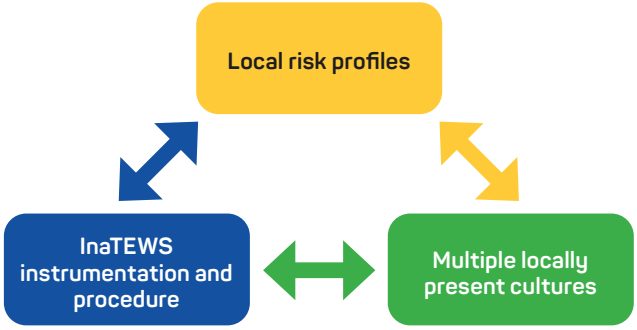

Figure 2: A model to analyse risk profiles, local cultures and InaTEWS systems.

Methods

Primary qualitative data were gathered between February and March 2023 and secondary data such as preparedness policies and reports were also reviewed. Semi-structured, in-depth interviews and focus group discussions were conducted with 72 participants from local community referred by snowball sampling and government agency officials selected through purposive sampling.

The community group included 37 residents from Teluk and surrounding villages. This included citizens active within the disaster risk reduction forum as disaster preparedness village representatives or Balawista lifeguards. The government group comprised 35 officials who worked in the Labuan district office, the local disaster management agency, Anak Krakatau Volcano watch post or the Indonesian Meteorological Agency and BNPB.

Interview questions concerned participant experiences of the 2018 tsunami and included who they expected to provide warnings and call for evacuation as well as any improvements they would recommend.

Data analysis followed Stake's (1995) 3-stage approach: categorising data, identifying correspondences and patterns and developing naturalistic generalisations. A deductive (research question-driven) and inductive (data-driven) approach was combined using the atlas.ti software. Results aim to support analytical generalisation on the (mis)alignment of the InaTEWS with disaster cultures and their effect on preparedness.

Ethics approval was obtained from the National Research and Innovation Agency (BRIN), # 04012023000010, 26 January 2023.

Results

The analysis highlighted that although participant insights had considerably evolved since the 2018 tsunami, warning practices had not necessarily. Findings are outlined following 3 temporal phases of (1) before the 2018 tsunami, (2) what the 2018 tsunami revealed and (3) lessons learnt and applied following the 2018 tsunami.

Before the 2018 tsunami

Fieldwork revealed that the 1883 Krakatau eruption-induced tsunami shaped people's memories and practices. Research participants from the community group identified toponyms that indicate the tsunami landing sites, including the Longok neighbourhood in Sindang Laut village (meaning 'seawater that stops by') and Belangkas hill road situated 6 kms from the coast and named after the 'horseshoe crabs' found in Bojong Canar village (personal interviews, February 2023). Like toponyms, oral traditions passed on over generations serve as reminders of the 1883 tsunami. Some community members referred to tsunami as *Caah Laut* (flood from the sea) or *Kalembak* (rolled by waves), although these terms are being replaced by the better-known term 'tsunami'. Few families shared stories of the 1883 Krakatau eruptions, portraying the volcano as an evil entity luring people to the sea. However, this was limited and did not concern other people recently migrating into the area.

Regarding traditions, the 1883 tsunami gave rise to *Haul Kalembak,* an annual commemoration held by descendants to remember family members lost to the tsunami. Some participants viewed the event as a spiritual necessity, but suggested it should also serve as an opportunity to disseminate preparedness messages to communities. The same applies to the *Ruwatan Laut* or *Nadran,* a sea purification ritual created through the hundreds of acculturations of Islamic and Hindu cultures in Pandeglang. Fishing communities still carry out the ceremony under private sponsorship, leaving some to criticise the ritual as a tourist event.

Despite the memories and traditions linked to the 1883 eruption, community participants regarded the Anak Krakatau eruption as a beautiful attraction benefiting the local economy. Fishers shared how they did not perceive the volcano as a threat to be worried about as they were used to mooring their boats on the volcano island and waking up the next morning to find their boats covered in volcanic ash.

Before 2018, all community group participants indicated an understanding of tsunami as preceded by an earthquake, as they had been taught on television. This aligns with the earthquake-centred tsunami communication established by government agencies between the Meteorological, Climatological and Geophysics Agency (BMKG), BNPB and the Volcanology Agency. While Pandeglang Regency published a disaster risk assessment document in 2013 following the risk assessment guidelines issued by BNPB (2012), neither the guidelines nor the risk assessment document (see examples at Figure 3) considered non-tectonic tsunami origins.

Most community participants said they did not believe another tsunami would hit their area. They considered the installation of tsunami evacuation signs in 2012 and 2015 useless. Scepticism towards the local government and other emergency management practitioners was commonly expressed through statements such as: 'you are scaring people', 'life is God's business' and '[a] tsunami is just some news on television' (personal interviews, February 2023). A Balawista lifeguard offered another perspective and criticised the Local Disaster Management Authority (BPBD) of Pandeglang for installing signs using 'threatening wording' without consulting the community.

What the 2018 tsunami revealed

The 2018 tsunami highlighted how strongly disaster cultures centred on earthquake-centred tsunami. This earthquake-centred disaster culture extends to community perceptions of risk, the roles and responsibilities of agencies, the national choices of monitoring instrumentation as well as warning procedures.

Interviews with community members and focus group discussions revealed that villagers heard and felt the sound and tremors from the Anak Krakatau Volcano eruption in 2018. They were used to these since childhood, even though the tremors felt stronger and longer on 22 December. The natural signs did not warn the community and some villagers witnessed the arrival of the tsunami waves firsthand only later. As shared by one participant, a wave 3–4 metres high with foam 'white and long, like a group of ducks swimming in the middle of the sea' was visible from afar accompanied by a thunderous train-like sound and a gust of wind. Community members and government officials attributed the chaotic situation to confusing the tsunami for an extreme tidal wave. Communities had been repeatedly taught through training, socialisation and television news that an earthquake must precede a tsunami. One community member referred to this as 'patented', thus infallible wisdom.

According to observers at the Anak Krakatau observation post (9 February 2023), the volcano continuously increased its activity in June 2018. Its status was ranked based on a ministerial guideline (Kementerian ESDM 2011) at 'beware' or level II and was not changed to level III or IV (i.e. 'likely eruption') because the volcano is situated in the middle of the sea and 'it is far from the community, there was no need to evacuate anyone'. The Volcanology Agency only considers areas that can be affected by ash, sand, hot clouds, volcanic bombs

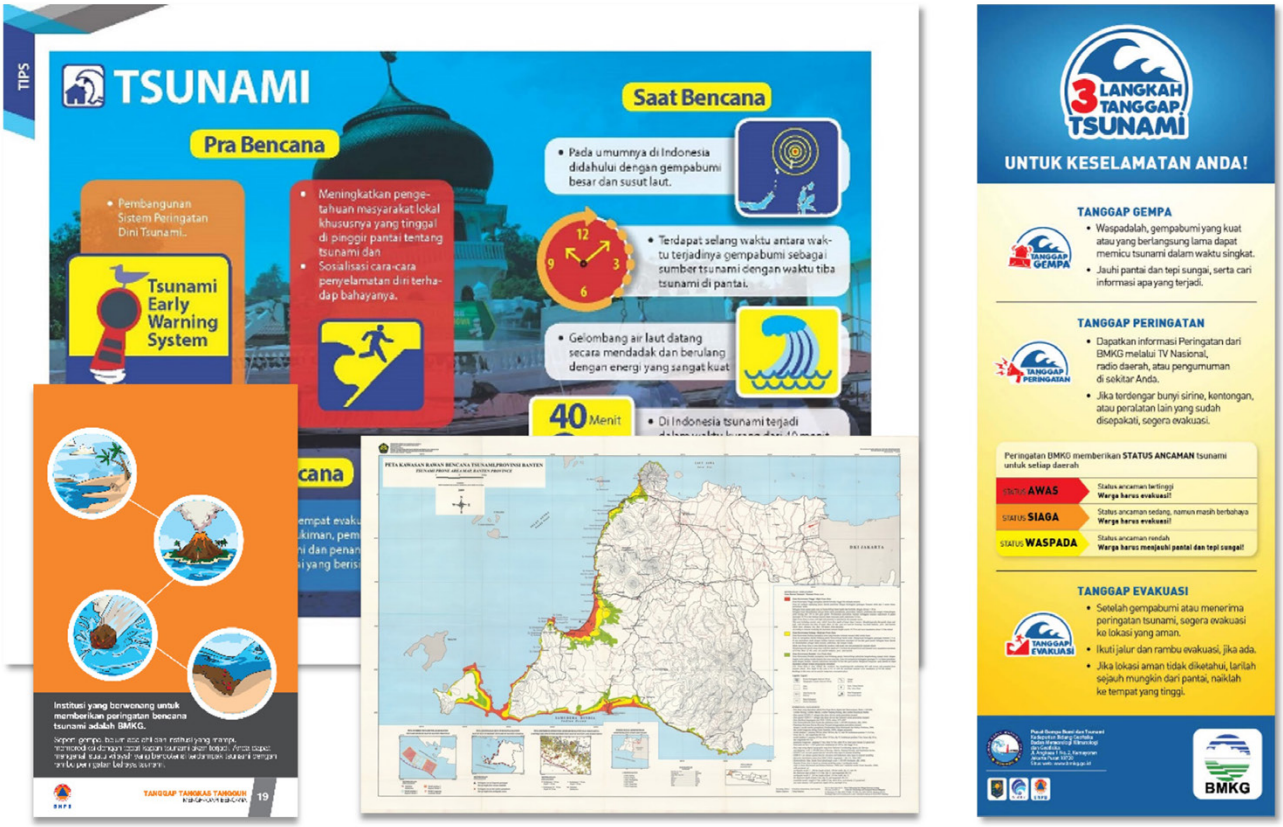

Figure 3: Examples of community tsunami preparedness materials.

Source: Volcanology Agency (2009); BNPB (2019b, 2019a); BMKG and IOTIC IOC UNESCO (n.d)

or lava flows within a 5 km radius. This may suit continental regions but is not sufficient for volcanoes at sea or in coastal areas where a tsunami may follow. Likewise, the 2018 tsunami was detected by several sea-level measuring devices installed by the Geospatial Agency along the coast but detection was too late for warning communities (Muhari *et al.* 2019).

Community and local government officials viewed BMKG as the authorised and trusted agency to provide official statements regarding earthquake and tsunami events. At the local level, BPBD Pandeglang officials considered themselves as mere users of early warning services in that they follow and relay information, warnings and statements received from the national BMKG, BNPB offices and the Volcanology Agency, and their provincial government. This partially aligns with the BPBD mandate in Presidential Regulation 93/2019, including providing information on disaster-prone areas, communication and education and a 24/7 warning dissemination service.

BMKG installed 2 tsunami sirens before the 2018 tsunami, each with a 0.5–1 km radius on the 307 km coastline of Pandeglang Regency. This was insufficient. Moreover the sirens were only periodically tested during trainings and were not activated on the night of 22 December 2018 (Borrero *et al.* 2020). Community members approved sirens as a warning method, yet these are controlled by the provincial BPBD and national BMKG, not by the local BPBD Pandeglang office. BPBD Pandeglang thus relies on WhatsApp, communication radio and loudspeakers to disseminate warnings and instructions to the community.

Post-2018

Following the 2018 tsunami, research participants reported a significant shift in their tsunami threat perception. This was reflected in increased acceptance of preparedness information. During fieldwork, community members living near the tsunami siren installed in Teluk village explained that the siren functions as a warning only in the event of a tsunami triggered by an earthquake. They also emphasised the distinctive features of their region, highlighting that the siren does not alert for non-tectonic tsunamis, which are considered a real threat. Interestingly, participants had become sensitive and responsive to earthquakes – a fact made visible through self-evacuation following the 2018 tsunami. This practice is not common in Indonesia, where residents often wait for top-down instructions before taking actions and evacuating.

The Pandeglang local government improved its spatial planning document by considering tsunami threats in zoning. Numerous institutions and organisations provided support between 2019 and 2022 to prepare a Disaster Emergency Response Plan, a Flood Disaster Contingency Plan and to form a Disaster Risk Reduction Forum to foster information sharing and to improve disaster management. The forum comprises practitioners, academics, government entities, members from the private sector and the media. Pandeglang government upgraded the classification of BPBD from Type B to Type A, which should provide additional budget. However, community members and

BPBD officials have not experienced much change (personal interviews, February 2023). Preparedness activities still do not consider the threat of non-tectonic tsunami and BPBD Pandeglang has not yet established agreements for tsunami warnings and quick reaction procedures. Government participants did not consider traditions such as *Haul Kalembak* worthy to tap into to improve community awareness.

In terms of technology, various warning devices were installed by BMKG, BNPB and the Volcanology Agency. However, BPBD and community representatives said their groups had not been involved in the process. This raises concerns about maintenance and continued functionality of introduced technologies. In contrast, sea surface monitoring devices were installed by BRIN using an approach involving fishers and water tour guides to help maintain the devices and some are trained to access data and perform simple troubleshooting (BRIN official, personal communication November 2022).

Several local and national disaster management officials described the 2018 tsunami as a wake-up call to develop a tsunami warning system that can detect non-tectonic tsunami sources. They emphasised the importance of aligning agencies in terms of policy, technical equipment and data gathering and use. Tangibly, the Anak Krakatau observation post now conveys major observation changes to BPBD Pandeglang, the BMKG Tsunami Warning Centre and other agencies through WhatsApp groups. Previously, and as per-procedure, the information was only sent to the Volcanology Agency central office in Bandung. Despite efforts to enhance integration, obstacles arose and BMKG and the Volcanology Agency developed joint standard operating procedures. However, challenges emerged due to disparities in metadata, skills and incompatible monitoring equipment, hindering further integration. According to a BMKG official (December 2022), '[w]e could not use the data from Anak Krakatau itself because there was much noise from the volcano, and we had difficulty analysing the tectonics'. BMKG and Volcanology Agency officials have discussed alternative non-tectonic monitoring scenarios. This includes observation and warning decisions based on the morphology and characteristics of volcanic eruptions, volcanic activity status and the influence of meteorological conditions that may trigger a tsunami. However, these are still in the discussion and (international) research stage.

Discussion

Results are considered from 3 perspectives: multiple disaster cultures, InaTEWS procedures and the local risk profile. For multiple disaster cultures, before the 2018 tsunami, there was a similarity in perceptions across community groups (e.g. recent migrants or people long involved in associations), local government and emergency management agencies. These groups primarily associated tsunami as being exclusively triggered by earthquakes and considered Anak Krakatau as non-threatening (although some agencies gave higher importance to tsunami preparedness). Despite memories of the 1883 non-tectonic tsunami as reflected in toponyms, local traditions and family stories, community members, particularly fishers, used the volcano island as a mooring spot and incorporated the volcano into their daily lives. Likewise, the Volcanology Agency did not consider the volcano as a potential tsunami source and other agencies did not consider Anak Krakatau in their mandates.

Factors that may explain this include the tourist commodification of traditions and rituals that can lead to erasing a deeper connection to the environment and an ability to read natural signs (Nazaruddin 2022). This, associated with social change, including rising economic imperatives, led to developing a scepticism of evacuation signs and preparedness outreach. Specifically, it weakened the collective memory of Anak Krakatau as a potential hazard. A participant, a descendant of an 1883 victim, mentioned that many people left Labuan after the 1883 tsunami. However, migration rates into this tsunami-prone area have been increasing. This contrasts with the more 'sedentary' Simeuluens who have preserved a memory of the 1907 tsunami through oral tradition and have largely avoided the catastrophic effects of the 2004 tsunami (Rahman, Sakurai and Munadi 2018; Sutton *et al.* 2021), which was tectonically induced and has influenced Indonesian collective memory and procedures.

Disaster cultures and the InaTEWS institutions, instrumentation and procedures were aligned before 2018 and are only marginally less so since 2018. This study showed that all participants reported perception changes. This was especially so for community members whose firsthand experience differed from what they had been taught about tsunami and their risk awareness and preparedness had increased. This was also reflected in people self-evacuating after earthquake in August 2019 and January 2022 in response to natural signs of tsunami. However, local government and emergency management actions did not follow. Material and training remains inadequate in addressing non-tectonically induced tsunami. While there are efforts to improve planning, BPBD's capacity and the installation of new instrumentation, such as sea-level monitoring devices, these actions have yet to result in improved coordination and preparedness efforts.

Cultural factors are important. Major disasters like the 1883 and 2004 tsunamis have been argued to significantly shape community perspectives, memories and preparedness (Gaillard, Clavé and Kelman 2008; Solnit 2009). However, the depth of these changes is worth questioning. The 2004 earthquake-triggered tsunami without doubt had a long-lasting and profound effect. It led to the establishment of the InaTEWS in 2008 and to the geophysical BMKG agency being assigned as the lead tsunami agency. In contrast, observations suggest that the 2018 tsunami led to short-term lessons learnt that were not consistently applied. In Labuan, all other agencies than BMKG still considered their role as 'mere users' of tsunami information. Agencies have developed a strong sense of ownership and expertise within their specific domains, hindering effective information sharing and collaboration during emergencies. The key challenge lies in fostering collaborative environments among agencies, reflected in shared procedures. For social groups institutionalised through laws and mandates, disaster cultures evolve and solidify over time. In the Indonesian context, achieving systematic reform that breaks down silos is contingent on a robust political will at the highest levels.

Ultimately, (mis)alignments between disaster cultures and the InaTEWS are of little effect if local risk profiles are not considered. The devastating effect of the 2018 tsunami in Palu and Sunda Strait and further possibility of non-seismic tsunami (Zorn *et al.* 2022) underscore the need for disaster cultures to not centre on seismically induced sources. Cascading hazards result from combined volcanic, hydrological, geophysical and social dynamics and this must be reflected in a comprehensive multi-risk approach and inter-agency alignment. Local knowledge and experiences must be incorporated into policymaking and preparedness strategies to include the risks and challenges communities face. Without official warnings, other natural signs such as roaring sounds, tremors and white sea foam can serve as warnings for communities to take immediate life-saving actions (Rafliana *et al.* 2022). Therefore, these signs should be incorporated into risk communication and awareness campaigns.

Conclusions

Examining (mis)alignments following the triangle approach can help to assess if tsunami warning systems are comprehensive and relevant to local communities. In some cases, alignment between the 3 elements of local risk profiles, the InaTEWS and multiple locally present disaster cultures can be improved. This can be done by involving community members in warning technology maintenance, tailoring awareness-raising materials to the local risk profile and linking awareness-raising with existing local traditions. The *Haul Kalembak* ceremony can serve to reconnect communities with natural tsunami warning signs. More reform of the InaTEWS is necessary and must overcome cultural and structural barriers that have formed over time. By addressing (mis)alignments, authorities can help communities to understand and respond to tsunami risks, which ultimately enhances preparedness and reduces the negative effects of future tsunamis.

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Flipping the script: young people mobilise adults to increase participation in disaster risk reduction

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Abstract

The established practice for increasing young people's inclusion in disaster risk reduction holds that adults play a vital role in realising young people's full participation. This involves providing young people with a seat at the table or facilitating their inclusion to ensure their voices are heard. However, when adults are both decision-makers and facilitators of inclusion, the drivers of exclusion often go unaddressed. This paper describes a co-design method used by The Resilient Towns Initiative to improve youth participation in disaster risk reduction. It was devised through working with young people in the New South Wales Snowy Valleys, an area affected by Australia's summer bushfires in 2019–20. The approach relied on supporting the conditions for young people to increase their participation via cultivating a youth voice, generating ideas, creating a vision, bringing in adults, and building legacy to sustain momentum. Outcomes indicate that this approach nurtured cross-generational relations, raised the profile and esteem of young people and built skills, knowledge and resources. This addressed some structural barriers to inclusion and, more broadly, social inclusion in a regional area.

Introduction

Following the 2019–20 bushfires, numerous programs aimed at increasing the role of local communities in disaster risk reduction have been initiated, with community-centred approaches to recovery seen as the gold standard (Sanderson *et al.* n.d.). Yet despite the best intentions, there remains groups that are excluded from full participation, including young people (Young and Jones 2019; Gaillard 2021).[1] Across the scholarly and practice literatures on supporting youth participation, it is common for adults to mobilise young people so that their perspectives are included (Mitchell, Tanner and Haynes 2009). This demonstrates the central position of adults in decision-making and their influence over how excluded groups are involved. With 2 in 5 children affected by the 2019–20 bushfires (being either affected directly or knowing someone who was adversely affected) (UNICEF Australia and Royal Far West 2020:12), it is crucial that the drivers of youth exclusion are understood and addressed to ensure full participation.

Addressing youth exclusion in disaster risk reduction, we argue, is based on equity and promotes initiatives that are with, for and about young people (Gibbs *et al.* 2013). Looking to identify better youth inclusion in a regional New South Wales bushfire recovery program, The Resilient Towns Initiative developed a series of forums over a 20-month period to increase young people's participation. The forums 'flipped' the concept whereby adults would normally mobilise excluded groups. Instead, the forums supported young people, generated community recovery projects and, only then, brought in adults to help refine and build projects for actionable outcomes. Building young people's voice is important because, as Couldry (2010:vi) observed that 'voice is not merely about verbalising', but the process of 'giving an account of oneself and what affects one's

1. 'Young people' and 'youth' are understood here as community members between the ages of 12 and 30.

Local residents gathered at community halls to work together at the forums.

Image: T. Heffernan

life', which is 'an irreducible part of what it means to be human'. Through a focus on how excluded groups can generate ideas and work with authorities down the track, our approach showed how embracing the diversity of voices is important to maximise a community's resilience (Mansfield 2020), which is important in hazard-prone areas. This approach prioritises excluded groups, advances their ideas about how positive change can occur and highlights youth as fully-fledged agents of change in disaster risk reduction (MacDonald *et al.* 2023). Outcomes for this example indicate that codesigned, youth-driven measures nurture cross-generational relations, raise the profile and esteem of youth and builds their skills, knowledge and resources. This can address structural barriers to inclusion and promote social inclusion.

The Resilient Towns Initiative

During 2022, there was extensive flooding in Australia and all states and territories experienced flood events. The flood event that is the focus of this report was experienced in late February to early March. The greater Uki area is located in the Tweed Shire local government area in the north of the Northern Rivers region in New South Wales. The record flooding that was experienced followed a period of wetter-than-average conditions, with higher rainfall, greater soil moisture and higher groundwater levels.

The Snowy Valleys area in southern New South Wales was severely affected by the 2019–20 summer bushfires with almost half the local government area (4,500 km^2) being burnt and 260 dwellings fire-affected or destroyed. The Resilient Towns Initiative was a university-led, locally implemented initiative undertaken over 2021–23 that involved collaboration between researchers from the University of New South Wales and RMIT University, the Red Cross, Anglicare and local and New South Wales governments. The initiative involved 7 towns and villages in the area and aimed to support these communities to build their recovery. A series of public activities was developed using participatory action methods (Wates 2014) that were later refined after feedback from participants about what worked for them (see Table 1). At the heart of these activities was the question 'How can we make our communities safer?', which required attendees to identify local hazards and increase community capacity and preparedness.

The initiative was not established as a research project but sought to co-design and implement a series of activities with communities to instigate locally driven recovery. Facilitators of The Resilient Towns Initiative provided a 'light-touch' approach to encourage people to play a larger role in local emergency management, including disaster recovery. The literature on disaster recovery, for example, shows that a key problem often lies in top-down command-and-control approaches by responding agencies that can be poorly suited to community-centred recovery (Sanderson 2019a). Ongoing systemic change is underway that is reshaping how recovery is framed, including the narrative on who 'owns' recovery, namely communities. Extending this, established principles from community

development and humanitarian assistance were used to guide each of the phases:

- Disasters are not natural (hazard + vulnerability = disaster) (Kelman 2020).
- Disasters are part of daily life; bad things happen every day, but people recover.
- Marginalised and excluded people are especially at risk (Wisner *et al.* 2014).
- Strong communities comprise cohesive, organised groups with a plan (Sanderson 2019b).

These principles focused attention on the existing strengths of the community and highlighted the need for additional measures to promote safety and inclusion. The initiative loosely relied on adaptive management principles (Bixler *et al.* 2023) including building a local theory of change. While no age restrictions were placed on people's participation, few young people attended. This prompted the team to adapt activities to specifically cater to young people's needs and aspirations.

The process: building youth participation

A co-design methodology (see Robinson, Halford and Gaura 2022) was used and involved the pooling of technical and local knowledge to catalyse change and to influence the conditions for improved youth involvement. This was supported by collecting and integrating youth feedback to further support the co-design process and ensure young people felt heard and represented. Adults were excluded from discussions, acknowledging the well-established barriers to young people being consulted and heard, and therefore their ability to contribute to community planning. The methodology also embraced physical spaces where youth congregate. These approaches helped to adapt and progress each engagement phase listed in Table 1 so that they suited young people's needs and their preferred style of working.

Stage 1: Cultivating a voice

Participants attended a 2-hour introductory session to understand when and where young people felt their voices were heard the most and least in their communities. The online real-time feedback website, Mentimeter, was used to gather and present anonymous responses. Participants could then speak to the ideas generated, which was a safe and peer-focused environment to share information. Couldry's (2010:vi) observation about the centrality of voice to one's individual agency and what it means to be human highlights how the ability for some groups, such as young people, to contribute and influence community planning is often at odds with local power dynamics, including age and social hierarchies that impose and perpetuate inequalities. For this reason, it is not enough to be able to communicate; voice must be exercised and defended. In the case of young people, this includes voice and agency maturation. The maturation of voice and agency requires providing opportunities for young people to be heard and considered, their agency acknowledged and their ideas noted. Hosting an event without the presence of adult members, including parents, school staff and after-school carers, meant barriers were temporarily removed. Barriers include young people not being properly consulted, adults being the main decision-makers and the sense that young people's ideas would come under adult scrutiny.

Stage 2: Generating ideas

In an environment where young people lack a platform to be included in disaster risk reduction initiatives, events that garner their ideas and deduce the main themes are important. At a subsequent forum, young people worked in small, self-selected groups to generate ideas to a focus question about enhancing community safety. From the perspective of organisers, keeping the identified barriers at bay during activities was important. This was achieved through emphasis on 'blue-sky thinking', embracing ideas wholeheartedly and entertaining both serious and non-serious ideas.

Blue-sky thinking: This is a core part of building young people's ideas about positive change and is premised on solution-focused ideas that highlight what is important for achieving a shared goal. Answering a question about creating safer communities, participants were encouraged to 'think big' and not constrain themselves by focusing on idea logistics and feasibility. At the same time, the co-design nature of the events meant young people understood that not all ideas would succeed to the project building phase. This lessened the degree to which participants felt disillusioned.

Table 1: The phases and outcomes of co-design to support locally led recovery.

Townhall meeting	Action planning 1	Action planning 2	Check-in meeting(s)	Preparedness plan
The initiative is introduced.	Community response: 'How can we make our community safer?'	Community identifies opportunities to address themes.	Identify additional capacities (if needed).	Plans written by community, based on a local not-for-profit template.
Questions fielded and likely outcomes identified.	Core themes compiled.	Who, what, when, where and why attributed to opportunities.	Nurture cross-sector and community relationships.	Storage and upkeep of the plans discussed.
Trajectory of events to support locally led recovery				

Embracing ideas: It is crucial to acknowledge participation and affirm and promote a youth voice to help young people feel their participation is warranted (Forbes, Simmons and Willems 2018). For this reason, all ideas were embraced and noted down to champion the credibility to young people, their ability to brainstorm and their confidence to present ideas.

Humour: Throughout the forums, silly and humorous (i.e. non-serious) ideas were encouraged. As voice is about 'giving an account of oneself' (Couldry 2010:vi), one way to build agency and presenting skills was to avoid unnecessary scrutinisation and to encourage self-expression, even if it was obvious that an idea was said in jest. The forums reinforced trust, credibility and safety outside of school and home environments and the process was more important than the ideas generated.

Ideas were summarised at the end of the forum and the overarching themes were teased out and endorsed by participants, including:

- more things to do that are safe in the town
- improved public safety precautions (e.g. better lighting, fencing, footpaths)
- additional resources and facilities to improve the quality of life of people in the town
- establishing a regular communication channel or youth committee.

Stage 3: Values and vision

A follow-up meeting was held where young people collaboratively developed a vision for making their community safer while considering the established themes, ideas and opportunities. The vision was:

> *A safer community will promote the strength of our town, the connections between people and good communication channels. This will lead to community growth, cohesiveness and resilience.*

This vision was used to frame the work young people had embarked on ahead of a meeting with adults, framing it in a language that was understandable to adults and, more broadly, to community decision-makers, such as council.

Stage 4: Bringing in the adults

At the final event, adults attended a community forum where young people presented their vision and project ideas. Invitations and an overview of the previous forums were sent to parents, school staff and teachers, after-school program coordinators, local businesses, local non-government organisations, community societies and clubs as well as to local government councillors and council staff. Attendees were encouraged to mingle and sit among each other to reduce generational or family clustering. The ideas were then presented and attendees were encouraged to use the session to help build young people's ideas into actionable projects. Project ideas included:

- improving the skatepark (where young people spent a lot of time)
- updating lighting and fencing in public spaces
- establishing online youth spaces, such as a Discord server
- assembling a youth committee that could feed into adult committees.

Participants embraced the philosophy that the solution to resourcing or other issues could be found locally. This inspired them to think about how social networks could be harnessed and what resources were needed for each of the ideas. At the close of the community forum, attendees worked together to select 2 projects under each theme, identify the next 3 steps involved, designate a project timeline and nominate interested parties or groups who could own or support the project from idea to implementation.

Young people worked in small groups at the forum to brainstorm ideas.

Image: T. Heffernan

Young people and adults working together finding possible solutions to risk reduction projects.

Image: T. Heffernan

Stage 5: Legacy building

Given that the project lifecycle of the initiative was determined by external funding, it was important to ensure youth engagement and project ideas could be sustained. This was achieved in 3 ways. The first was to build momentum and buy-in at each event through young people being seen by their community as taking seriously the management of the community and its hazard profile. Secondly, momentum was achieved by identifying the priorities and anticipated outcomes for each project so that a timeline could be created, providing direction and accountability to achieve project outcomes. Finally, organising existing community groups to take ownership of each project helped to instil purpose and drive. A youth after-school program[2] was tasked with coordinating documentation and future meetings.

Outcomes: building agency and ensuring legacy

Effectively 'flipping the script', that is, changing the starting point from which disaster recovery is carried out, requires engagement of young people as under-consulted and often excluded. In doing so, both young people and adults play a vital role in recovery after disaster. Young people raise novel ideas or frame things in different ways, which offers a different perspective. Young people were passionate about improving public safety (theme 2) such as public lighting and fencing around play areas. Poor lighting or the risk of balls rolling onto the road highlight a lack of physical infrastructure but also draw the attention of adults who may not frequent these areas. If safety is improved in any area it benefits the entire community. A change in this perspective deepens a community's understanding of their risk profile and can establish stronger cross-generational links.

By embracing these ideas, young people could engage with their peers and adults at the forums and outside the context of home and school. Forums are an example of an emerging focus on addressing disaster risk reduction exclusion through non-formal education opportunities (Seddighi *et al.* 2023). Disaster risk reduction is today embedded in formalised education[3], however, not all students excel in this environment. Some feel excluded by it or, due to absenteeism, miss out on important education. Forums are a means of filling knowledge gaps and mobilising young people's ideas outside the context of home and school and reinforces that risk and hazards are a part of life and that everyday solutions can be identified by working within communities. For this reason, while 'disaster' was rarely the explicit focus of brainstorming and discussions at the forums, the positive social relations and opportunities for young people to give an account of themselves and what affects their lives, created the potential for collaboration and networking. These positive interactions, networking opportunities and collaborations were aimed at improving safety and will pay dividends in the future.

Conclusions and next steps

This paper outlined a codesigned method for working with young people to increase their agency and participation in disaster risk reduction. The method was adapted based on activities designed by practitioners, government and non-government representatives working as part of The Resilient Towns Initiative in the New South Wales Snowy Valleys region. Disaster risk reduction initiatives need to be with, for and about young people and a series of forums provided opportunities for participants to 'flip the script', develop youth agency, grow a pool of ideas and to enact disaster recovery differently. In a world where young people are often viewed as vulnerable and in need of protection, this project demonstrated the critical role that young people can play in contributing to understanding and responding to their local environment needs. Parents, teachers and community groups have expressed interest in developing projects further and establishing youth councils and ways for young people to be heard at formal events for community planning. While ameliorating the exclusion of vulnerable groups would appear to be a complex issue, codesigned, community-centred and youth-focused projects demonstrate great promise.

More information about the initiative is available at: www.youtube.com/watch?v=SkO78FeVcWo.

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2. Starting F.R.E.S.H, part of the Anglicare NSW South, NSW West and ACT bushfire recovery program.

3. For more information, see the 'Local links and learning' report in the reference list by the James Martin Institute for Public Policy and the NSW Department of Education.

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Bushfire risk, messaging and older people: setting a research agenda

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Abstract

Intense bushfires are going to become more prevalent in Australia because of changes in the climate. Also, the population of older people in bushfire areas is increasing. Under the new Australian Fire Danger Rating System, 'catastrophic' bushfire danger days are those when houses may not be able to be defended and, as such, the advice from authorities is that people should leave early, prior to the advent of fire. Leaving early is particularly important for vulnerable groups in communities, including older people. Experience from Australia's summer bushfires in 2019–20 suggests that leave-early messages were not communicated effectively and were not enacted. This paper presents an overview of bushfires and bushfire messaging in the Australian context and the associated risk to older people. It identifies gaps in the current understanding of the intersection of these issues and lays out a plan for future research in this area.

Introduction

The 2019–20 summer bushfires presented a real-time example of the growing influence of climate change on weather conditions that contribute to catastrophic bushfires. On a national scale, Australia was dangerously underprepared for the 2019–20 fire season (Commonwealth of Australia 2020). For south-eastern Australia, this was the 'worst bushfire season ever encountered' (Government of South Australia 2020; Gergis and Cary 2020; Morton 2019). The fires caused 33 deaths (25 in New South Wales) and significant property destruction and damage (Government of South Australia 2020; Owens and O'Kane 2020).

In Australia's bushfire history, catastrophic bushfire events were few enough to be regarded as anomalies (Commonwealth of Australia 2020). However, catastrophic bushfire days, and the conditions that cause them, are likely to increase over the next 50 years (van Oldenborgh *et al.* 2021; Commonwealth of Australia 2020; CSIRO 2020).

Australia has an ageing population. The percentage of people aged 65 and over has increased from 4.6% in 1922 to 16% in 2021 (Australian Institute of Health and Welfare 2021). The Australian Institute of Health and Welfare indicates that this trend will continue. By 2066, older people in Australia will represent approximately 21% of the population. Most older people live in private dwellings (ABS 2017) and 'ageing in place' is the intention of this cohort. This has implications for disaster planning and management because older people represent a vulnerable group (Fountain *et al.* 2019; Howard *et al.* 2017; Orimo *et al.* 2006). For this group, risks associated with bushfires are heightened and older people are overrepresented in bushfire fatalities (Commonwealth of Australia 2020), especially in rural areas (Handmer *et al.* 2019; Handmer and O'Neill 2016; Haynes *et al.* 2010). Many older people face complexity when planning for bushfires. They may require help to prepare for bushfires (Commonwealth of Australia 2020; Owens and O'Kane 2020) and research has shown that older individuals may be hesitant to evacuate before a fire breaks out, which highlights the need for targeted efforts that promote a 'leave early' action (O'Neill and Handmer 2012).

There is a paucity of research about how older people interpret messaging for bushfire planning (Fountain *et al.* 2019). This paper provides an overview of the growing threat of bushfires in Australia and the associated risks that older people face. It emphasises the importance of messaging that instructs safe evacuation. We identify gaps in knowledge regarding evacuation planning and preparedness practices of older individuals living in areas threatened by bushfires. We also consider the interpretation of 'leave early' messaging and the challenges encountered in enacting leave early plans. The paper concludes with a proposed

research agenda to better understand how older people may interpret bushfire messaging to improve how they create plans and enact them and the intended actions of older people living in bushfire-prone locations.

Bushfire in the Australian context

According to climate projections, Australia will experience dangerous fire conditions in the future. Fires are predicted to be more intense, more frequent and be of longer duration (Commonwealth of Australia 2020; Bruyere *et al.* 2020; IPCC 2021; Pausas and Keeley 2021). Destructive and self-running fires will become more prevalent, the return interval of catastrophic events will shorten and bushfire seasons will extend, accompanied by more days with consistently high bushfire danger ratings (Bruyere *et al.* 2020; Commonwealth of Australia 2020; Piper 2020). In 2022, Australia's fire rating index added a new category of catastrophic to account for this expected enhanced level of danger (Chuvieco *et al.* 2021; NEMC n.d.). Historically, catastrophic bushfires in Australia have been regarded as anomalies (Commonwealth of Australia 2020), but over the next 50 years, the conditions that cause them will be enhanced (van Oldenborgh *et al.* 2021; Commonwealth of Australia 2020; CSIRO 2020). Catastrophic bushfires have an intensity so great they generate weather conditions to produce fire-generated or 'pyro cumulonimbus' storms (Piper 2020; Commonwealth of Australia 2020). These fires are 'the most dangerous conditions for a fire' and most homes have not been constructed to withstand the intensity of them (AFAC National Council for Fire and Emergency Services 2023). Therefore, the risk to residents living in bushfire-prone areas will increase, as will the need for them to be well-prepared for such events.

Australia's major cities and suburbs adjacent to and within dense native vegetation have experienced regular episodes of severe fires (Blanchi *et al.* 2010; Gibbons *et al.* 2012). Dwellings and populations in peri-urban settlements (the places in-between urban and rural areas) face an increased bushfire risk (Rauws and de Roo 2011; Bardsley *et al.* 2018). Due to housing affordability and lifestyle choices, these peri-urban locations are attracting an influx of population including tree changers (Bond and Mercer 2014; Paton 2006), a proportion of whom are older people (ABS 2010; Westbury 2021). Researchers have found that people living in peri-urban communities may not fully realise bushfire risk (Bond and Mercer 2014; Bardsley *et al.* 2018; Browne and Minnery 2015) and assume that emergency services agencies will protect them and their homes. This combination of risk, lack of awareness and a growing older population poses significant challenges for communities, service providers and first responders.

Self-preparedness and locally led initiatives are important (Akama *et al.* 2012). Post-bushfire studies have found that self-efficacy (taking the initiative to follow through with a plan of action) is an important variable affecting community resilience (Randrianariosa *et al.* 2021) and, alongside well-informed disaster preparedness, is a key predictor of good recovery. However, research conducted by the Australian Red Cross found that while people were aware of climate-related hazards, only 2 in 5 people interviewed were taking active steps to prepare for the next fire season and less than 50% of participants in bushfire-prone areas thought their community was ready for a future bushfire event. The research also found that only 20% of participants had identified an evacuation refuge (Randrianarisoa *et al.* 2021). Other studies have found that bushfire plans created did not correlate with actions taken in a fire event. For example, despite an intention to leave to avoid a bushfire, respondents reported that they delayed leaving until it was too late or stayed to defend their property (Strahan and Gilbert 2021a; Strahan and Gilbert 2021b). This is a complex and confounding set of challenges.

Communicating warnings and preparedness

Whittaker *et al.* (2020:2) state that:

> *…a good warning message is distinguished from a poor one by its content – including information about the nature, location, guidance, time, and source of the hazard or risk – and style – including its specificity, consistency, accuracy, certainty, and clarity.*

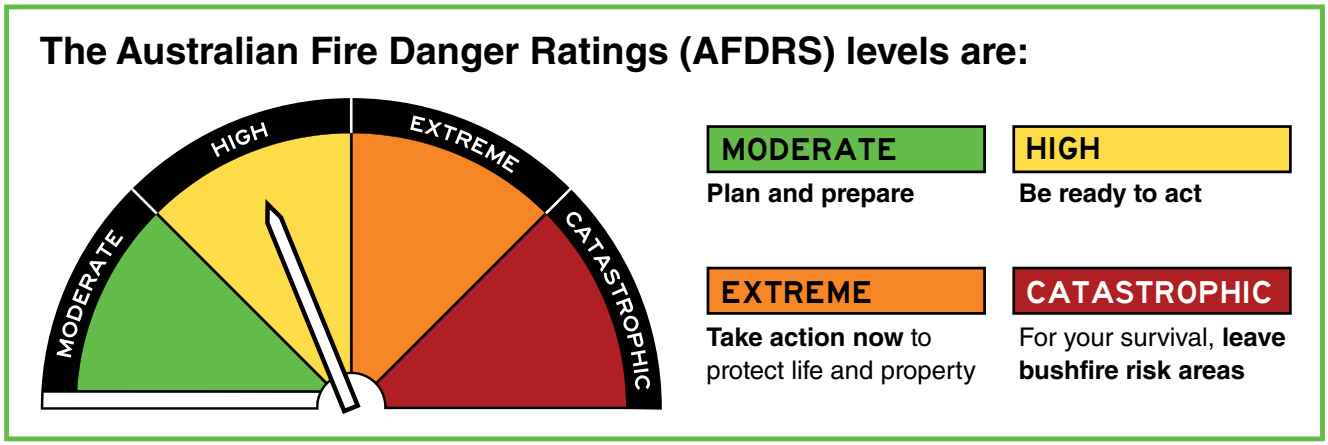
After the bushfires in 2019–20, numerous submissions to the Royal Commission into National Natural Disaster Arrangements by several state governments (Western Australia, Queensland, Victoria and New South Wales) and the Bureau of Meteorology identified inadequacies in both the national bushfire warning system and community messaging (Commonwealth of Australia 2020). Specifically, concerns were raised about the inconsistency of hazard rating levels between states and the lack of clarity in advice issued to the public about when to leave (Commonwealth of Australia 2020).

Recommendations of the royal commission specifically addressed the need for a nationally consistent fire danger rating system. Recommendation 13.2 (Education on the Australian Fire Danger Rating System) called on state and territory governments to provide education on the rating system, including the potential danger and associated actions for each rating (Commonwealth of Australia 2020).

Bushfire messaging and communication

On 1 September 2022, an updated Australian Fire Danger Rating System came into effect. The system is a 'simplified, action-oriented fire danger rating system' to 'improve public safety and reduce the impacts of bushfires' (AFAC National Council for Fire and Emergency Services 2023). Its stated benefits include improved information and communication, better decision-making tools and a 'truly national system'. It has 4 ratings, each with an associated action (Figure 1).

It should be noted that until the 2009 Black Saturday bushfires in Victoria, the danger rating approach emphasised preparation and having 'pre-defined triggers' indicating when to leave (Handmer *et al.* 2019). The current approach to bushfire planning has shifted and greater emphasis is on people leaving.



Moderate	**Plan and prepare** Most fires can be controlled. Stay up to date and be ready to act if there is a fire.
High	**Be ready to act** Fires can be dangerous. There's a heightened risk. Be alert for fires in your area. Decide what you will do if a fire starts. If a fire starts, your life and property may be at risk. The safest option is to avoid bushfire risk areas.
Extreme	**Take action now to protect your life and property** Fires will spread quickly and be extremely dangerous. These are dangerous fire conditions. Check your bushfire plan and ensure that your property is fire ready. If a fire starts, take immediate action. If you and your property are not prepared to the highest level, go to a safer location well before the fire impacts. Reconsider travel through bushfire risk areas.
Catastrophic	**For your survival, leave bushfire risk areas** If a fire starts and takes hold, lives are likely to be lost. These are the most dangerous conditions for a fire. Your life may depend on the decisions you make, even before there is a fire. Stay safe by going to a safer location early in the morning or the night before. Homes cannot withstand fires in these conditions. You may not be able to leave, and help may not be available.

Figure 1: Australian Fire Danger Ratings and advice for each rating (AFAC National Council for Fire and Emergency Services 2023)

Leave early messaging

Each Australian state and territory is responsible for producing its bushfire messaging in line with the Australian Fire Danger Rating System. Emergency information and warnings are communicated in numerous ways, including roadside signs, websites, social media, traditional media outlets, mobile apps and text and voice messages (Commonwealth of Australia 2020). Using a variety of communication methods is intended to increase message reach to a wide audience (Commonwealth of Australia 2020; Mehta *et al.* 2022).

Ahead of catastrophic bushfire days, the message issued by all governments is that the safest course of action is to evacuate from places that are at risk to safer places. This is 'leave early' messaging. The intent of leave early messaging is that residents leave their place of residence before the risks of the fire grows too great.

Communicating bushfire risk on catastrophic-rated bushfire days has some identified problems and there is difficulty of achieving leave early responses from at-risk communities (Bardsley *et al.* 2015; Government of South Australia 2020). For example,

there may be a misinterpretation of the leave early message by receivers as the message is deemed to be relevant only once a bushfire has started. During the bushfire, the 'leave early' message is not heeded sufficiently by communities. Research on previous catastrophic bushfires found that residents failed to leave early due to a lack of the observable bushfire threat; residents were relying on signs of smoke or flames to prompt their evacuation (Johnson *et al.* 2012; Thornton and Wright 2012; Trigg *et al.* 2015). The realisation by residents that they should have left sooner often came too late (Whittaker *et al.* 2020; Government of South Australia 2020a).

The Royal Commission into National Natural Disaster Arrangements and other state enquiries and reviews report challenges caused by poor communication and imprecise messaging. Late evacuation created traffic congestion on roads, threatened the safety of evacuees and posed challenges for responding ground crews (Commonwealth of Australia 2020).

Older people and acting on leave early messages

Older people can be vulnerable during emergency events for reasons related to reduced or impaired mobility, lack of social support, decreased physical capabilities and loss of independence (Halcomb *et al.* 2022). In addition, older people may have limited access to communication technology that can limit their exposure to disaster-related apps and warning systems (Howard *et al.* 2017). Many information providers are increasingly transmitting bushfire messaging through websites, social media and mobile apps. Notably, there is an observed digital technology gap, with many older people less willing to embrace technologies (Hill *et al.* 2015; Knowles and Hanson 2018; Wilson *et al.* 2023; Suhaimi *et al.* 2022). Many are unable to access internet-based and mobile phone messaging (Fountain *et al.* 2019). According to Akama *et al.* (2012) and Trigg *et al.* (2015), older people may find print-based bushfire information to be 'excessive' and difficult to interpret and apply to their own situations. Information packages delivered to households of older residents have been found 'unopened and unused' (Akama *et al.* 2012). So, for older people, planning for bushfires is likely to be more complex than for others in the community (Cooper *et al.* 2020; O'Neill and Handmer 2012). In the event of an emergency situation, households comprised of older residents tend to rely on television or radio and have a preference for telephone calls to a landline (Fountain *et al.* 2019; Howard *et al.* 2017).

Given these observations and personal preferences, the existing approaches to communicating bushfire warnings to older people and encouraging a leave early response requires approaches that cater for their abilities and preferences. Analysis by Akama *et al.* (2012) of communication models indicated that it is crucial to adapt messaging to suit community needs and to emphasise community agency. The future research agenda needs to examine the contribution that older people can make to communication as co-constructors of community resilience, rather than passive consumers of messaging (Beilin and Paschen 2021).

Conclusion

Given the circumstances and expectations of older people regarding bushfire preparation and planning, a research agenda into specific needs of older people should consider effective communication and education approaches.

Research should be conducted with, rather than simply for or about, older people. This is an important aspect to address research gaps and incorporate the strengths, knowledge and abilities of older people in the community into solutions that can better inform local government and bushfire emergency response efforts.

Identifying ways that will encourage and facilitate older people to leave early on a catastrophic bushfire day may improve the resilience of older people living in hazardous areas. Improved leave early messaging and action will also support ground crews that have fewer residents requiring their assistance when fighting fires. For vulnerable citizens, early evacuation poses considerable challenges. Older people are an under-researched group regarding disaster preparedness and response. There are specific considerations relevant to this cohort that need to be addressed within bushfire messaging and communication.

Existing bushfire planning guidance materials issued by firefighting authorities reveals ambiguity and lack of precision around leave early messaging. This is particularly problematic for older people who have mobility issues, lack transportation or are reliant on home support services. For these people, leaving early is complicated. Existing guidance materials do not include specific advice on how this complexity might be navigated (see CFA 2021; DFES n.d.).

There is a place for a deeper analysis of the communication materials distributed by emergency services organisations specific for older people and an investigation into the barriers to leaving early could be investigated.

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Fire and Emergency New Zealand delivers its research and evaluation strategy

Edward Langley

Fire and Emergency New Zealand

In 2022, Fire and Emergency New Zealand published its first *National Research and Evaluation Strategy 2022-2032*.[1] But what was the reason behind this and how does the strategy support the organisation?

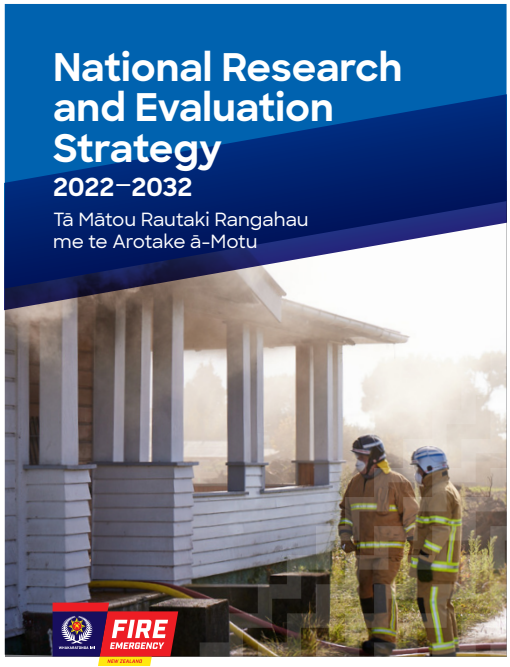
Fire and Emergency New Zealand's legislation highlights the importance of evidence-based services and we use research and evaluation (alongside other approaches) to uncover the evidence we need. This could be evidence on how we can increase the diversity of our workforce through to what works in terms of community recovery. At Fire and Emergency New Zealand, Te Ao Mārama is the team responsible for producing this evidence. This includes research, evaluation and library services.

The name, Te Ao Mārama, comes from a Māori term that is commonly delivered in oratory, *'Ki te wheiao, ki te ao Mārama'*. It has its genesis in the Māori creation story and refers to the transition from darkness into light; from a place of uncertainty to certainty.

In 2021, it was decided that Te Ao Mārama should lead the development of a national research and evaluation strategy so that Fire and Emergency New Zealand could have greater confidence that the evidence we produce feeds into organisational priorities. Ultimately, this is about getting greater impact and value from our investment in research and evaluation. This is more important than ever in a more financially constrained environment.

How the strategy supports the organisation

The strategy provides 2 clear outcomes. Firstly, it provides a set of principles for research and evaluation by which we can hold ourselves to account. Secondly, it gives a set of priority areas to focus our efforts on. We expand upon each of these below.



During the strategy development, we agreed on 3 guiding principles for this work, being useful, usable and used. They may sound familiar to you if you have seen the AFAC *Research Strategy 2022-2027*[2], but they were created independently of AFAC. But what do we mean by useful, usable and used?

Useful means that the research and evaluation we produce provides the right information at the right time for decision-makers. We need to ensure we're asking the right questions, which means working closely with stakeholders and end users to understand the big decisions that are coming for the organisation. It also means that when we

are scoping a research or evaluation project, our focus is on the business problems or decisions being made before we consider what the research and evaluation questions are.

Usable means that we produce research and evaluation in a timely and accessible way. Fire and Emergency New Zealand uses plain English in its reports and different media to communicate the evidence in ways that work for end users. This includes using methods like sense-making sessions, storytelling, interactive slide decks and presentations to provide engaging and relevant outputs for the organisation.

Used means that a key measure of the success of research and evaluation investment is that outputs are used as part of the evidence base in decision-making. Fire and Emergency New Zealand is committed to evidence-based decision-making, which means both decision-makers and those involved in creating evidence have a role in ensuring this happens.

Having these principles has enabled Te Ao Mārama to hold ourselves to account. They have formed the basis of the impact reviews we complete with internal stakeholders following delivery of a project and to evaluate the services we provide. In addition to the 3 guiding principles, the strategy has enabled Fire and Emergency New Zealand to identify 5 priority areas for investment in terms of research and evaluation:

- Our people - people are the most important resource for our organisation. People are our biggest investment and it is our people who deliver outcomes for communities. Useful and usable insights help us plan for a sustainable, adaptable and responsive workforce that is safe and prepared in an increasingly complex operating environment.
- Our communities - we strive to make our decisions closer to the communities we serve in line with the organisation's broader direction and for everyone to know what decisions they are accountable for. This helps our communities prepare for, respond to, and recover well from emergencies. Integrating research and evaluation insights with our community engagement processes allows us to support communities to become increasingly resilient by reducing their vulnerability to threats.
- Our risks - keeping pace with change means we must identify opportunities to help achieve our strategic priorities. We maintain awareness of current and emerging risks that could impact on our ability to provide valued and trusted services to communities. Research and evaluation provide evidence for the insight and foresight that underpins our awareness of future trends that are relevant to our success.
- Our commitments - we work with Māori as *tangata whenua* (people of the land), improving our environmental performance and creating a fairer workplace. Research and evaluation provide insights into how we can meet these commitments and carry out our responsibilities as a provider of emergency management functions and regulatory compliance responsibilities, openly and with integrity.
- Our organisation - responsiveness to communities is integral to our ability to protect and preserve lives, property and the environment in a changing operating environment. Evidence and insights from research and evaluation, combined with incident data and community feedback, informs how we adapt our capability so that our services are trusted and valued, now and in the future.

The strategy has provided the Te Ao Mārama team with a useful lens through which to view its work and focus its efforts.

To find out more about the strategy or research and evaluation at Fire and Emergency New Zealand, contact reserach@fireandemergency.nz.

Endnotes

1. *National Research and Evaluation Strategy. At: https://portal.fireandemergency.nz/assets/FENZ-documents/Fire-and-Emergency-National-Research-and-Evaluation-Strategy-2022-32.pdf.*

2. *Research Strategy 2022-2027. At: https://www.afac.com.au/docs/default-source/ru/afac_research-strategy_final_v1-0.pdf?sfvrsn=2.*

Connecting learning from a world of emergency experience

Peter Grzic

RedR Australia

In October, RedR Australia invited professionals with diverse experience in both the Australian emergency management sector and international humanitarian assistance to share what lessons can be drawn from these different contexts.

The workshop, held in Naarm (Melbourne) on Wurundjeri Country, brought together disaster and crisis response practitioners from a wide range of disciplines. Participants were drawn from RedR Australia's vast network of humanitarian deployees and trainers who had experience working and volunteering with organisations including AFAC, Australian Red Cross, Country Fire Authority, Emergency Management Victoria, Fire Rescue Victoria, State Emergency Services, Victoria Police, and state and local governments.

RedR Australia's CEO Dr Helen Durham said the workshop provided an opportunity to share knowledge across agencies and disciplines.

'The emergency sector in Australia delivers valuable work. As international humanitarians, we have also seen great examples of disaster management from around the world. So today has been all about bringing together diverse views', she said.

Interactions were lively, with many participants recognising the need for knowledge sharing and discussion in this area. There is an appetite for further opportunities to unpack transferable lessons between international humanitarian practice and the Australian experience.

Starting the conversation

An exploratory approach gave participants the opportunity to shape discussions. An online survey was circulated prior to the workshop to identify areas of interest for participants and the greatest opportunities for learning.

Throughout the workshop, participants worked in small groups and engaged in open discussion on their chosen topics. A series of facilitated discussions and prioritisation exercises were then applied to refine and define key lessons and recommendations.

RedR Australia will share these findings to support continuous improvements for emergency responders and the communities they work with.

Themes and recommendations

People-centred approach is best practice

Affected people should always be placed at the centre of humanitarian action, with a heavy emphasis on the need for community participation and ensuring responders are held accountable by the people they seek to assist. This emphasis draws on core humanitarian principles of humanity and impartiality, and a human rights-based approach that recognises that the inherent dignity of affected people and the right to minimum standards of assistance.

This contrasts with the evolution of Australian emergency management practice and its traditional emphasis on hazards and immediate response. Investment in training, resources and standardised coordination systems for response should be balanced with relief requirements and ensuring that the needs of affected people are met.

Some reflections and recommendations:

- While communications to the public are generally effective in Australia, greater emphasis on 2-way communication and engagement would benefit the response. This will empower communities to act, contribute and hold responding agencies to account.
- More humility before community is needed and a greater willingness to learn from experience, knowledge and practices of First Nations peoples. This includes the need for 'slow-listening' to build relationships and trust.

The workshop was a forum for discussions between people in the humanitarian and emergency management sectors.

Image: RedR Australia

- There is a need for better cultural competency and inclusion practices. Response and relief efforts need to genuinely improve engagement with multicultural communities and consideration for people living with disability. This is something that humanitarian practice continues to prioritise across all roles and through dedicated projects.
- Replicate the coordinated assessment and analysis of affected people's immediate and longer-term needs. This is a standard process in both humanitarian and domestic emergency management in other countries that includes the diverse needs of affected people and makes the collection of sex, age and disability disaggregated data a standard.

Enhanced contribution from non-government organisations

The Australian emergency management sector is characterised by strong government leadership at all levels with formal plans laying out detailed roles and responsibilities. While these characteristics are generally positive, they can limit the participation of non-government organisations and the community.

The rigidity of a hierarchical approach to emergency management can inhibit meaningful input from the non-government sector that has a great deal to offer, such as connection to community, international experience and a diversity of perspectives.

An empowered and coordinated non-government role in Australian emergency management could foster increased flexibility and innovation through diverse expertise and stronger connection to community. It could also create an imperative for consistent approaches, particularly to relief and recovery, as non-government organisations work across many communities could advocate effectively for harmonisation.

Additional recommendations:

- A shift in the coordination of relief and recovery is needed away from the traditional hierarchical command-and-control structures used in response operations (e.g. AIIMS) towards inclusive, systems-based approaches that allow for meaningful participation of non-government organisations and communities.
- Stronger coordinated advocacy from non-government organisations is needed. Speaking with one voice (e.g. through the Australian Council of Social Services and state or territory bodies), non-government organisations can advance best practice accrued from domestic and international experience.
- Improving emergency management training and systems for non-government organisations not typically playing key roles in the emergency management sector will strengthen their ability to meaningfully participate. Similarly, community-focused government departments and agencies would benefit from specialised training.
- Improve mapping of government and non-government organisations in preparedness to better understand available resources and services.

Relevance of extensive global standards and resources

Humanitarian organisations have developed a range of international standards and guidance documents that could be valuable in the Australian context. To date, this extensive pool of resources has been left largely untouched. Workshop participants related stories of Australian agencies paying for the development of guidance that replicated resources that already existed in multiple languages.

The international nature of these resources means they are designed to work in diverse contexts and require little or no adaptation for use in Australia. The most significant barriers seem to be awareness of their existence and differences in terminology, both of which can be easily overcome.

Similarly, standardised tools and approaches to inter-agency coordination and information management for relief and recovery are also available. These typically place an emphasis on open and transparent access to information for all agencies at all levels, which enables a decentralised approach to situational awareness and decision-making.

Existing international guidance, standards and resources are available, and have direct relevance to Australian emergency management covering:

- communication and accountability to affected people, including with people from different cultural and linguistic backgrounds
- community participation and feedback mechanisms
- evacuation centre management and other services for displaced people
- minimum standards for relief assistance
- inter-agency information sharing and coordination tools
- coordinated, inter-agency needs assessment and analysis
- surge capacity systems, standards and frameworks
- role of the military in emergency response and relief
- training, simulations and preparedness for relief operations
- ensuring safety and wellbeing of children and other vulnerable groups
- addressing sexual and gender-based violence in emergencies and response operations
- psycho-social support for people affected by crises
- integrating gender, disability, age and environmental considerations
- planning and delivering assistance in dynamic contexts with unclear timelines
- legal and institutional preparedness to receive international assistance.

Moving forward

The workshop was initiated by RedR Australia and the findings and recommendations will be used to guide further work to connect and learn across the emergency management and international humanitarian sectors.

The recommendations identified by participants as being the most important and most easily adopted in Australia:

1. Promote the use of global standards and guidance within Australia.
2. Introduce coordinated assessment of the needs of affected people, based on a recognition of the diversity of the population and the holistic impact of the emergency.
3. Improve and expand emergency management training for organisations not typically involved.
4. Improve situational awareness for relief and recovery by using inter-agency information management tools and systems used in humanitarian response.
5. Strengthen coordinated advocacy from the non-government sector through dedicated forums that promote learning from international experiences.

Workshop coordinator Peter Grzic was excited to bring together experts with valuable experience.

‘Today, lots of people commented that this is a much-needed forum, so I’m hoping this will be the start of a long journey of knowledge sharing’, he said.

RedR Australia trains and deploys technical experts to support humanitarian operations around the world. With more than 30 years’ experience as a humanitarian organisation and a stand-by partner to the United Nations, RedR Australia builds greater knowledge and learning between the international and domestic emergency management sectors. This workshop demonstrated that there is more to say and more to learn.

Workshop participants shared experiences and lessons to identify further work.

Image: RedR Australia

Indo-Pacific Cooperation Network: showcasing Japan's disaster readiness and resilience

Gabriel Scomazzon

AFAC

In September 2023, the Australian Institute of International Affairs and the Japan Foundation hosted a week-long program in Japan for the Indo-Pacific Cooperation Network. The research tour and policy roundtable brought together a group of early-career disaster resilience practitioners from the Indo Pacific region.

Over the course of 12 months, the 2023 cohort of the Indo-Pacific Cooperation Network will focus on specific social and policy aspects of disaster resilience, and ultimately work to establish a piece of research as the end product from a series of tours and meetings across Japan, Australia and the South Pacific.

For the initial phase of the program, I joined 14 other early career practitioners from Australia, Japan, the Pacific Islands, Southeast Asia and America who met in Japan for a series of research tours, meetings and site visits. With disaster resilience as the focal point, we assessed how Japan prepares for, responds to and recovers from disasters that have struck in the past and preparations for future events. I was privileged to present on the work being done by AFAC, such as community preparedness and the Australian Fire Danger Rating System and the AFAC National Resource Sharing Centre including resource-sharing developments, and deployment activity.

Japan historically has been affected by multiple major earthquakes and tsunamis. This is due to its proximity to the Ring of Fire, a region that traverses the rim of the Pacific Ocean and the site of many volcanic eruptions and earthquakes every year. Due to this geography, Japan serves as one of the most tectonically active places on Earth. For context, every year Australia records on average 100 earthquakes that reach magnitude 3 or greater. Japan experiences between 1,500 and 2,000.

Attending the Cabinet Office Dialogue on Disaster Risk Reduction.

Image: Gabriel Scomazzon

Visiting the site of the former local disaster management building at Minamisanriku, epicentre of the Tohoku Earthquake.

Image: Gabriel Scomazzon

While statistics like this may be daunting for international observers, in Japan it has become embedded in daily life. News broadcasters run monthly simulations to prepare for these events. Citizens receive daily alerts via apps and television. Tourists receive safety information as part of tours around the cities. Disaster response is embedded into the Japanese psyche.

Australia's history is marked by events such as 2019–20 bushfire season, Black Saturday (2009) and Ash Wednesday (1983). Equally, Japan has certain key events that are seared into memory: notably the Great Kanto Earthquake (1923), Typhoon Ise-wan (1959), the Great Hanshin-Awaji Earthquake (1995), and the most recent Great East Japan Earthquake or Tohoku Earthquake (2011).

It was the latter that served as the backdrop for our visit, as the impacts continue to echo through Japanese society and inform policymaking and emergency response procedure to this day. We may have our own statistics around the recent 2019–20 bushfire season event, but for Japan, this was the fifth most powerful in the history of seismology. It knocked the Earth 6.5 inches off its axis. It physically moved Japan 4 metres closer to America.

When speaking to cabinet officials, media organisations and civil society groups about the earthquake response, the study group observed a shared resolve to honour the memory of those who had died by responding more effectively next time. Impacted sites were preserved to support this. For example, a school damaged by the Tohoku Earthquake has been frozen in time and space, rooms torn open, chalkboard remaining on walls and grass beginning to grow through the cracks. To outsiders it was confronting and sorrowful, but Japanese school groups would flow around us, learning about what had occurred and the changes that followed.

Such changes have been rapid and profound, with each disaster event adding further layers to Japan's overall response procedures. The country has a highly centralised government

Souvenirs from Australian international assistance in the wake of 3/11.

Image: Gabriel Scomazzon

structure and during an emergency command and control is reliant on a federal 'top-down' model. At present, their protocol dictates that within 120 minutes of a disaster occurring, the Cabinet Office dispatches a Cabinet Office Survey Team and establishes an on-site disaster management headquarters. The headquarters is comprised of the Prime Minister and all ministers of Cabinet to ensure one unified decision-making point.

Actions like these are possible because of the existence of Japan's *Disaster Countermeasures Basic Act* (1961), which provides a comprehensive strategic disaster management system that is reviewed and revised following each subsequent major event. Japan has also legislated a Disaster Management Operation Plan (for each government agency/organisation), a Local Disaster Management Plan (for each prefectural Council) and a Community Disaster Management Plan (established between residents and businesses on a voluntary basis).

Support mechanisms exist in the form of Japan's National Police Agency, Fire and Disaster Management Agency and Japan Coast Guard. The Self-Defence Forces (SDF) (equivalent to the Australian Defence Force) are also engaged. In contrast to Australia's disaster arrangements, Japan has empowered its SDF to respond to domestic disaster relief as a core responsibility. This means they are mandated to have a certain amount of personnel, vehicles and equipment on standby and as a result have established capability zones across Japan.

In a manner similar to Australia's international resource-sharing arrangements, Japan has recently signed a Reciprocal Access Agreement with Australia and has standing agreements with 8 other countries. These agreements function as military agreements to provide a legal framework for greater defence cooperation between the Australian Defence Force and the SDF during times of crisis.

There were many other elements to Japan's preparedness, response, and relief efforts that were canvassed during our trip, however it was fitting that our final day closed with us learning about local community. The importance of reaching out to a neighbour, or helping at a local recovery centre, are universals that Japanese society has embraced as a matter of survival, but they are also principles the global community could and should embrace.

Safeguarding crowded spaces against terrorism

Milad Haghani

University of New South Wales

Crowded places are susceptible to terrorist threats, necessitating proactive safety measures encompassing legislative action, risk assessment mandates and heightened public preparedness.

The global community has seen a notable upsurge in population growth, accompanied by a heightened enthusiasm for events and mass gatherings, particularly in the post-pandemic era. While these shifts undeniably enrich the vitality of communities, they simultaneously introduce novel security and risk management challenges.[1] Australia, akin to numerous other nations, has encountered a heightened interest in events and mass gatherings. The successful hosting of the Women's FIFA World Cup is an example of Australia's embracing of such collective events and gatherings.

Festivals, sporting events, concerts and public celebrations draw large crowds. However, the volume of people and the significance of these gatherings make it crucial to assess and address their inherent risks. Crowded spaces have become potential targets for terrorism, necessitating a comprehensive approach to assess and mitigate associated risks. Throughout history, there have been numerous incidents where crowds became targets of violence and terrorism. Tragic events like the 2002 Bali bombings, the 2015 Paris attacks and the 2017 Manchester Arena bombing serve as stark reminders of the vulnerabilities associated with crowded spaces.

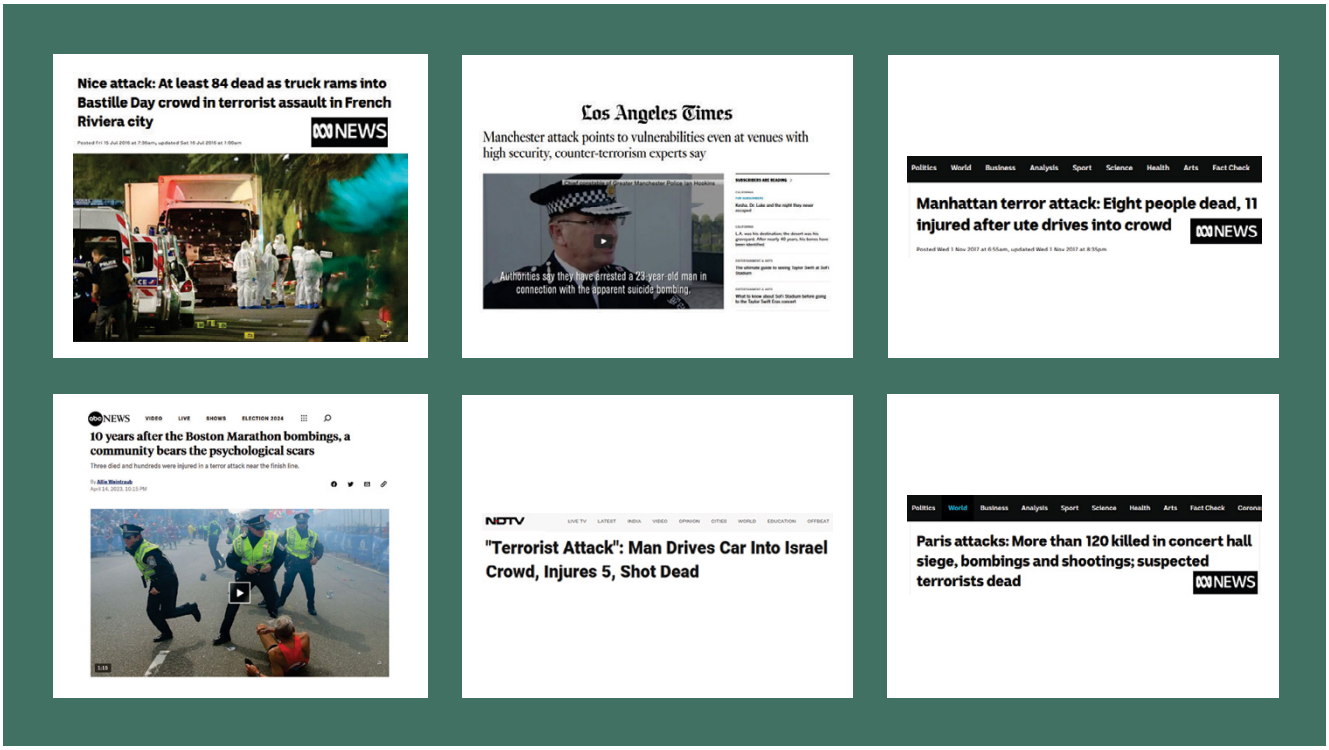
According to the Global Terrorism Database[2], nearly 150 terrorist attacks have been identified against concerts, festivals and mass gatherings between 1970 and 2019.[3] The potential risk is acknowledged in Australia's counter-terrorism strategy 2022.[4]

How legislation can help protect crowded places

Legislation plays a pivotal role in establishing a structured framework to manage and minimise risks within crowded spaces. It provides a basis for risk assessment, contingency planning and resource allocation and fosters a proactive approach to safety. In the United Kingdom, the development of Martyn's Law[5] underscores the recognition for legislative action to enhance crowded space security. Named after Martyn Hett, a victim of the Manchester Arena bombing in 2017, the law makes it mandatory for venue and event organisers to implement thorough security measures. Provisions include the requirement for thorough risk assessments, enhanced communication between stakeholders and the development of tailored security plans.

In Australia, legislation would establish consistent security protocols across various crowded spaces, ensuring that risk assessment, emergency response plans and communication plans are uniform and efficient. Legislative requirements would compel event organisers and venue owners to proactively address security concerns, fostering a culture of prevention rather than reaction. Clear guidelines would facilitate the allocation of resources, both financial and personnel, for security measures that ensure venues are adequately equipped to handle potential threats.

Incidents like the Lindt Cafe siege in Sydney in 2014 underscore the importance of effective security measures. Australia, with its vibrant event culture and propensity for large gatherings, could greatly benefit from enacting legislations similar to Martyn's Law. By doing so, the nation could create a standardised approach to safeguarding crowded spaces. The presence of comprehensive legislation would boost public confidence in attending crowded events.



Crowded spaces have become potential targets for terrorism around the world.

Analytical tools to evaluate and mitigate risks

Security risk assessment mandates bring forth new needs and requirements for event organisers including the need for objective and evidence-based analytical tools. These tools play a significant role in assessing and mitigating risks in crowded spaces. These assessments include several factors or variables:

- Threat environment: This includes analysing intelligence reports, threat assessments and monitoring global and local terrorism trends. Factors such as the presence of known terrorist organisations, previous attacks in the region and geopolitical considerations should be considered.
- Event or venue profile: Factors like the expected attendance, event type (e.g. sporting event, concert, festival), significance or symbolism of the venue and the profile of attendees can influence the level of risk.
- Location and surroundings: The geographical location of the venue or event can inform the risk assessment. Factors such as proximity to potential targets, neighbouring buildings or infrastructure, accessibility of escape routes, proximity to local law enforcement and the local security environment should be evaluated.
- Previous incidents: This includes factors such as past incidents, both terrorist-related and other security breaches, that have occurred at similar venues or events.
- Crowd dynamics and physical layout: Factors such as crowd density, movement patterns, potential bottlenecks and response capabilities of the crowd in emergency situations should be assessed. Understanding how the crowd may behave during an incident can inform risk-mitigation strategies.
- Physical security measures: Evaluating existing physical security measures in place is important. Factors such as the presence and effectiveness of access control systems, surveillance cameras, perimeter barriers and screening procedures should be considered. The assessment should identify any gaps or vulnerabilities in the security infrastructure.
- Emergency response and evacuation plans: Assessing the adequacy of emergency response plans and evacuation procedures is critical. Factors such as the availability of trained personnel, communication systems, medical facilities and the coordination with local law enforcement and emergency services should be evaluated.

A variety of analytical tools can be developed and used concurrently in relation to each event to allow a comprehensive approach in risk assessment and mitigation. Data-driven risk metrics tools can help evaluate the likelihood of an attack. By assigning scores or levels to the risk factor variables, the overall terrorism risk level can be assessed. Using scenario modelling, various hypothetical risk scenarios can be created and analysed. This helps to understand the potential effects of different threats, allowing for the identification of vulnerabilities and the development of appropriate responses. Crowd simulation software can play a role by allowing for virtual testing of emergency response scenarios. The application of

AI-based computer vision systems can also amplify surveillance capabilities by enabling automated identification of anomalies and abnormal behaviour that could lead to early detection of suspicious activities.

The adoption of these protective measures by venue owners and event organisers necessitates 2 steps. First, the development of tools by researchers and experts, and second, the acquisition of tools by organisers, along with the training or hiring of staff who are proficient in using such tools. Alternatively, these tasks can be outsourced to enterprises that are equipped with these capabilities and expertise.

How public preparedness helps build resilience

Public preparedness and community education are layers of protection against terrorism in crowded spaces. Building public awareness regarding potential threats, promoting vigilance and educating individuals about evacuation procedures and the best emergency response can significantly enhance the resilience of individuals and communities. Collaboration between government, security professionals, community leaders and the media can facilitate effective dissemination of such information.

To improve public preparedness and education, governments and organisations can invest in awareness campaigns on crowd safety. Involving community leaders, schools and businesses in these initiatives has potential to foster a culture of security consciousness and resilience. This can be embedded in the general safety education offered at schools, for example. Students can act as 'knowledge vectors', disseminating this crucial information within their community and raising the levels of community preparedness over time.[6] This might ultimately lead to an improved safety culture within communities.

Summary

While Australia is generally considered a low-risk country for terrorism threats, it is essential to recognise that a single incident can have catastrophic consequences. Legislation plays a vital role in establishing a framework for protecting crowded spaces. In Australia, there is a recognised gap in the existing emergency management guidelines concerning terrorism risk assessment and mitigation for crowded spaces. *Australia's Strategy for Protecting Crowded Places from Terrorism*[7] was a major step forward in this direction, but more can be done in mandating risk assessment and safety protection. Martyn's Law is an example of legislation specifically designed to enhance security in crowded public places. The protection of crowded spaces from terrorism requires a holistic approach that encompasses evidence-based and accurate risk assessments and analytical tools. In implementing these measures, information sharing and collaboration between organisers, professional security teams and law enforcement and emergency authorities will be challenging but crucial. Public preparedness and education can also help build resilience.

Investing in crowd safety measures may entail additional challenges and costs, but it is ultimately an investment in human lives. Research in other contexts, such as road safety, demonstrates society's willingness to incur certain costs to reduce the risk of harm to lives. Further research could quantify societal willingness to pay for enhanced public safety measures in the context of mass events.

Once these capabilities and tools are developed locally and become standard practice, they have the potential to significantly enhance public safety. This expertise can also be leveraged globally; showcasing the role of Australian experts and companies can offer in providing enhanced security measures. This export of knowledge and solutions to regions with potentially higher risks of terrorist attacks can contribute to bolstering global safety standards. By fortifying its public spaces with comprehensive security solutions, Australia will reduce the attractiveness of its events as targets for terrorists and malicious actors. Such a deterrent reinforces the benefits of investments in public safety.

Endnotes

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Resilient Australia Awards celebrate inclusivity and innovation

Alana Beitz

Australian Institute for Disaster Resilience

The winners of the Resilient Australia Awards were announced in Perth on 22 November, recognising recent efforts and new ideas that build community resilience to disasters.

The Resilient Australia National Award Ceremony celebrated winning and highly commended initiatives over 6 award categories – National, Community, School, Local Government, Mental Health and Wellbeing and Photography.

Making emergency planning and risk information accessible and inclusive was a strong theme among the winning initiatives, with projects focused on increasing resilience and preparedness for people with disability, culturally and linguistically diverse communities and young people. Community-led projects were also prominent, empowering a sense of ownership and agency for people as they prepared for and recovered from disaster events.

AIDR Executive Director Margaret Moreton said, 'We are inspired by the commitment and consideration of this year's entries across all categories in the Resilient Australia Awards, and the show of support for and within communities, often amid times of uncertainty and change.

'As we advance our efforts to increase disaster resilience across Australia, this year's entries show we are now working to bring more people along the journey with us. This inclusive approach brings us closer to our goal to support safer communities before, during and after disaster', she said.

Now in its 24th year, the Resilient Australia Awards honour initiatives by communities, organisations and individuals that are taking action to reduce disaster risk and build resilience. AIDR acknowledges the Minderoo Foundation for their sponsorship which supported community members to attend the National Award Ceremony.

AIDR Executive Director Dr Margaret Moreton addresses attendees at the 2023 Resilient Australia Awards National Ceremony in Perth.

Image: AIDR

Resilient Australia National Award

Winner - Person-Centred Emergency Preparedness Certificate Course, University of Sydney

This is a world-first program providing actionable guidance on person-centred and capability focused inclusive disaster risk reduction. This co-designed, nationally consistent course has bridged the gap on how to enable responsibility sharing between emergency services, people with disability and the services that support them; demonstrated by significant evaluation results.

Michelle Villeneuve of the Centre for Disability Research and Policy at the University of Sydney said, 'For government and emergency services, disability has been sitting in the too-hard box for a very long time. They have been hungry for the information and a course that allows them to invite people with disability into the conversation'.

AIDR Executive Director Dr Margaret Moreton and NEMA Deputy Coordinator-General Dr Jill Charker present the Resilient Australia National Award to representatives of the Person-Centered Emergency Preparedness Certificate Course.

Image: AIDR

Highly Commended - Delivering community focused messaging in Gurindji language during major NT floods, Bureau of Meteorology and Northern Territory Emergency Services

Interpreters joined emergency services and the Bureau of Meteorology at press conferences for weather events in the Northern Territory to deliver real-time, in-language emergency messaging to remote communities impacted by major flooding. This collaborative approach had success in March 2023 during a major flood event southwest of Katherine.

Darren Johnson from Territory Regional Growth said, 'I'm proud of the fact that we were able to help and assist. We received a lot of feedback from the people who were involved in the event, and that made me feel quite proud that we were able to bridge that language barrier'.

Highly Commended - Flood Resilience in Action: 2022 and Beyond, JDA Co.

JDA Co.'s decade long work in flood resilient design began as a pro-bono grassroots action after the 2011 Queensland floods. The events of February 2022 tested the design, with 50 homes impacted and 45 reporting that the resilience works were successful. This work has become the catalyst for the Queensland and New South Wales governments Resilient Homes Fund programs.

James Davidson of JDA Co said, 'The weekend of the floods in 2022 I was a bit nervous, but within a few hours I started getting texts from home owners saying, "thank you so much'' and "this is working". Quite a lot of people were back in their homes within a matter of days'.

Resilient Australia Community Award

Winner – EMBER, The Flagstaff Group

The EMBER (Emergency Management Backpack Evacuation Resource) program addresses the gap surrounding individuals living with disability and emergency preparedness. It contains free emergency planning resources and emergency 'Go' bags that cater for a range of disabilities. Initially designed for residents in the Shoalhaven local government area of New South Wales, it continues to grow throughout New South Wales.

Belinda Franklin from The Flagstaff Group said, 'Things that I've witnessed is people taking pride and really being empowered about the fact they have a plan, they're using EMBER checklists and the backpacks are a real catalyst for conversations'.

Belinda Franklin of the Flagstaff Group accepts the Resilient Australia National Community Award in recognition of the EMBER project.

Image: AIDR

Highly Commended - CALD Community-Locally Led Risk Reduction Project, Australian Red Cross

This project engaged established, as well as new and emerging, CALD communities to ideate, design and implement locally led and culturally appropriate actions to empower CALD communities to identify their gap in knowledge about emergencies and to co-design localised initiatives to strengthen emergency resilience.

Shanti Ramasundram from Australian Red Cross said, 'The imperative was to consider CALD community voices before, during and after emergencies and place them at the centre of the decision-making around existing emergency management arrangements involving their communities'.

Resilient Australia School Award

Winner - Harkaway Primary Manifesto and Bushfire Safety Committee, Harkaway Primary School

Harkaway Primary School has rewritten the teachers manual. Harkaway students have collaborated with fire agencies, educators and experts to help design, develop and test new approaches to Child Centred Disaster Risk Reduction, and educated university students, presented at conferences and assisted in the development of a research-informed approach to bushfire education.

AIDR Education and Engagement Senior Project Officer Ella Wilkinson presents the Resilient Australia National School Award to Harkaway Primary School Principal Leigh Johnson for the school's project, The Harkaway Primary Manifesto and Bushfire Safety Committee.

Image: AIDR

Leigh Johnson, Principal from Harkaway Primary School said, 'Bushfire awareness has always been a thing here at Harkaway. It's really important for our kids not to simply have some knowledge or facts about bushfire and bushfire safety - but for them to actually be safe'.

Resilient Australia Local Government Award

Winner - Towards Community Led Emergency Resilience, Adelaide Hills Council

A new Community Resilience Team is building strong relationships with the community to become better prepared for future emergencies. As the council's understanding of the community's bushfire experience deepens, it is developing new strategies, processes and operations. This includes staff training and new community programs, events and a dedicated community network.

Miranda Hampton, Senior Community Resilience Officer, Adelaide Hills Council said, 'It's about working with our community so that we can support them as they develop their own initiatives for what they think will actually work best for them, for their disaster preparedness and their recovery'.

AFAC CEO Rob Web presents the Resilient Australia National Local Government Award to the Adelaide Hill Council team for their winning project, Towards Community Led Emergency Resilience.

Image: AIDR

Resilient Australia Mental Health and Wellbeing Award

Winner - Post-Flood Repair and Recovery Initiative, Shedding Community Workshop Inc

Following the February 2022 New South Wales flood event, this small-scale workshop transformed to support hundreds of volunteers to salvage, assess, clean, repair, donate and deliver

flood-damaged items to flood-affected communities. Thousands of items were repaired, saving over 20 tonnes of waste from landfill', and the workshop offered a safe and trauma-informed space for all people to recover.

Sophie Wilksch, Director, Shedding Community Workshop Inc. said, 'It became quite evident to us that at the same time as supporting them with repairs we were also needing to support their wellbeing. There was something that clicked in me where I realised it's not about the repairs, it's about people coming together'.

Joanna Quilty of the NSW Reconstruction Authority accepts the Resilient Australia National Mental Health and Wellbeing Award on behalf of Shedding Community Workshop for the Post-Flood Repair and Recovery Initiative project.

Image: AIDR

Resilient Australia Photography Award

Winner - Unconventional Firefighting, Stephanie Rouse

Armed with only a leaf blower and dropped in the middle of Arnhem Land by helicopter, these Indigenous rangers respond to wildfire like nobody else. These rangers don't receive recognition through service medals, news stories or awards. Seeing their country healthy is why they are there, and why they continue even when times get tough.

Stephanie Rouse from ALFA NT said, 'This photo isn't just about how resilient the workers are working in extreme conditions, it also demonstrates the development of a resilient landscape that is being shaped through long term fire management practices to prevent large-scale bushfires'.

Stephanie Rouse's photograph features on the front cover of this edition of the *Australian Journal of Emergency Management.*

Highly Commended - SA SES Swiftwater Technicians, Jayme Moreland

South Australian State Emergency Service Swiftwater Rescue Technicians preparing to undertake a rescue in freezing cold water, in the dark early hours of the morning. Resilience is the selfless act of volunteers breaking through their body's natural self-preservation response to not want to be in the bone-chilling water, in order to save a stranger's life.

The Resilient Australia Awards are sponsored by the Australian Government in partnership with the states and territories. More information at: www.aidr.org.au/raa.

Jamie Yibarbuk (left) of Bawinanga Aboriginal Corporation is the subject of the winning image in the Resilient Australia National Photography Award, 'Unconventional Firefighting', captured by Stephanie Rouse (right) of Arnhem Land Fire Abatement NT Ltd.

Image: AIDR

Disaster Challenge final showcases innovative solutions in emergency management

Nathan Maddock

Natural Hazards Research Australia

A concept for young people aged 13–18 to take a leading role in disaster resilience in their local area took out the 2023 Disaster Challenge run by Natural Hazards Research Australia in Melbourne.

Youth Guardians was the winning concept by Lydia Wardale. The concept responded to the wicked problem posed by the Disaster Challenge: In the midst of disruption, chaos and calamity, how can resources from across society be accessed and connected in new and innovative ways to improve disaster response and link those who have the resources and supports with those that are most in need?

Lydia, a recent Masters graduate in development economics and public policy economics from the University of Queensland said, 'My solution to the wicked problem empowers teenagers to use their knowledge and experience'.

The inspiration behind the concept comes from Lydia's own experience as a teenager during the 2011 Brisbane floods, where the family home was flooded.

'Youth Guardians would be a youth-led engagement program for 13- to 18-year-olds to cultivate disaster resilience in their local area.

'Youth Guardians would provide young people with knowledge on disaster resilience and climate adaptation, while empowering them to connect and innovate in their communities, building on local strengths and tackling local challenges and adaptation for likely future emergencies', she said.

Lydia Wardale was the Disaster Challenge winner and received the award from CEO Andrew Gissing.

Image: Natural Hazards Research Australia

Disaster Challenge 2023 finalists, from the left: Kathy Tran, Chloe O'Brien, Maya Walton, Dr Catherine Kim, Lydia Wardale, Dr Kate Saunders, Dr Jess Hopf.

Image: Natural Hazards Research Australia

Held on 12 October 2023, the eve of the United Nations International Day for Disaster Risk Reduction, the Disaster Challenge invited early career researchers, undergraduate and postgraduate students to present solutions to the wicked problem. Natural Hazards Research Australia will work with Lydia over the next 12 months to explore her concept further.

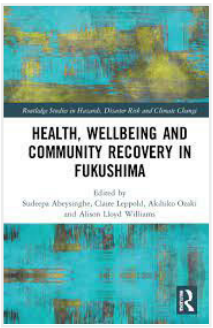
Joint runners-up, Maya Walton, Chloe O'Brien and Kathy Tran, undergraduate students from the University of Technology Sydney, showcased their concept 'Climate Day: Disaster preparedness in high schools', which would build community resilience and emergency preparedness to help alleviate young people's climate anxiety through immersive education experiences with the help of virtual reality.

Dr Catherine Kim from the Queensland University of Technology, Dr Kate Saunders from Monash University/Queensland University of Technology and Dr Jess Hopf from Oregon State University represented their broader team at the final and were also awarded as runners-up for their concept 'Flood vulnerability index for Brisbane City'. The team drew on their experiences of the 2022 flooding in Queensland to tackle the overwhelming amount of data available during an emergency with a concept for an app to give individuals insight into what flooding in their area will personally mean for them and their family.

The Disaster Challenge was adjudicated by an expert judging panel with vast amounts of disaster management expertise, comprising Dr Margaret Moreton, Executive Director at the Australian Institute for Disaster Resilience; Jamie Devenish, Manager Community and Communications at Victoria State Emergency Services and Dr Mittul Vahanvati, senior lecturer in sustainability and urban planning at RMIT University. The day also featured a special keynote from the Australian Red Cross' Andrew Coghlan on the theme for the International Day for Disaster Risk Reduction, Fighting inequality for a resilient future.

The 2023 Disaster Challenge was coordinated by Natural Hazards Research Australia and hosted with support the Australian Red Cross, AFAC, the Country Fire Authority, the Department of Energy, Environment and Climate Action Victoria, Emergency Management Victoria, Fire Rescue Victoria, the Inspector-General for Emergency Management Victoria, Monash University, RMIT University, the University of Melbourne and the Yarra Ranges Shire Council.

Health, Wellbeing and Community Recovery in Fukushima



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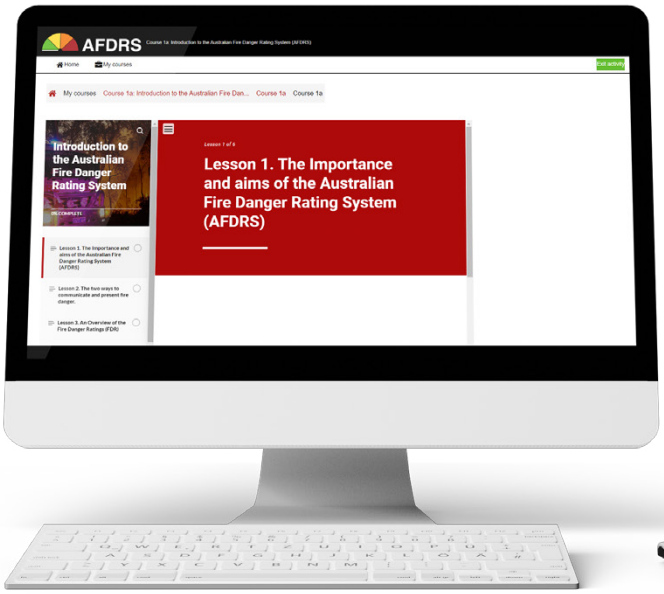
We live in an increasingly uncertain world, where emergencies and disasters are becoming frequent, severe and overlap. Building resilient and hopeful futures requires that we review and redefine our understandings of what disaster recovery is, listen to diverse experiences and learn from the past. This book draws on the Fukushima nuclear disaster in Japan in March 2011, when an earthquake, tsunami and nuclear accident resulted in almost 20,000 deaths and the displacement of hundreds of thousands of people. Since that time, there has been ongoing controversy over the long-term social and health effects of this disaster.

This book is divided into 15 chapters that addresses different aspects of how communities have lived with the legacy of the Fukushima disaster. The list of authors includes Japanese and international researchers, professionals, volunteers and community members; many whom directly experienced the event and the long recovery process.

The book successfully achieves a critical approach to the social aspects of recovery and invites the reader to reflect on how health and wellbeing are influenced by the interactions between social and institutional structures. Chapter 1 helps the reader situate the case of the Fukushima disaster in the field of disaster recovery. This chapter is followed by Part I, focusing on the experience of professionals from the sectors of healthcare (Chapter 2), mental health (Chapter 3), education (Chapter 4) and the law (Chapter 5) who were involved in the aftermath and recovery. Section 2 explores the recovery experiences of communities and living with risk after the event in terms of monitoring radiation levels (Chapter 6), assessing health (Chapter 7) and promoting mental health (Chapter 8). The third section discusses how pre-existing social inequities can obstruct the recovery process. Based on real examples, the book provides in-depth analyses of the influence of gender disparities (Chapter 9), migration status (Chapter 10) and the stigma that the people of Fukushima endured for many years in the media. The fourth section reflects on the complex relationships between community engagement, participation and wellbeing and how these contribute to build hope for the future. The first chapters highlight the importance of acknowledging school children (Chapter 12), volunteers and community members (Chapter 13) as valid and important social actors, while Chapter 14 addresses the challenge of integrating expert and local knowledge to reconstruct and decommission after a nuclear disaster. Finally, in Chapter 15, the editors provide their views on the unique contributions of each one of the previous chapters and emphasise the need to develop understandings about disasters and long-term recovery by drawing lessons from the past and integrating different forms of knowledge. To do this, they propose an interdisciplinary dialogue that includes professionals, decision-makers, researchers and community members from a diverse ages, abilities and backgrounds. In this way, we can develop better ways to protect mental health and wellbeing after complex, cascading or compounding disasters like those experienced in Fukushima and other places in the world.

This book, *Health, Wellbeing and Community Recovery in Fukushima,* is valuable material for any researcher, professional, policy maker or person living with hazard risk. One of the book's greatest strengths is its capacity to integrate, critically and respectfully, the perspectives of authors from different backgrounds, disciplines and lived experiences. In this way, this book succeeds in modelling its message that we should learn from the past through collaborative and inclusive dialogue to build hopeful futures where communities can live with risk in ways that supports community and individual wellbeing.

Australian Fire Danger Rating System Updated eLearning courses



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The AFDRS eLearning update is a collaborative effort between AFAC and state and territory fire agencies, and aims to support users of the AFDRS to adjust to the new concepts, components and products.

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Course 2 – Applying the AFDRS

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