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The *Australian Journal of Emergency Management* is Australia's premier journal in emergency management. Its format and content are developed with reference to peak emergency management organisations and the emergency management sectors—nationally and internationally. The journal focuses on both the academic and practitioner reader. Its aim is to strengthen capabilities in the sector by documenting, growing and disseminating an emergency management body of knowledge. The journal strongly supports the role of the Australian Institute for Disaster Resilience as a national centre of excellence for knowledge and skills development in the emergency management sector. Papers are published in all areas of emergency management. The journal encourages empirical reports but may include specialised theoretical, methodological, case study and review papers and opinion pieces. The views in the journal are not necessarily the views of the Australian Government, Australian Institute for Disaster Resilience or its partners.

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Foreword

Dr Margaret Moreton

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Since the inaugural Australian Disaster Resilience Conference was hosted in Perth in 2018, the event has seen incredible growth in participation and interest. Speakers and delegates are now drawn from all levels of government, the non-government sector, business, philanthropy, the community sector and communities. In 7 years, what began as a small and highly enthusiastic gathering of 80 people in Perth has grown to the sell-out crowd of 600 people we welcomed in Sydney.

Each year, the conference program was curated from a large number of proposed abstracts. The program's diversity and breadth has become a drawcard for delegates and speakers alike. Details about the event can be found on page 153 of this edition of the *Australian Journal of Emergency Management.*

However, this is not the only driver of the event's increasing attendance. The business case for disaster resilience and risk reduction is recognised by increasingly diverse sectors of society including insurance, finance and the economy, the built environment and infrastructure, the natural environment, the health and wellbeing sectors, research and development and the arts and cultural sectors. We have diverse groups involved in this work including Indigenous groups, groups focused on children and young people, gender-diverse individuals and groups and those with disability. Partners of AIDR are diversifying and they are attending the conference because of the value of learning about and sharing risk reduction and resilience expertise.

Broadening our engagement and fostering a sense of ownership for disaster resilience and risk reduction beyond the traditional emergency management sphere is an important shift. The challenge is how we build the capability, the knowledge and the literacy to sustain this. This is the work that AIDR continues to focus on and the work that we were proud to share through this year's conference program.

The Australian Disaster Resilience Conference also had a presence in the AFAC24 exhibition, including the AIDR Knowledge Centre and poster display, Resilience Lane and the AIDR stand. We were heartened to welcome so many visitors to the stand, which was described by visitors as the 'kitchen bench' where people would gather to chat. The team at AIDR are proud to provide this hub of knowledge and connections and will keep the door open to support people working to build resilience and reduce risk.

The door is open for you to connect with us, and for you to connect with each other. Engaging with diverse sectors opens up the diversity of thought and perspectives required to strengthen a systemic approach to our work. By bringing different sectors, parts of society, views and perspectives to the conversation, we can better understand how decisions made in one area impact another, and how our priorities can intersect and support each other.

The AIDR Knowledge Hub continues to be the digital home of knowledge and connection for our stakeholders. It is a national, open-source platform that supports and informs policy, planning and contemporary good practice in disaster resilience and hosts important publications and resources such as the *Australian Journal of Emergency Management,* our Handbook Collection and the Disaster Mapper.

I encourage you to connect with us. Connect with our knowledge and events and connect with each other. Together we will drive the systemic change needed to create a resilient future.

Cyclone Tracy 50 years on: a Christmas unlike before

National Emergency Management Agency

Christmas morning is a time to spend with loved ones, a chance to acknowledge and thank each other and for many children to open presents. However, on Christmas Day 1974, residents of Australia's top end faced the immediate and devastating aftermath of Cyclone Tracy.

This was not the first cyclone to hit Darwin. But this cyclone, and the damage it brought with it, was different as it was one of the most destructive in Australia's history. Tragically, 71 people were killed and over 600 were injured. The cyclone also decimated the area of Darwin, destroying 5,000 homes and countless small businesses.

Christmas of 1974 became a time where, rather than families celebrating together and unpacking presents, they were packing up their belongings and leaving what was left of their homes and working out what came next.

At that time, Major-General Sir Alan Stretton CBE, AO, was head of the Australian Government Natural Disasters Organisation and he oversaw the evacuation of most of Darwin's population. This occurred, in large part, through the use of both military and civilian aircrafts.

This year marks 50 years since Cyclone Tracy and the establishment of Australia's first national emergency organisation.

Creation of the first national emergency organisation

Cyclone Tracy was not the only disaster to occur in 1974. Brisbane also experienced devastating flooding in January of that year. This was brought on by the above-average rainfall across Australia during 1973. The effects of these floods was widespread,

The Darwin suburb of Wagaman was flattened during the cyclone.

Image: National Museum of Australia

including damage to roads, railways, power lines and bridges. The consequences from this event were felt in many ways, including to community connectivity, local economies as well as by first responders.

The events of 1974 highlighted the lack of national coordination for response to and recovery from large-scale disasters. The Australian Government understood that it was not just the immediate damage caused that needed action, but also that people were exposed to hazards following the event. These included hazardous materials, lack of access to clean water and supplies, limited shelter as well as places to safely keep their belongings.

The Australian Government established a body to help the states and territories after extreme events that would support coordination, increase stability, provide funding and consider mitigation for future hazards. The Cabinet created the Natural Disasters Organisation in February 1974 and Major-General Stretton was chosen to lead the organisation due to his wide military experience in World War II, Korea, Malaysia and Vietnam. The organisation was formed within the Department of Defence.

The new agency was initially staffed with 15 people to manage large-scale disasters. The early days was a period of determining a mandate and finding ways to work within existing systems. Only a few months after its establishment, the agency was activated in response to the destruction caused by Cyclone Tracy. It became clear that the organisation was going to be needed on an ongoing basis to support states and territories. This was the beginning of the relationship between Australian governments to improve ways to manage emergencies.

Establishing the Darwin Reconstruction Commission

In February 1975, the Australian Government established the Darwin Reconstruction Commission (DRC) to reconstruct Darwin with the aim of completion within 5 years. This was part of Prime Minister Gough Whitlam's pledge to make 'a determined and unremitting effort to rebuild your city and relieve suffering'. The DRC achieved its goal in fewer than 3 years; an amazing feat considering the extent of the devastation.

While Darwin is a thriving city today, the legacy of Cyclone Tracy remains in the collective memory of those who experienced the event and those who have lived there, or visited, in the decades since.

Continuing the legacy of national emergency management

The Natural Disasters Organisation continued within the Department of Defence until December 1992. It then transferred to the Attorney-General's Department portfolio as Emergency Management Australia (EMA). It was formed primarily to manage severe bushfire-related events and the post-disaster recovery period. The first Director-General of EMA was Commodore Clem Littleton AO RAN.

At the time, EMA was the Australia's primary emergency management agency. It provided national leadership in emergency management that helped to reduce risk to communities. EMA championed that emergency management is a shared responsibility between the Australian Government and the states and territories. As part of this, it coordinated the Australian Government's response to requests for assistance during emergency situations, both in Australia as well as overseas. It also played a major role in education and training for the emergency management sector and improving systems.

Joe Buffone PSM was the last Director-General of EMA and he had extensive experience in security and disaster management, including coordinating and responding to major emergencies in Australia and internationally.

EMA transferred to Department of Home Affairs in 2022 and became the National Emergency Management Agency (NEMA). The agency is the first of its kind, an enduring entity that provides end-to-end support for Australian communities before, during and after disasters, at the national level.

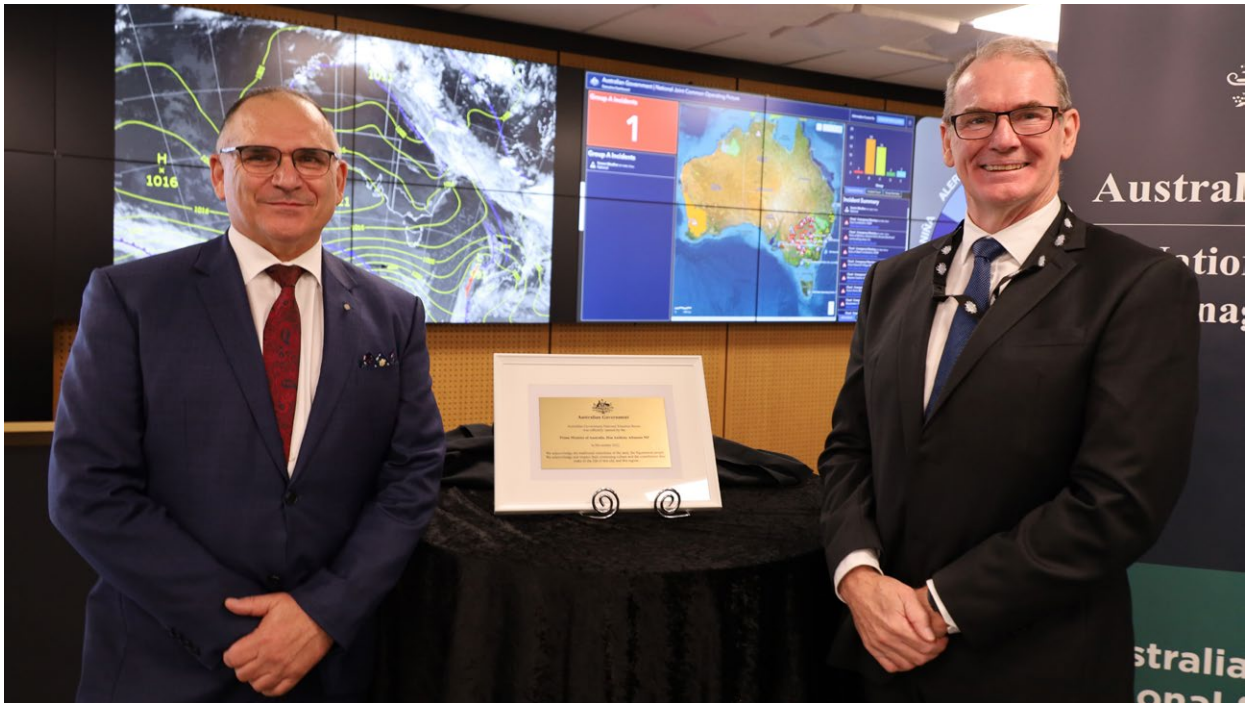
NEMA has completed a second year of operation and it has been a busy 2 years. From compounding and complex disasters in Australia to global geopolitical issues, coordinated emergency management in Australia has never been more important. NEMA is working to:

- improve Australia's emergency management capabilities and resilience
- address legacy challenges, reduce current disaster risks and plan for the future
- enable timely and targeted support Australian communities.

Brendan Moon, NEMA's Coordinator-General said, 'We learnt a lot from the devastation caused by the Brisbane floods and Cyclone Tracy in 1974. This country has experienced many disasters over the last 50 years.

'While the natural and human involved hazard environment has become more complex, we have continued to evolve our capabilities and our partnerships with an eye to the future. Our eyes are firmly on ensuring we have a whole of nation scalable capacity to deal with any crisis and we continue to reduce risk in all we do.

'Agencies like the Natural Disasters Organisation and EMA provided the foundations for our work and we now need to build on that legacy and continue learning and evolving to best serve the needs of communities', he said.



Deputy Coordinator-General, Emergency Management and Response, Joe Buffone AM and Coordinator-General Brendan Moon in the National Situation Room, Canberra.

Image: NEMA

Since July 2022, Australia's Disaster Recovery Funding Arrangements have been activated for 109 disaster events in 316 local government areas, which represents 58% of Australia's 539 local government areas.

Joe Buffone, Deputy Coordinator-General for NEMA's Emergency Management and Response Group said, 'While the states and territories have primary responsibility to respond to disasters, we support them to prepare for, and respond to, nationally significant crises.

'Through data-informed decision-making, we guide national policies, fund projects and can deliver resources to support when the states and territories are stretched beyond capacity.

'We contribute to saving lives, reducing harm and mitigating the consequences of disasters that maintains public trust in the emergency management system', he said.

The future of emergency management

The disasters that devastated Australian communities in the mid-1970s have shaped and influenced the Australian Government's approach to emergency management today. The establishment of a national body to support states and territories has provided much needed resources, coordination and national guidance over the last 50 years.

The scale, complexity and frequency of current and future disaster risks presents challenges to communities globally. Australia is certainly no exception.

The 2022 State of the Climate Report[1] projects Australia will face:

- higher air temperatures and more heat extremes
- longer droughts in the south and east of the country
- intense, short-duration rainfall
- increased number of dangerous fire-weather days and longer fire seasons in the south and east
- rising sea levels
- increased number of marine heatwaves.

The Australian Government builds on the foundations of emergency management in Australia in order to respond to hazards, both now and into the future.

NEMA works to improve how Australia responds to emergencies by helping communities prepare for and recover from future events. NEMA forms partnerships with other international governments to promote a global response to global challenges. NEMA is future-focused and strengthens Australia's ability to recognise disaster risk and build resilience across the country.

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New tactics for a new era: how emergency management needs to change

Professor Daniel P. Aldrich

Northeastern University, USA

Our world has entered an age of shocks and disasters. The number of meteorological high-risk events (such as floods and storms) has been rising and the time between them is shortening.[1] Nations around the world have less time to prepare for new shocks and less time to build the financial, administrative and personnel capacity they need for effective responses.

Australia also faces a new era in terms of shocks and disasters. In recent years, there have been multiple fires (including the Darling Downs and Wanneroo bushfires) as well as Category 5 cyclones (such as cyclones Darian in 2022 and Ilsa in 2023). Flooding alone cost $5 billion[2] in a year that researchers from the Australian National University labelled a 'year of opposites'[3], yo-yoing between wet and dry. Drought and heat pose major health challenges in rural and urban centres as demonstrated by increasing numbers of hospital emergency visits. Australia, like other nations around the world, has entered a new stage of hazards and it needs new tools to manage and respond to them.

For decades, emergency and disaster management has involved top-down, government-centred approaches that prioritise spending on physical and grey infrastructure after disaster events. That is, we wait until bad things happen and spend money on seawalls, fire trucks and building repairs after the shocks are done. But we can break this cycle.

I have worked with a social enterprise for the past several years doing surveys and fieldwork across Australia and have had conversations with hundreds of residents and business owners. We advocate for a bottom-up approach that is centred on community resources, especially social capital (the ties between us), along with the places where that social capital is built. These places and spaces that build connection and trust are known as social infrastructure and they include libraries, parks and pubs.

An increasing amount of qualitative and quantitative data shows that our ties to other people (bonding, bridging and linking social capital) influence if we survive and thrive during crisis events. Research on the 2019–20 summer season bushfires[4] shows that greater social identification with the disaster-affected community, greater continuity of social group ties and greater formation of new social group ties improved outcomes for communities. This finding has emerged from other crises in other nations, including in North America and Japan. How can we build these types of connections between neighbours and other residents?

Parks (linear reserves, cricket grounds, playgrounds), public spaces (community houses, plazas, city halls), places of worship (synagogues, mosques, churches, temples and shrines) and social businesses (coffee shops, video arcades, bowling alleys, bars and pubs) provide spaces where people can connect with others. Our research[5] underscores that these facilities and places facilitate relationships with people from different groups and beyond the typical close family

and friends networks. These bridging ties are the most critical because, by connecting to people different from ourselves, we gain new insights, information and access to resources.

This may sound commonsense. But, during a recent conference masterclass held in Canberra with more than 60 communication professionals from not-for-profit organisations and government agencies, more than half said that their organisations did not consider social capital in their planning (and a handful said they had never heard of the term). Our analyses of spending from a variety of Australian states and cities show that most disaster-related money flows into large-scale grey infrastructure (bridges, roads and trucks) rather than grassroots activities that foster local connections or research that can better map how strong (or weak) connections really are.

The good news is that social enterprise Resilient Ready and I carried out a 'snapshot' project under the Disaster Risk Reduction Fund.[6] We had to go out and rent lots of chairs to make space for a lot of people who wanted to discuss the issue. In talking with more than 70 participants in South Australia at the Adelaide forum, about half stated that social capital plays only a small role in their work in planning for and responding to disasters. The numbers were about the same when we asked our audience if they worked with social infrastructure facilities such as libraries, neighbourhood houses and community centres. The forum showed there is much work to be done.

Positive change requires leaders to 'lean in' and try something new. We recognise and applaud the SAFECOM[7] team in doing just that; putting focus on and funding towards the critical role that people connections and the places where people connect bring to the organisations and institutions that try to keep them safe and thriving during shocks.

Findings from the snapshot project, which included surveys, interviews and forums, identified several recommendations for the South Australian (and Australian) emergency management sector. First, let's embrace and strengthen social capital and social infrastructure in everyday life, not wait for a crisis or disaster to bring people together. Several programs can help build social ties ranging from Neighbour Day to local block parties to more elaborate community currency programs that incentivise volunteering. Next, let's develop a unified definition of 'social capital' and 'social infrastructure' so we can all understand and use common terminology in everyday contexts. Agreeing on its importance and then defining social capital will help organisations in and outside of government to prioritise it.

I invite every government department, emergency services organisation and non-government organisation to share relevant data to bring holistic social capital and social infrastructure measurement to the nation. Let's encourage stakeholders to think differently about their data and how it can contribute to measurement tools and capabilities that will positively change how we prepare and survive future shocks. Ideally, this will let us overlay social capital heatmapping and social infrastructure measurements with risk assessments and vulnerability data.

We cannot make these changes and investments fast enough. In an era of rising temperatures and rising sea levels, we need to help communities be resilient to shocks and disasters. And social capital and social infrastructure can provide low-cost, community-centred ways to do this.

Professor Aldrich visited Australia in March 2023 to work with social enterprise Resilient Ready on delivery of a 'snapshot' project in South Australia.

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THIS ARTICLE INTRODUCES 3 LITERATURE REVIEW PAPERS THAT TOGETHER EXAMINE THE CURRENT PRACTICE, TRAINING AND CHALLENGES OF DECISION-MAKING IN EMERGENCY MANAGEMENT.

The challenges of decision-making in emergency management, the cognitive aids people use and the decision-making training they receive

Peer reviewed

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Introduction

Emergency management is a complex socio-technical system in which people operate in hierarchies of teams (Bearman et al. 2023). At the heart of this system are people making decisions to achieve the best outcomes possible for the community. In this context, decisions are made by individuals and teams based on their situational awareness and goals derived from organisational doctrine, training, norms and values. This is underpinned by cognitive functions of perception, attention, memory and language. Decisions must be executed by enacting or communicating a plan to others and monitored using feed-forward and feedback information.

Individual and team decision-making occurs at all levels of emergency management: from the responders who attend the emergency to the incident management teams that coordinate the response, to teams of senior personnel who make decisions about resources and provide strategic oversight and the executives who consider organisational capabilities and the socio-political context of the organisation's response. Table 1 details the levels of emergency management decision-making. Each of these levels have similarities in the way they make decisions, but also have their own unique challenges and requirements.

For example, a road crash rescue officer must form an awareness of the situation (the potential hazards and the location, nature of entrapment and injuries of patients). They must develop and execute an extraction plan, which may involve relocation of the vehicle, stabilisation, space creation, freeing the patient from entrapment and extracting the patient from the vehicle. Throughout the process information needs to be obtained and decisions communicated to other road crash operators and medical personnel and police so that actions can be coordinated efficiently and effectively.

The incident controller in an incident management team managing a large bushfire must build situation awareness based on potential influences of weather, terrain and vegetation on the fire, the location of critical infrastructure, fire prediction modelling and reports from operators attending the incident. Decisions need to be made about the fire management strategy, the location of resources, road closures, the provision of information and warnings to the public, and the management of incoming resources, all in the context of the predicted fire situation several hours into the future. This requires an effective flow of information into the incident management team and clear and timely communication by the team both internally and externally (e.g. with the police, media, local community and politicians).

Table 1: Levels of emergency management decision-making.

Level	Function	Illustrative example
Executive	Considers the wider socio-political context of the organisation's response, ongoing organisational capabilities, accountability issues and likely consequences.	The organisation's executive management and senior staff from the office of the responsible government minister(s).
Strategic	Defines what to do as the organisation's response to the emergency.	Senior staff from both the organisation and participating agencies at a regional, territory or state incident management centre.
Tactical	Specifies how the response effort is to be carried out.	On-scene or near-scene Incident Controller and multi-person incident management teams, representatives from other participating organisations and agencies.
Operational	Implements the response effort at the scene(s).	On-scene Incident Controller and operational staff in key roles (e.g. safety officer).

Source: Penny (2024b)

Decision-making is a critical part of emergency management and is one of the 7 non-technical skills identified by Hayes et al. (2021). The other non-technical skills are communication, coordination, cooperation, leadership, situation awareness and coping with stress and fatigue. Decision-making has a very close relationship with situation awareness and many authors consider situation awareness to be the 'front end' of the decision-making process (Alison and Shortland 2021; Mosier and Fischer 2010; Tolcott 1992). Communication is closely related to decision-making since others need to be informed of the decisions that have been made and where appropriate involved in the decision process (Hayes et al. 2021). Other non-technical skills, such as leadership, coordination, cooperation and coping with stress and fatigue are also related to decision-making (Paton 2003; Thomason et al. 2024). Effective decision-making requires sound and timely decisions based on an adequate understanding of the situation, a suitable decision-making approach and the appropriate involvement of others in the decision-making process (Hayes et al. 2021).

This edition of the *Australian Journal of Emergency Management* includes 3 papers examining different aspects of decision-making. These papers are designed to assist people working in the emergency management sector. While the papers are all written by members of our research team, each lead author adopted their own approach, method and style as appropriate to address the topic. Each of the papers consider key issues of current concern for emergency managers.

Butler et al. (2024) explores the literature on 3 key challenges for emergency management: stress and fatigue, interoperability and ethical dilemmas. Each area is discussed to explore the nature of these challenges, how these challenges are likely to evolve and what helpful advice can be found to mitigate them. The paper concludes that, to better meet these challenges, organisations need to develop appropriate doctrine and training, develop supportive organisational cultures and learn the lessons of previous critical incidents.

Penny et al. (2024a) describes the types of cognitive aids that have been developed to assist emergency management decision-makers. These aids vary according to their intent and the context in which they are applied. Strengths and limitations of the cognitive aids are discussed. The paper concludes that, while cognitive aids can be useful, they are not a silver bullet for emergency management decision-making. The correct tool (correctly designed) must be correctly applied in the correct context by trained and competent end users.

McLennan et al. (2024) examines emergency management decision-making training and discusses current practice and issues. This review showed that decision-making competence is a depreciating asset that needs to be maintained and that a range of options for training emergency management decision-making exist. The paper argues that it cannot be assumed that participation in emergency management decision-making training will result in improved performance. That can only be determined by appropriate training outcomes evaluation programs. Organisations need to deliver training that is appropriate, accessible, matched to the skills of the tasks, appropriately resourced and methodically evaluated.

The scope of these literature reviews was restricted to research in emergency management or in closely related industries (medicine, military, aviation) that could be applied to emergency management. As with most literature reviews, the decision about what to include and what to leave out was difficult, particularly as we were compiling useable research findings for practitioners. The information that we ended up including in the papers was considered to be the most relevant to people in decision-making roles (career and volunteers) working in emergency management in Australia. There is more literature that

could have been included and each paper could have been considerably longer. The papers try to strike a balance between covering important issues in each of the topics while being succinct enough for emergency managers to read and use.

Collectively, the 3 papers represent a coherent body of knowledge on emergency management decision-making. This provides a concise summary of research findings so emergency managers are better equipped to respond effectively to current and emerging challenges they are likely to face.

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A review of cognitive aids and their application to emergency management in Australia

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Introduction

High-consequence decision-making during highly complex events is a difficult combination of science and art (Penney et al. 2022; Reale et al. 2023; Ingham 2009). Although emergency management practitioners and teams generally have good capability to respond and are adaptive to the demands placed on them, their cognitive resources will at times be stretched by dynamic, uncertain, time pressured and high-stakes events. Fundamental cognitive processes (such as perception, attention, memory, reasoning, judgement and decision-making) can become overloaded leading to task performance that is less fluid, slower and susceptible to errors or omissions. Good systems, training, planning and preparedness help practitioners respond effectively to these incidents. However, they are still very likely to find these events challenging. To assist practitioners in these environments, a number of cognitive aids have evolved and have been adopted by individuals and organisations alike.

The term 'cognitive aid' was first used in the 1970s and was initially used to describe decision-support systems (McLaughlin and Byrne 2020). In the 1980s, cognitive aid was used to describe various tools and systems that supported other cognitive processes (Reason 1987). For the purposes of this paper, we use an expanded version of the Marshall (2013) definition of cognitive aid to encompass a broad range of tools used to support the operational performance of individuals and teams working under pressure. This definition goes beyond Marshall's (2013) task focused aids to include decision models, frameworks and systems; checklists, aide memoires, standard operating procedures and standard operating guidelines.

This paper reviews the literature on the different cognitive aids that are or could potentially be used in emergency management with the aim of providing more clarity about what cognitive aids are and how they can be used to support complex task performance in emergency management.

Abstract

Decision-making in disasters and major crises faced by emergency services globally is a difficult combination of science and art to master. To assist decision-makers in these environments, a number of cognitive aids have been developed and subsequently adopted by individuals and organisations alike. However, these aids vary according to their intent and the context in which they are intended to be applied. This review explores the use of cognitive aids in the context of emergency management and explores how existing knowledge regarding the use of cognitive aids from other industries may be translated to emergency management. An iterative literature review of academic and industry material related to cognitive aids during incident and crisis response across a broad range of international emergency service and other industries within the last 20 years was completed. Ultimately, cognitive aids are not a silver bullet when it comes to decision-making in the emergency management context. The correct tool (that is correctly designed) must be correctly applied by trained and competent end users. The Australian emergency management sector may benefit from future research exploring how these existing tools adhere to the good practice principles identified in this study.

Various attempts have been made to categorise cognitive aids, either based on the cognitive processes needed to complete the task at hand (McLaughlin and Byrne 2020) or based on their methods and target outcomes (Fletcher and Bedwell 2017; Burian et al. 2018). In this paper, we adopt a modified version of the Burian et al. (2018) taxonomy and classify cognitive aids according to their purpose and intended application (prior to, during or after an event). Figure 1 shows this taxonomy, with the distinction between the extent to which they are:

- primarily cognitive or behavioural in nature (vertical axis)
- primarily intended for individual or team application (horizontal axis)
- primarily intended for use prior to, during, or post an event (colour coding).

We acknowledge that these are artificial distinctions, but they are useful to discuss cognitive aids and can help direct emergency management practitioners to the right type of cognitive aid depending on their needs and circumstances. Each of the tools is discussed in relation to this taxonomy in 5 categories that emerged as the review was completed. The categories are:

- decision process and behavioural tools
- tools to support analysis
- checklists
- operational procedures and guidance
- cues and alarms.

Method

This study involved an iterative literature review to identify academic and industry material related to cognitive aids during incident and crisis response across international emergency services and other industries over the previous 20 years. The review provided a narrative synthesis of the use of cognitive aids within the context of emergency management as well as explored how existing knowledge regarding the use of cognitive aids from other industries translated to the emergency management context. The review used search terms including and synonymous with decision models, frameworks and systems, checklists, aide memoires, standard operating procedures and standard operating guidelines within emergency management and industry contexts. References of included works were reviewed for additional suitable material. Databases included those available through the research team's tertiary institutions, Google Scholar and Research Gate and open source material. Industry material was also reviewed from emergency services agencies where available. The search identified more than 6,000 titles published in the last 20 years. The papers were reviewed for relevance with 79 papers found to address the topic. Narrative synthesis of the 79 articles was conducted to provide a comprehensive picture of the subject matter and to guide new findings and conclusions (Fielding and Thomas 2001; McNeill and Chapman 2005).

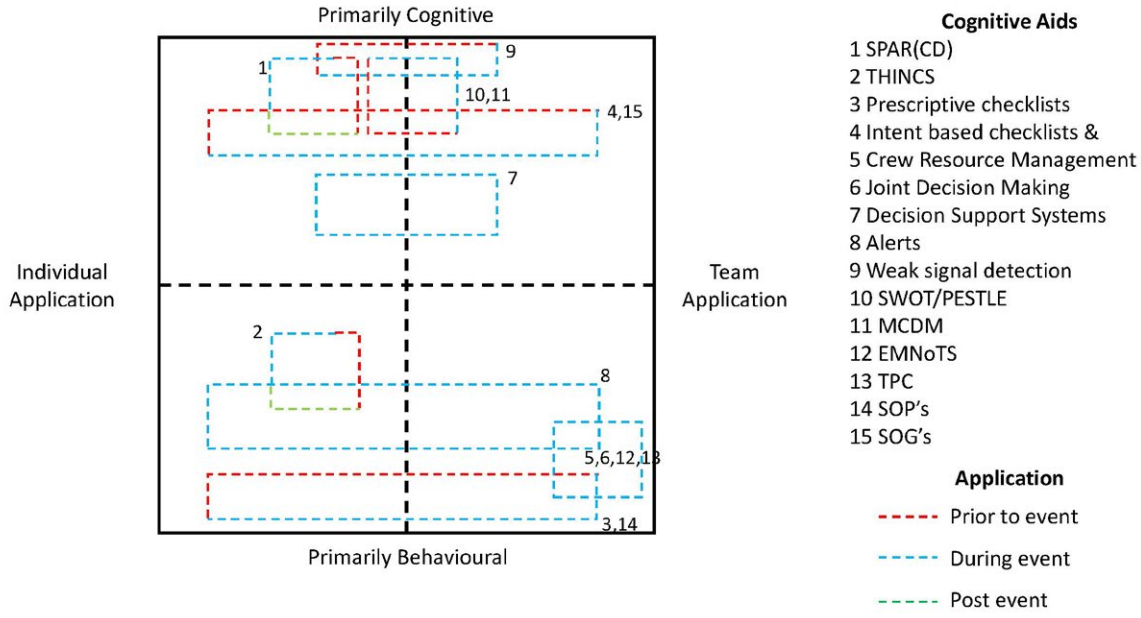

Figure 1: Depiction of cognitive aids based on the extent to which they are primarily cognitive or behavioural in nature (vertical axis), primarily intended for individual or team application (horizontal axis) or primarily intended for use prior to, during, or post an event (colour coding).

Source: Based on Burian et al. (2018)

Results

Decision process and behavioural tools

Cognitive aids are designed to:

- facilitate decision-making through structured and semi-structured non-technical processes such as decision frameworks and models
- facilitate enhanced analysis and sensemaking of multiple and complex criteria
- assist the development of a common operating picture where all personnel share a clear understanding of the situation, environment and actions or
- provide real-time intelligence and options.

They can be used prior to an event for planning or during an event in real time. They are key to the training of new personnel and once learnt, are designed to improve the process of decision-making during an incident. When applied correctly they can assist with a more consistent process of decision-making (Launder and Penney 2023a). However, they do not and cannot necessarily ensure that a correct decision is made in any particular circumstance. They require the user to be familiar, if not competent, with their application prior to use in real world situations.

At a tactical level, emergency management decision-making is typically driven by naturalistic intuitive processes (Klein et al. 1993; Penney et al. 2022; Reale et al. 2023). At the strategic level of emergency management, where there is often time and increased political and community consequences, more involvement of structured analytical processes in decision-making is generally required. Within military and emergency management contexts, established tools that facilitate structured analytical decision-making (e.g. decision ladders, step-based protocols) share common elements including extended situational analysis (e.g. risk identification, assessment and evaluation) and the identification and comparison of multiple options.

An example of a cognitive aid is the Situation Awareness – Context – Decision Strategy – Planning – Action – Review (S(CD)PAR) model developed by Launder and Penney (2023a). The model focuses on an individual decision maker, however, it could also be applied as a meta-level framework to help incident management teams understand the overall decision-making process. S(CD)PAR identifies 6 stages of an ideal decision-making process, which can be separated into pre-decision, decision and post-decision phases. The theoretical S(CD)PAR framework has been translated into a practical operational guide in the SPAR(CD) model (Launder and Penney 2023b) for use across industries and contexts allowing for consistent training, application and post-incident examination of high-risk, time-sensitive decisions and the identification of common decision errors.

Other examples of cognitive aids to assist decision-makers are crew resource management (CRM) and non-technical skills (NTS) frameworks. CRM was developed as a training program to reduce the incidence of human error in the aviation industry (Kanki et al. 2019; Gross 2014) but has also been applied to the field of emergency medicine (Kemper et al. 2017). Rather than decisions being made by an individual (the chief pilot), CRM involves the use of all available resources from information, equipment and especially other people. CRM is a systematic way of assisting a decision maker to make more accurate and robust decisions by using 'collective cognitive skills to gain and maintain situational awareness and develop our interpersonal and behavioural skills to establish relationships and communicate with everyone involved' (Mulenburg 2011, p.13). This helps to combat the issues of human error and failures of cognitive and social skills that were found to be the primary cause of accidents in complex socio-technical environments (Flin et al. 2003; Kanki et al. 2019; Gross 2014).

NTS frameworks are related to CRM and can help to improve performance and reduce error. Several NTS behavioural marker systems that have been developed for these are:

- The Incident Command Skills (THINCS), Butler et al. (2020)
- Team Process Checklist (TPC), Bearman et al. (2023)
- Emergency Management Non-Technical Skills (EMNoTs), Hayes et al. (2021).

THINCS is focused on the individual while EMNoTS and TPC are team-oriented. Unlike S(CD)PAR which is primarily cognitive in its purpose, CRM and NTS frameworks are more behavioural. EMNoTS, for example, identify 7 behavioural markers that index NTS performance, such as communication, coordination, cooperation, leadership, situation awareness, decision-making and coping with stress and fatigue (Hayes et al. 2021). These systems help people to understand what good performance looks like, allow better management of NTS performance in real time and provide a basis for continuous improvement programs (Butler et al. 2020; Hayes et al. 2021).

A different approach has been adopted by the Joint Decision Model (Lamb et al. 2021) that is designed to encourage responders to bring together available information and coordinate goals, decisions and actions to provide a common structure or frame to support responders to jointly consider single and interagency goals. As such, it is designed to facilitate team decision-making. The model's framework comprises 5 linear phases (Waring et al. 2020, p.632):

1. Gather information and intelligence to establish situational awareness and a multi-dimensional understanding of events.

2. Assess risks and develop a joint working strategy.
3. Consider powers, policies and procedures relevant to the situation, and whether these may assist or constrain decisions.
4. Identify options and contingencies.
5. Take action and review what has happened to feed into situation assessments and amend plans if necessary.

When applied correctly, the model can assist to engage all stakeholders, reduce potential blind spots through shared awareness and encourage buy-in to the decision-making process. However, to do this, all participants must be competent in the use of the framework and share common understandings and systems. This may be difficult to achieve (at least without extensive training) in the current Australian emergency management context where different functional command systems including the Australasian Inter-service Incident Management System™ (AIIMS) and the Incident Command and Control Structure Plus (ICCS Plus) (ANZPAA 2022) are applied and different levels of expertise and experience are present across jurisdictions and organisations (AIDR 2023).

Tools to support analysis

There are a number of cognitive aids that help people to analyse aspects of the situation to support decision-making. These are primarily cognitive in their application.

In industries that require the analysis of multiple opposing quantitative and qualitative criteria (e.g. oil spill response, airlines, airports and air traffic management) the application of multi-criteria decision-making methods have become standard practice (Wu et al. 2017; Dozic 2019; Wang et al. 2022; Li et al. 2022; Yang et al. 2021). Multi-criteria decision-making methods involve advanced algorithms and the use of fuzzy logic systems, which can account for uncertainty of outcomes within criteria (Dozic 2019; Wang et al. 2023). While such systems can facilitate enhanced analysis of complex information against multiple criteria, they have not (so far) been applied operationally in an emergency management context.

Decision-support systems are software or applications designed to assist decision-making through the provision of real-time intelligence, the prediction of potential outcomes or suggested courses of appropriate action. Examples include applications designed to evaluate a mortgage or plan a road trip (Becker et al. 2022). Within the context of emergency and military services, decision-support systems have been integrated into firefighting (e.g. Zarghami and Dumrak 2020; Tian et al. 2023; Nagarajan et al. 2023; Ujjwal et al. 2023; Wheatly et al. 2023; Xu et al. 2023; Kc et al. 2023), police operations (e.g. Theodosiadou et al., 2023; Sandhu and Fussey 2021; Wu 2021), emergency management (e.g. Kaur and Bhatia 2023; Sun et al. 2021; Bernabei et al. 2021) and military operations (e.g. Lee et al. 2023; Hunter and Bowen 2024; Johnson 2023). As decision-support systems become more commonplace and the integration of AI-supported decision-support systems into emergency management contexts occurs, the influence of trust and the relationship between decision-makers and decision-support systems becomes critical. Inappropriate levels of trust, both in terms of too little or too much, can result in the potential misuse or disuse of decision-support systems (Appelganc et al. 2022; Parasuraman and Riley 1997; Rieger et al. 2023).

Other simplistic, yet equally important tools such as SWOT analysis (Strengths, Weaknesses, Opportunities, Threats) are embedded in business strategic decision-making (Koseoglu et al. 2019). Within emergency management, PESTLE (Political, Economic, Social, Technical, Environmental, Legal) is commonly applied (Penney et al. 2022; AFAC 2016; Sarwar et al. 2017) and is an analytical method best suited to complex systems that require extensive analysis (Christodoulou and Cullinane 2019). Tools such as SWOT and PESTLE provide predetermined and structured categories to assist users focus on relevant themes and categorise information, while continuing to allow freedom of analysis and interpretation within those categories.

Checklists and aide memoires

Checklists and aide memoires have likely been used informally for hundreds of years (Chapparo et al. 2019) but their formal use is attributed to the United States Airforce following a fatal crash in 1935 of a test flight in a new aircraft (Higgins and Boorman 2016; Hayes et al. 2020). An important distinction between types of checklists is between prescriptive checklists, which are primarily behavioural and specify tasks that must be completed and intent-based checklists, which are cognitive and guide decision-making. At a detailed level Chaparro et al. (2019) categorised checklists according to whether they are:

- sequential, where steps are expected to be completed in order
- laundry lists, where the order of task completion does not matter
- iterative, where the checklist is cycled through a number of times
- diagnostic, such as those commonly used in medicine or aviation to identify a medical condition or troubleshoot a systems malfunction
- criteria of merit, which assists the user to evaluate the performance of candidates under assessment.

Many of the checklists identified in this study were either sequential or laundry list checklists.

Checklists commonly used in emergency and crisis management are the suite of AIIMS and Emergency Management Professionalisation Scheme[1] functional role aid memoires. Other checklists in emergency management identify key tasks for regional and state coordination centres (Hayes et al. 2020) and seek to reduce biases (Brooks et al. 2020). Studies from a range of industries have demonstrated the potential effectiveness of checklists in improving team adherence to critical steps, increasing standardisation of performance, reducing mental workload and assisting fault-finding and trouble-shooting (Koseoglu et al. 2019; Greig et al. 2023; Torre-Concha et al. 2020; Hales and Pronovost 2006; Higgins and Boorman 2016).

Good checklists are simple, applicable to different settings and provide the potential for measurement when reviewing performance (Torre-Concha et al. 2020). They can also be beneficial for training purposes especially when the task is complex or requires extensive or detailed sequences of actions (Marshall 2013). However, checklists also have limitations. Checklists that duplicate other guidance, are too complex or are considered inappropriate for the task at hand may lead to reduced rather than improved performance and may be rejected by the intended users (Chaparro et al. 2011; Torre-Concha et al. 2020; Anthes, 2015; Reijers et al. 2017; Marshall 2013). Checklists that are too prescriptive or too long may likely inhibit operational discretion required for adjustment and decision-making in complex environments. Organisationally, even a good checklist that is poorly implemented, not supported by appropriate training or poorly integrated with existing processes can result in poor outcomes and user rejection (Anthes 2015; Reijers et al. 2017; Guy et al. 2022; Rose and Bearman 2013). Finally, completing checklists can provide a false impression that work is well done and the associated tasks are well understood by people completing them (Reijers et al. 2017).

Operational procedures and guidance

Standard Operational Procedures (SOPs) are documented rules and steps that must be followed when a specific incident is encountered (Butler et al. 2021). By comparison, Standard Operational Guidelines (SOGs) are not prescriptive, provide principle-based guidance with inherently greater flexibility and can be considered a 'starting point' for operations (Weinschenk et al. 2008). Both SOPs and SOGs serve a purpose to facilitate effective coordinated response to disasters (Taber et al. 2008) allowing different teams to follow predefined steps through SOPs or working towards a unified intent through SOGs.

Effectively an operational equivalent to checklists, SOPs are prone to being inappropriately abandoned in favour of operational discretion (Butler et al. 2021) where fire services commanders disregard required processes and actions in favour of their own strategies and priorities. By comparison, where SOGs were implemented, it was found that firefighters would comply with the SOGs in 90% of situations (Weinschenk et al. 2008). Across military and emergency service environments SOPs are typically used as training tools and are more likely to be stringently followed by novices, whereas experienced practitioners prefer to use operational guidelines and personal discretion (Penney et al. 2022).

Outside of fire services operations, SOPs are extensively used within controlled medical and laboratory settings where they can bring compliance with best practice, harmonise laboratory practices, reduce user errors and can be used as training tools (Barbé et al. 2016; Guerra-Farfan et al. 2023). SOPs are not without fault. Sasangohar et al. (2018) found that 'an abundance of outdated procedures and procedures plagued by information overload' were common in the offshore drilling industry. Within dynamic and complex environments inappropriate protocols restrict reasonable and necessary flexible situational action and can become a hindrance to effective coordinated action (Taber et al. 2008).

Cues and alarms

Cues are signals that prompt personnel to execute a specific action. Within the emergency management context they include establishing operational and reporting timelines and rhythms. By comparison, alarms are audible or visual (or a combination of both) warnings used to alert people to critical changes to their environment. Common fire service examples at a tactical level include the low-pressure warning whistle on a self-contained breathing apparatus set, the motion sensitive personal distress alarm carried by search crews and the atmospheric or chemical alarms of chemical and gas detection equipment. At the broader emergency management level, examples include community warnings involving threat levels and required responses (AIDR 2013, 2021). For emergency managers, alarms can be used for purposes such as warning of impending decision and trigger points, the approach of reporting deadlines as well as upcoming meetings. For maximum effect, Omori et al. (2017) report that alarms and alert signals should involve flashing lights accompanied by clear, consistent, concise and candid warning messages (auditory and visual), although the potential for distraction and sensory overload needs to be carefully considered.

An alternate form of alarm is the use of early and weak signal detection design to identify and alert emergency management practitioners to impending natural disasters before they would typically be identified (Jongman et al. 2015). A potential problem with alarms is that people can become attenuated to or complacent of alarms. For

1. Emergency Management Professionalisation Scheme, www.emps.org.au.

example, the frequent sounding of the motion sensitive personal distress alarms during large fires when firefighters leave breathing apparatus sets unattended often leads to complacency. It is also the case that people don't immediately comply with alarms, even in situations where speed is of the essence. Instead, people typically consider the false alarm rate and other potential reasons why the alarm may have occurred before responding (Endsley et al. 2003; McLeod et al. 2005). As Bearman (2013) noted, it is important to remember that 'alarms occur in an ongoing stream of events in the operational environment, where the operator is constantly building an understanding of their current situation and responding to external stimuli' (p.13).

Discussion and conclusion

This study included a literature review and narrative synthesis of cognitive aids within emergency management and industry contexts. It was useful to draw distinctions between the cognitive aids based on whether they were decision process and behavioural tools, tools to support analysis, checklists, operational procedures and guidance or cues and alarms. Decision processes and behavioural tools help people through the process of decision-making and interactions with others. Checklists, protocols and guidelines assist decision-makers step through tasks that will help them resolve an incident. Cues and alarms prompt attention to aspects of the situation. Each of these cognitive aids can be described in terms of the extent to which they are primarily cognitive vs behavioural, team vs individuals and whether they are used prior to, during or after an emergency.

The implications of this review are fourfold. First, emergency management agencies and practitioners need to identify the outcome they are seeking to achieve and then select the correct cognitive aid that will assist to achieve this outcome. Figure 1 can be used to help think through the different ways that cognitive aids can support decision-making. Second, emergency management practitioners need to acknowledge that poorly designed cognitive aids may cause more harm than good regardless of whether they are applied in the right context. Third, to improve the use of cognitive aids during emergency events, agencies need to ensure practitioners are appropriately trained in the aid's selection and use. Finally, emergency services agencies need to recognise the different needs of their staff depending on their expertise and cater for this in the tools they provide. Critically, there is a difference between the way tools are applied between novices and experts with novices tending to adhere strictly to defined steps and protocols while experts desire greater discretion to apply principles within the dynamic nature of an individual event.

Ultimately, cognitive aids are not a silver bullet when it comes to decision-making in the emergency management context. The correct tool (that is correctly designed) must be correctly applied by trained and competent users. Cognitive aids that seek to extend and support the cognitive limitations of individuals and teams to facilitate skilled performance in demanding conditions are a critical but often under-used aspect of decision-making.

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Emergency management decision-making in a changing world: 3 key challenges

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Abstract

Managing emergencies is taxing for individuals due to the stress of making decisions in dangerous, high-stakes and time-constrained environments. These complex, dynamic environments also make it difficult to coordinate as other responders perform different roles that may have conflicting goals. This study explored some of the challenges faced by emergency management decision-makers through a literature review of 70 papers identified from SCOPUS and EBSCO database searches. Three major challenges for emergency management were identified: stress and fatigue, interoperability and ethical decision-making. Each of these challenges is examined to explore their nature and how they are likely to evolve in the future. This paper provides helpful advice on how to mitigate these challenges. We argue that to better meet these challenges, emergency services organisations need to develop and maintain appropriate doctrine and training, develop a supportive organisational culture and effectively learn the lessons of previous critical incidents.

Introduction

Emergency management can be taxing for individuals and teams due to the stress of making decisions in dangerous, high-stakes and time-constrained environments. Emergency management practitioners make decisions in environments that can be fast-moving, uncertain, ambiguous, complex and often chaotic (Hayes et al. 2022; National Ambulance Resilience Unit 2015; Rimstad and Sollid 2015; St George 2012; The Centre for Army Leadership 2024). Decisions in these environments are made in the context of high expectations from communities, politicians and the media and can be subject to intense post-incident scrutiny (Steen and Pollock 2022; Commonwealth of Australia 2023; Bosomworth et al. 2017). At the operational level, emergencies can be dangerous, traumatic, emotionally charged and highly pressured (Health and Safety Executive 2009; 2010). Moreover, emergency services personnel attend emergencies 24 hours a day and some emergencies can last for days or weeks.

Emergencies can also be difficult to coordinate because of the complexity and dynamism of the situation and the resulting stress. Frequently, the numerous people involved may have roles and goals that conflict (e.g. fire suppression versus crew safety). Emergency management practitioners work in single or multi-service response teams and, at large incidents, these may be managed by higher-level coordinating teams. Decisions are made at all levels with information passing up, down and laterally throughout the hierarchy (Bearman et al. 2018; Weick 1993). Emergency management at all levels (from operational to executive) typically involves people from different agencies who need to effectively cooperate, communicate and coordinate their actions. People from different agencies often bring different organisational doctrine, training, norms and values and may not have the same understanding of the situation

and may prioritise or pursue different goals (Penney et al. 2022). These can compromise the operational response and careful attention to cooperation, coordination and communication processes is required to maintain interoperability (Bearman et al. 2023).

Emergency management operates in a wider context of climate change that brings larger, more complex emergencies more frequently. Increasing globalisation brings more threats from terrorism and biosecurity failures that manifest in different and unexpected ways. This occurs in the face of fiscal austerity, where agencies are asked to do more with less. These competing pressures increasingly require emergency managers and practitioners to make decisions about the allocation of resources. Difficult decisions need to be made about which assets are prioritised for protection and which ones are not (Woinarski et al. 2023; 2024). Researchers have argued that more consideration of community values needs to be made in decision-making (e.g. Goddard et al. 2016; Government of NSW 2020), however, real-time operational decisions may not permit time for consideration of community values and needs. Woinarski et al. (2024) observed that emergency management decisions tend to represent societal or community values and sometimes may be shaped by legal constraints or directions. This presents ethical dilemmas for emergency management practitioners that may have dramatic consequences for both the people affected by the decisions and the decision-makers themselves (Boin and Nieuwenburg 2013).

This paper reviews the literature on stress and fatigue, interoperability and ethical decision-making to explore how these challenge the decision-making of emergency management practitioners, how these issues are likely to evolve in the future and how the challenges can be mitigated.

Method

Recent systematic reviews by Penney et al. (2022) and Reale et al. (2023) explored emergency management decision-making. The former focused on military and emergency services whereas the latter considered all occupations involved in safety critical decision-making. This study extends the timeline of Penney et al. (2022) up to 2023 and identifies emerging themes associated with emergency management practitioner decision-making.

Two SCOPUS and EBSCO database searches were conducted using the search terms for military and emergency services used by Penney et al. (2022). These terms were modified for the EBSCO search to reduce the number of publications to a manageable level. A total of 4,287 publications (EBSCO, 3,627; SCOPUS, 651) were identified. Title and abstract reviews were conducted on each database to select articles for further review.

This resulted in 115 published papers being identified as relevant. An additional 25 papers recommended by members of the research team were added to reduce the risk of missing relevant studies. The 140 articles were screened to remove papers from journals with less rigorous editorial controls by excluding those delisted by the Web of Science or listed on their 2023 predatory journals database, or articles that overlapped with other parts of the broader review (e.g. decision-making training). A total of 64 articles were removed, leaving 70 papers to undergo a full-text review. During this process, 3 themes emerged that significantly affect emergency management decision-making being stress and fatigue, interoperability and ethical decision-making.

Results

Stress and fatigue

Salas et al. (1996) define stress as a 'process by which certain environmental demands…evoke an appraisal process in which perceived demands exceeds resources and results in undesirable physiological, psychological, behavioral, or social outcomes' (p.6). Dietz et al. (2017) described 4 categories of emergency management stressors:

- Task demands: the time and need for a team to perform and switch between multiple tasks.
- Coordination demands: tasks associated with coordinating others.
- Threat demands: maintaining composure and performing well under pressure in difficult situations.
- Novelty demands: coping with rare or unique situations and uncertain environments.

Dietz et al. (2017) also produced a framework to illustrate how stress impacts on performance (see Figure 1).

Stress has significant consequences for situational awareness and decision-making (Sallis et al. 2022, Steen and Pollock 2022). Sallis et al. (2022) showed how the responses of fire and rescue incident commanders to stressful simulated incidents indicated information bias and distorted what information was accepted for decision-making. An interview study of police commanders by Steen and Pollock (2022) investigated the perceived effects of stress on decision-making and performance. The participant incident commanders reported that stress impaired their sense making by compromising their ability to perceive a situation and could have other effects such as making them over- or under-reactive. To mitigate these effects, the incident commanders relied on sourcing additional information from within the team or from other sources (e.g. police databases). They also reported that their impaired sense making could affect

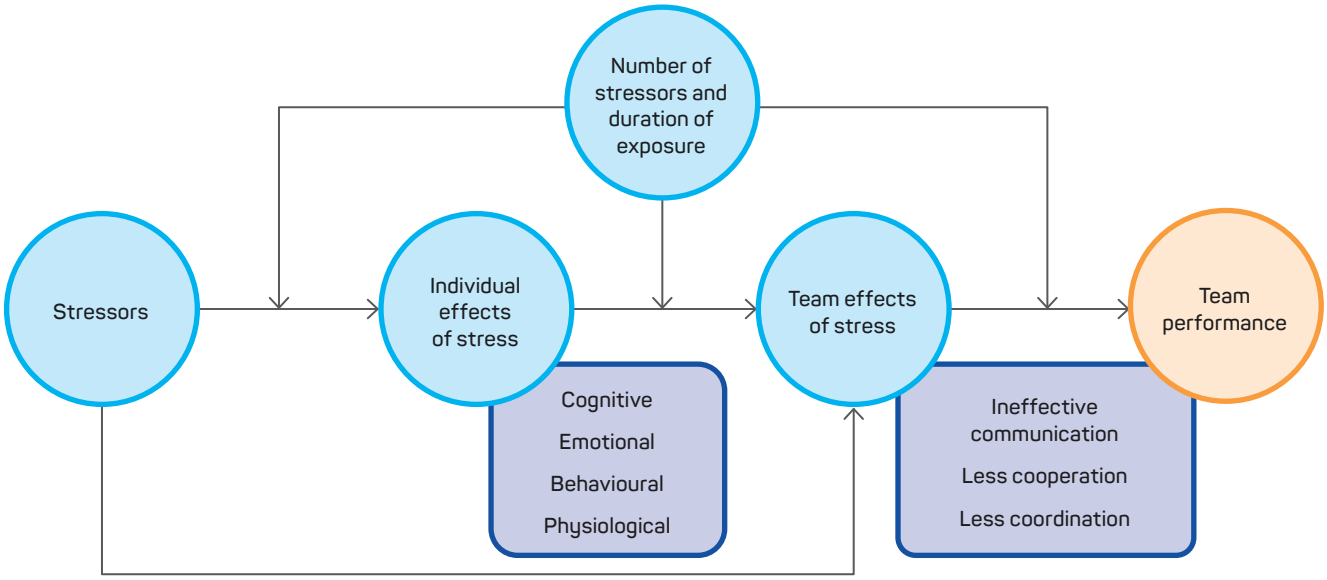

Figure 1: A model framework of the effects of stress on performance.
Source: Adapted from Dietz et al. (2017)

situational awareness, team collaboration and coordination effectiveness as well as organisational support for the use of professional judgement. Further, stress could result in inaction or inappropriate decisions to avoid the appearance of being indecisive.

To mitigate the effects of stress, Butler et al. (2021) recommended that personal resilience training should be added to existing firefighting training programs. One approach is the use of mindfulness techniques such as oneED (Braganza et al. 2018) and Attention Regulation Optimisation (Darses et al. 2023). Mindfulness is the purposeful paying of attention to the present moment, without judgement, that results in elevated levels of awareness (Crosweller 2022). Recent studies involving firefighters (Denkova et al. 2020; Waldron and Ebbick 2015), police (Hoeve et al. 2021; Withrow et al. 2023) and the military (Jha et al. 2020; Nassif et al. 2023) have found such techniques to be beneficial.

Another proposed solution is the use of wearable devices connected to a decision support system (Lai et al. 2021). Sensors in the wearable device measure the body's stress response and, if it exceeds a certain risk level, the decision support system is alerted and produces a recommendation to the wearer to assist his or her decision-making. While such interventions may support decision-making under stress, more research is required to determine a suitable product and to consider any potential unintended consequences of such systems.

Fatigue has been defined as an 'overwhelming, sustained sense of exhaustion and decreased capacity for physical and mental work' (Cella et al. 2002, p.528). Fatigue can result from physical and cognitive tiredness (Enoka and Dechateau 2016), poor sleep quality (Bentley and Levine 2016) and/or exposure to temperature extremes (Donnan et al. 2023). Related to this, sleep inertia (grogginess upon waking) has been found to impair decision-making up to 2 hours after waking (Dawson et al. 2021).

Fatigue can significantly influence emergency management decision-making. Brooks et al. (2018) found that fatigue was a contributing cause of decision-making errors at 3 bushfire disasters in Australia. Yung et al. (2021) highlighted that a drop in performance due to fatigue endangered both emergency managers and the public. Dawson et al. (2021) pointed out that the likelihood of fatigue resulting in a high risk of error is not necessarily linked directly but dependent on context. They also highlighted that there is often a false perception of fatigue as low risk (due to an inherent coping capacity).

Yung et al. (2021) identified 4 fatigue risk factors being work organisation; physical environment; personal, social or cultural factors and task characteristics. They found that these risk factors differ across the various emergency services. Medical first responders mainly experienced issues with personal, social or cultural aspects compared to the police where it was work organisation and firefighters experienced all factors equally. Fatigue outcomes also varied. Police and firefighters mainly experienced physical health issues whereas medical personnel experienced physical and mental health issues and performance issues (e.g. accidents) equally. This emphasised the importance of fatigue risk management and that it should address workplace, personal and domestic risk factors to prevent short- and long-term outcomes. However, a review by Dawson et al. (2021)

highlighted that the work of first responders made managing fatigue-related risk inherently difficult.

Both Yung et al. (2021) and Dawson et al. (2021) recognised that cultural change across the emergency management organisations was necessary to understand fatigue as a high-risk phenomenon needing to be managed. Dawson et al. (2021) made recommendations to combat the effects of fatigue and its risks, including access to caffeine, facilitation of nap opportunities and education and training. They also acknowledged that successful implementation of these strategies needs to be targeted to account for differences between emergency management organisations and individuals and suggested that fatigue should become a feature of safety management systems. For example, Ferris et al. (in press) identified the fatigue-mitigation strategies recommended by Dawson et al. (2021) within the fatigue management strategies of a sample of ambulance services in Australia.

Interoperability

During an emergency, the lead response agency and other participating organisations must work together effectively to exploit areas of expertise and deliver a cohesive multiagency response (Brown et al. 2021). How effectively these organisations routinely work together is based on their interoperability (Pollock and Coles 2015). Interoperability can be defined as 'the capability of organisations or discrete parts of the same organisation to exchange operational information and to use it to inform their decision-making' (ACPO 2009, p.14). Power et al. (2023a) proposed an alternative definition where interoperability is 'a shared system of technology and teamwork built upon trust, identification, goals, communication, and flexibility' (p.4). In both accounts interoperability is essential for effective collaborative decision-making (Kapucu and Garayev 2011).

Despite its importance, interoperability remains a challenging aspect of emergency management. Pollock (2013) identified several common causes of interoperability failures based on a review of incident reports. These included ineffective communication, poor leadership, issues associated with situational awareness, and questionable decision-making. The Royal Commission into National Natural Disaster Arrangements (Commonwealth of Australia 2020) and Cole et al. (2017) found similar shortcomings. For example, the need for compatible communication and information transfer systems so emergency management practitioners can communicate across jurisdictions as well as to improve the use of internet-based technologies and applications to access digital information sources.

Waring et al. (2020) studied a major incident exercise to explore the multi-agency decision-making processes. They found that decision-making was compromised by issues associated with the development of situational awareness. These included withholding information, delays in sharing information, incompatible communication technologies and a lack of familiarity with other agency roles (so people

Figure 2: The UK Joint Decision Model overlayered with the phases of decision-making.

Source: Adapted from JESIP (2021)

don't know who to share information with). Each of these issues effect the ability of teams to execute their plans, which, in turn, contributed to decision delays.

In response to the problems of interoperability, the Government of the United Kingdom established the Joint Emergency Services Interoperability Programme, which developed a doctrine and a framework for joint working between the UK emergency services and other organisations supporting them such as local councils (JESIP 2013; JESIP 2016; 2021). To enhance interoperability, the doctrine introduced a set of principles to be adopted by all organisations involved in a major incident response. For example, to co-locate as soon as practicable and to establish shared situational awareness. The latter is to be achieved with the aid of an analytical Joint Decision Model (see Figure 2). An interoperability framework is also available in Australia; the Australasian Inter-service Incident Management System (AFAC 2017), based on 3 key principles, functional management, span of control and unity of command.

However, Pollock (2013) recognised that merely introducing new procedures was not enough to improve interoperability. In a follow-up review, Pollock (2017) compared observations from a large-scale exercise in 2016 with those recorded in a similar exercise in 2010 and found that several problems with interoperability remained unchanged, including those associated with information sharing. Also, there had been no improvement in learning lessons from incidents to enhance future interoperability. Pollock (2013) and Power et al. (2023a) advocated that for interoperability to be improved, cultural change needs to take place within the emergency management sector so that working together becomes part of what they value and believe. Power et al. (2023b) interviewed emergency managers to evaluate the UK framework and concluded that, to achieve the desired organisational changes across the emergency services would require 'adequate financial investment, a review of organisational structures, and metacognitive skills training on the social psychological components of interoperability' (p.30). It was acknowledged that this would take a considerable amount of time to achieve.

The literature of this review outlines several principles that may serve to enhance interoperability. House et al. (2014) found that effective interoperability is based on information sharing that leads to shared situational awareness and a common operating picture, which serves as the basis for joint decision-making. Similarly, Power et al. (2023a) found that ensuring an accurate common operating picture required clear and effective exchanges of information and communication practices. Both groups of authors advocated a decentralised approach to emergency management to enable teams to react appropriately to rapidly developing emergencies. It better facilitates decision-making by empowering individuals to make decisions without referring to a rigid chain of command. The approach can accommodate differences between agencies but requires each one to understand the work of the others to reduce uncertainties about interagency team processes (House et al. 2014).

Power et al. (2023a) identified 3 psychological principles that inform how interoperability may be embedded in a team: building cohesive goals, trust and secure team identities. Building cohesive goals helps establish trust and develop secure team identities. These principles directly influence multi-agency decision-making and teamwork. Three types of trust were found to be integral to interoperability:

- interpersonal trust
- cognitive trust (a belief that others can perform their role/tasks)
- group-based trust (developed between strangers sharing a social category such as emergency management practitioners).

A strong team identity encourages individuals to work with strangers to achieve overarching team goals and develop a sense of belonging to a multi-agency team rather than to an emergency service organisation (Power et al. 2023a). They concluded that all 3 psychological principles highlight how individuals accept working in a multi-agency team and when targeted in high-fidelity simulation training contribute to embedding interoperability into organisational culture.

Ethical decision-making

The reality of limited resources in emergency management means that decisions often have to be made about where assistance can be provided and where it cannot. For the decision-makers involved this can involve ethical dilemmas. Ethical decision-making can be especially challenging when a person's ethics and moral compass are at odds with the situation. A systematic review by Leider et al. (2017) showed how frontline medical personnel who adhere to ethical principles such as non-maleficence (do no harm) and a duty to provide care can, at times, have these severely tested. For example, where demand for medical treatment exceeds available resources, triage may include factors like an individual's age to prioritise patient treatment.

Ethical decision-making is particularly difficult in emergency management. The scale, complexity, dynamism, dangerousness and uncertainty involved have the potential to be overwhelming (Leider et al. 2017; Shortland et al. 2020). Emergency management practitioners may be operating within a degraded system of safety because of the lack of resources (Brooks 2014) and can be confronted

with least-worse (Shortland et al. 2020) or worst-case scenarios (Sunstein 2007). Further, novel situations can evoke stress and fatigue that compromises decision-making (Dawson et al. 2021) and people may have limited experience to inform their decision-making (Johnson 2014). Yet, emergency management practitioners are expected to be capable of making ethical decisions (Boin and Nieuwenburg 2013). These conditions are particularly unfavourable because ethical decision-making typically needs to be deliberative whereas emergency management and combat conditions tend to evoke intuitive responses (Messervey et al. 2023).

Ethical dilemmas can also have consequences for the people making the decisions. Boin and Nieuwenburg (2013) examined the events of the 'Memorial Hospital Tragedy' in New Orleans following Hurricane Katrina. They focused on the use of discretion by frontline medical personnel when making ethical decisions and how the outcomes significantly affected the lives of those involved and the decision-makers. They referred to the human costs as 'the moral costs of discretionary decision-making on the front lines' (p.368) (see Jacobsson et al. 2015). According to Ryu et al. (2023), these moral costs are moral injury and distress. Moral injury is derived from a substantial conflict between the critical situation and an individual's ethical principles and values and moral distress is defined by overwhelming feelings of powerless to do the right thing. In combat deployments with high volumes of casualties, they found the causes of moral injury and distress for military surgeons included guilt and seeing dreadful injuries.

Leider et al. (2017) in a review of ethical guidance for US healthcare providers, highlighted that at some point during critical incidents and disasters, emergency managers realise that they need to move away from meeting the needs of individuals to focus on the needs of the wider community. Thereafter a utilitarian approach is adopted, for example, to save as many lives as possible. Thompson et al. (2018) used scenarios with Canadian military personnel and described this process starting with recognising that ethical issues are involved, which then enables moral judgements to be made based on principles, values and perceptions of how fair/unfair, right/wrong and good/bad the situation is. Other influential factors include making judgements about how much harm would be caused, how ethical actions would be perceived, how ethical a choice was, the military 'rules of engagement'/ orders (e.g. to remain neutral) and the perspective adopted by a decision-maker when considering harm (i.e. from their perspective or from that of others). Leider et al. (2017) identified several principles associated with medical ethical decision-making. These included a duty to care, duty to plan, utilitarianism and equity.

Several ethical frameworks have been proposed that provide guidance for decision-makers to reduce ethical conflict (Caspar et al. 2020; Cuthbertson and Penney 2023). Ethical frameworks are well-established in health care and include guidance on how clinicians can best provide care during critical incidents and disasters as well as acknowledging the circumstances that may lead to moral distress (Lieder et al. 2017). One such framework for humanitarian workers (Clarinval and Biller-Andomo 2014) addressed ethical issues from the strategic to the operational level based on a defined set of ethical values: a collaborative, deliberative, ten-step approach to ethical decision-making and how to achieve and maintain high ethical standards. Boin and Nieuwenburg (2014) found collaborative crisis deliberation was a key factor of ethical decision-making, namely a process of collective reasoning to determine practical guidelines to deal with ethical dilemmas. Cuthbertson and Penney (2023) highlighted how the moral judgements of emergency management practitioners can vary based on their individual beliefs and perceptions of the communities involved. They noted a lack of ethical frameworks for the emergency services organisations. With respect to training, most military ethics training focused on awareness and was classroom based. There was little evidence this training would prove successful on the battlefield because it could not replicate the stressors of combat (Messervey et al. 2023). Appropriate organisational support for ethical decision-making in emergency management remains one of the key challenges for the sector.

Discussion

Three major emergency management decision-making challenges were examined that emerged from a comprehensive literature review. These were stress and fatigue, interoperability and ethical decision-making. Each challenge was discussed together with proposals to reduce their adverse effects on the quality of emergency management decision-making.

The volatile, hostile working environments of an emergency response evokes stress and fatigue, both of which influence the decision-making and performance of emergency management practitioners. Stress and fatigue can impair cognitive and physiological functions and can lead to human error and jeopardise the safety of emergency service personnel and others. This review highlighted fatigue as a significant hazard. Opportunities exist to develop fatigue management tools to mitigate the effects and accountability for fatigue management to become a feature of organisational cultures. Appropriate training is required to develop understanding of, and techniques to combat, the effects of stress and fatigue on decision-making (e.g. mindfulness training).

Interoperability problems that have not been resolved reflect the intransigence of the challenges they pose. Dominating is the failure of the emergency management sector to learn from past incidents to improve interoperability and the need to establish ways to address this to reduce the frequency of repeated errors and their consequences. The introduction of doctrine is not sufficient to overcome the challenges caused by interoperability. This review highlighted opportunities to enhance interoperability through cultural change, developing effective communication and information sharing systems, adopting a decentralised approach to emergency management, targeting key psychological principles in high-fidelity simulation training, financial investment and a review of the organisational structures.

Ethical decision-making is difficult and stressful and has the potential to cause moral injury and distress. The practicalities of the application and moral consequences of such decision-making during critical incidents are not well-established nor understood. There are opportunities to develop ethical frameworks to provide guidance to emergency management practitioners alongside ethics training that focuses on awareness and includes realistic simulations.

The development of appropriate training was a common thread running through each challenge; from high-fidelity simulations to enhance interoperability and mindfulness training to help people cope with stress and fatigue, to ethics awareness training to aid ethical decision-making. Similarly, changes to organisational culture were signalled to embed interoperability to reduce stress and fatigue and to support ethical decision-making. Yet, one safety critical issue bound the challenges together, that the emergency management sector fails to learn from critical incidents. Overcoming this failure would enhance and develop emergency management practitioner decision-making and improve safety during emergencies.

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Training to improve emergency management decision-making: what the research literature tells us

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Introduction

The importance of training for effective performance in high-stakes high-risk work settings has long been recognised. Writing in AD 70, the historian Josephus described the Roman Army's approach to training:

> *They do not wait for war to begin before handling their arms, nor do they sit idle in peacetime and take action only when emergency comes…Their battle-drills are no different from the real thing; every man works hard at his daily training…It would not be far from the truth to call their drills bloodless battles, their battles bloody drills.*
> (Josephus AD70/1981, p.195)

This glimpse into the past shows 3 essentials for effective workplace training: it is planned and organised, ongoing and task-focused.

A contemporary account is that training is 'the systematic acquisition of skills, rules, concepts, or attitudes that result in improved performance in another environment' (Goldstein and Ford 2002, p.1). This definition highlights that training is not only a systematic process that builds requisite skills and knowledge but that it also develops appropriate trainee attitudes and their understanding of the norms and unwritten rules of the work concerned. Simply exposing people to training situations is not sufficient for them to develop knowledge and skills; this will only occur if the activity results in learning.

Important points from the work of Goldstein and Ford (2002) relate to the design of training programs more generally. Their instructional systems model of training outlines 4 elements that follow a recursive process of:

1. assessing the needs for training
2. developing the training program to meet the needs
3. implementing the training program
4. evaluating the effectiveness of the training program (which links back to 1).

Abstract

The importance of training for effective performance in high-stakes, high-risk work settings is well-known. Successful training is the systematic acquisition of skills, rules, concepts or attitudes that result in improved work performance. Simply exposing people to training situations is not sufficient for them to develop knowledge and skills. This will only occur if the activity results in learning. While much training focuses on the development of technical skills, it is important to train people in non-technical skills, such as decision-making. This paper presents the results of a literature review of 95 peer-reviewed articles that consider the current training and exercise practices used to develop emergency management decision-making capability. The different approaches to training can be categorised into 4 types: discussion-based, operation-based, E-based and post-incident debriefs. This paper discusses current practice in emergency management decision-making training in each of these categories together with studies that have evaluated their effectiveness noting the generally limited nature of evaluation studies. To promote evaluation of training, several studies have developed tools to assess the effectiveness of training. Finally, key takeaway points related to emergency management organisational training and exercise programs are provided.

Thus, a training program is a system that requires ongoing evaluation and modification. This means that the design of a training program is never completely finished. Effective evaluation can address important aspects of:

- the desired learning outcomes being achieved (i.e. improved knowledge, skills, attitudes and other personal characteristics)
- the benefits exceeding the costs
- the learning transfer to the workplace.

Evaluation is an integral part of the design, development, delivery and implementation of a training program (Phillips and Phillips 2014). However, robust evaluation of training programs continues to be infrequently undertaken.

A learning framework commonly used to guide training and development programs of Australian Government agencies is the Center for Creative Leadership's 70:20:10 model (e.g. Johnson et al. 2018; New South Wales Public Service Commission 2015). In Victoria this model has been implemented to guide incident management team training (Slijepcevic et al. 2012). The 70:20:10 framework identifies 3 types of learning: experiential, social and formal (McCall et al. 1988). According to the model, learning should be made up of 10% formal training (structured learning activities), 20% through learning from others (e.g. peer feedback, coaching, mentoring, managerial feedback and lessons learnt) and 70% through on-the-job practise and challenging work-based assignments. Despite its popularity, the 70:20:10 model has been criticised for its atheoretical nature and the lack of empirical evidence to demonstrate its effectiveness (Clardy 2018; Johnson et al. 2018; Kajewski and Madsen 2013).

The term 'decision-making' can be defined as 'a commitment to a course of action that is taken in order to achieve a desired goal' (Alison and Shortland 2021, p.13). Exercising sound judgement and effective decision-making are a critical capability for emergency management operational personnel. By their nature, emergency environments can be very challenging and involve uncertain, fluid and high-stakes situations. Individuals and teams may need to make time-critical decisions, often based on incomplete, poor quality, conflicting or large volumes of information. Depending on the phase of an incident, decision-makers need to make the most of inadequate resources or coordinate the performance of a complex array of interdependent resources to ensure an effective response. Decision-makers need to consider the incident at hand and the safety of their crews as well as its consequences for communities, the environment and businesses. Decision-making is a non-technical skill and is intimately linked with situation awareness. Without a good understanding of what is going on it is very difficult to make effective decisions (Mosier and Fischer 2010; McLennan et al. 2006). Decision-making effectiveness also relies on other non-technical skills, such as communication, coordination, cooperation, leadership and coping with stress and fatigue (Bearman et al. 2023; Butler et al. 2019; Hayes and Bearman 2023; Hayes et al. 2021). While much training focuses on the development of technical skills (such as the correct use of equipment or analysing hazard prediction modelling) it is important to train people in non-technical skills such as decision-making.

There is general agreement in the training literature of the important distinction between 2 types of knowing (e.g. Kole et al. 2020):

- declarative or explicit knowledge (knowing that)
- procedural or tacit knowledge (knowing how to).

Declarative knowledge is fact-based and traditionally taught via lectures, seminars, books and manuals. By itself, it is of limited use to develop competence in decision-making (Muñoz et al. 2015). Retention of content is generally poor in the absence of opportunities to make use of the material in practice settings soon after the training session.

Procedural knowledge is acquired mostly through undertaking tasks, making decisions, receiving feedback and reflecting (Lamb et al. 2021; McLennan et al. 2005). Noe and Ellingson (2017) highlight how policies and procedures (i.e. explicit knowledge) can be readily taught but learning through experience plays a key role in helping a person to decide when and how to apply, adopt or set aside those practices (Butler et al. 2021). Health care research on the training of tasks requiring procedural/tacit knowledge and skills shows that these are better attained through simulations than through lectures (Nestel et al. 2011). Training procedural knowledge is therefore highly dependent on undertaking suitably designed job-related exercises and activities. Trainers and facilitators provide appropriate opportunities for trainees to self-reflect on the quality of their decision-making and how it could be improved (Ellis and Davidi 2005). There is also opportunity to improve procedural/tacit knowledge learning from decision-making on-the-job following an incident if suitable discussion among personnel involved is facilitated or reflective practice is undertaken (Ford 2021; Hoffman et al. 2014; Tannenbaum and Cerasoli 2013).

Rather than trying to examine the broader training and development literature, this study focused on the material most pertinent to developing the procedural/tacit knowledge central to emergency management operational decision-making capability. There is extensive literature dealing with traditional classroom and online training of declarative/explicit knowledge, however, the focus here is on learning that supports acquisition of the procedural/tacit knowledge for effective decision-making. Research by Skryabina et al. (2017) and Chen (2014) considered 3 categories of activities:

- scenario and simulation-based training and exercises
- post-incident learning
- evaluation of training.

The rationale for this study including the third area of evaluation is that it is a critical component of a systematic approach to delivering an instructional system (Dipboye 2018; Goldstein and Ford 2002). The aim of this paper is to bring together key findings reported in recent emergency management decision-making training research literature.

Method

A narrative literature review was used in this study. This approach was the most appropriate for the primary aim of identifying substantive research findings from the literature, rather than evaluating the overall state of emergency management decision-making training research. Initial searches by using ScienceDirect, Scopus, Web of Science and PSYCHINFO proved disappointing. Few relevant reports were identified and several important and well-known works were not identified.

The method adopted subsequently was to examine the first 1,000 abstracts generated by searching the Google Scholar database using 'emergency management decision-making training' as the descriptor. This resulted in 83 published papers being selected on the basis of their title and abstract, of which 54 were relevant. A further search of the Google Scholar data base using 'incident command training' as the descriptor identified 2 additional references. Using the 'cited by' Google Scholar search facility, papers that had cited each of the 56 references were checked and an additional 39 relevant references were identified. Searches of the reference lists of these 39 works did not find new references, resulting in a final total of 95 published papers selected for detailed reading. As an additional check, an EBSCO Ultimate search was undertaken for peer-reviewed abstracts over the period 2000 to 2023 using the search terms (emergency management OR crisis management OR disaster management OR public safety) AND (decision-making OR decision-making OR decision-making process OR decision-making process) AND (training OR education OR development OR learning). No additional references were located. For data extraction, content analysis of the selected papers was used to identify the training activities used to develop emergency management decision-making capability and their effectiveness.

Results

Based on Chen (2014) and Skryabina et al. (2017), training and exercise activities can be categorised into 3 groups: discussion-based, operation-based and intermediate electronic-(E-) based exercises. These intermediate forms of training fall between discussion-based and operation-based activities and include hybrid computer-supported activities and virtual/augmented reality activities (Chen 2014). In addition, another important learning opportunity is presented by post-incident debriefs. Table 1 lists the types of training and the exercise activities and objectives. The current practice in emergency management decision-making training in each of these categories and the studies that evaluate effectiveness are discussed, noting the generally limited nature of the evaluation studies. To promote better evaluation of training, several studies are identified that have developed tools to assess the effectiveness of training. Lastly, we make some general points about training and organisational programs.

Discussion-based training and exercises

Workshop exercises

Alexander (2000) recommended workshop exercises as a low-cost way to bridge the gap between theoretical classroom-based instruction and practical experience in the field. Scenarios can be postdictive reconstructions of previously occurring events or hypothetical constructions of possible future emergencies. Alexander (2000) suggested building blocks for constructing and conducting scenario exercises and emphasised the importance of scenarios that encouraged participants to think through the consequences of their decisions and actions.

Alison et al. (2022) suggested workshops should incorporate 'grim storytelling': imagining negative situations in which all courses of action result in bad outcomes. The purpose is to support decision-makers' to imagine rare, high-impact events and make 'least-worst' decisions to help them manage such situations actively and constructively. This suggestion is based on a frequent criticism levelled at emergency services organisations following disasters and large-scale critical incidents of a failure to act in time or even to act at all (Alison et al. 2022; Waring et al. 2020). This is attributed to redundant deliberation leading to decision inertia. Redundant deliberation is a pathological hesitation arising from overthinking choices among difficult options and is likely to occur where there is no standard operating procedure or similar to provide guidance. It also occurs where decision-makers have not been exposed to enough of these events to build up a repository of expert knowledge. Grim storytelling is similar to the 'pre-mortem' proposed by Klein (2007) and 'worst-case scenario thinking' proposed by Johnson (2014). No evaluation studies of emergency services workshop exercises could be located during this study.

Table 1: Types of training and exercise activities and objectives.[1]

Activity category	Activity type	Features	Objectives
Discussion-based	Workshop	Presentation/critical discussion.	To identify issues and possible improvements through discussion.
	Tactical decision game	Facilitated discussion about a simulated emergency situation involving a deliberately challenging scenario.	To quickly test knowledge of policies, plans, procedures; identify potential pitfalls and explore alternative courses of action.
	Table-top exercise	Facilitated discussion about a simulated emergency situation.	To reinforce knowledge of policies, plans and procedures.
E-based	Computer-supported simulation exercise	Dynamic simulation of a challenging emergency situation with notional information inputs from other agency sources.	To test knowledge of policies, plans, procedures with real-time feedback on the effectiveness of decisions.
	Virtual/augmented reality-based simulation exercise	Psychologically immersive simulation of a challenging dynamic emergency situation with information inputs from other agency sources.	To test knowledge of policies, plans and procedures in a psychologically immersive task environment with real-time feedback on the effectiveness of decisions.
Operation-based	Drills	An assessed activity - usually a single, specific activity or operation with personnel from a single agency, typically under time pressure, involving crews and/or an on/near-scene incident management team.	To assess proficiency and provide feedback to improve the performance of an individual or team activity or operation.
	Emergency management centre exercise	A simulated emergency involving emergency management centre personnel.	To practice, assess and improve via feedback the communication, coordination, command-and-control functions of the multi-agency emergency management centre team.
	Field exercise	A multi-agency, multi-jurisdictional, multi-discipline simulation of a large-scale emergency involving emergency management centre strategic and field teams tactical and operational activities.	To practice, assess and improve via feedback the communication, coordination, command-and-control functions of the multi-agency emergency management centre team and the on-scene emergency response teams activities in an interactive manner over an extended period of time.
Post-incident learning	Debrief after-action reviews	A meeting of personnel who participated in a response to review the management of critical incidents that occurred during the emergency.	To establish what worked well and what did not in order to identify what needs to be changed by way of procedures, planning, equipment and training.

1. Following Skryabina et al. (2017) and Chen (2014)

Tactical decision games

Tactical decision games (TDGs) (Schmitt 1996) are simulations that provide low-fidelity, low-cost emergency management decision-making training. Originally developed for the military, these are scenario-based games, typically brief and conducted in small group settings. They can be a postdictive reconstruction of an aspect of a previous emergency event or a hypothetical scenario devised to challenge particular aspects of participant decision-making competence (Crichton 2009). Objectives of TDGs:

- Exercising and practising decision-making skills in the context of agency operating principles.
- Assisting participants to develop a shared understanding and recognition of possible problems they may encounter.
- Building a repertoire of problematic situations that can be quickly recognised and acted on during emergency situations.

Crichton (2009) provided a detailed account of planning and conducting TDGs and a suggested protocol for conducting post-TDG debriefs. No evaluation studies of TDGs in emergency management decision-making contexts could be located in this study.

Tabletop exercises

Tabletop exercises can be considered as extensions of TDGs in that they are more complex simulations of longer

duration and involve a greater number of participants with a wider range of operational roles. Dausey et al. (2007) evaluated 31 tabletop exercises in the US involving simulated responses to human-made and naturally occurring public health threats. They proposed 6 lessons learnt for designing and conducting tabletop exercises being that exercises should:

- be designed to achieve a specific objective
- be as realistic in content as possible while remaining logically feasible
- be designed around problematic issues rather than scenarios
- be conducted so that decision-making is forced, targeted and time-delineated
- involve a limited number of participants
- be designed and executed to benefit from collaborative engagement of representatives from other likely participating agencies and external (to the sponsoring agency) developers and facilitators.

Operations-based training and exercises

Drills

Skyrabina et al. (2017) described drills as coordinated and supervised exercises to test a single operation or function. Drills are widely used to provide training on new equipment or systems, to develop or evaluate new protocols or procedures and to practise and maintain current skills (AIDR 2023). There is limited published research that considers the effectiveness of drills in emergency management. Skyrabina et al. (2017) outlined some research that measured changes in individual performance. However, these studies relied on self-reports and did not evaluate improvements in decision-making skills.

Emergency management centre exercises

Emergency management centre exercises involve personnel who work in teams at strategic levels of emergency management. The exercises can include people from multiple agencies. In such exercises, the emergency management centre (e.g. a regional coordination centre) manages a simulated incident or set of incidents as if they were managing a real operation. Actors may be employed to play external personnel (such as police or the media) or to simulate radio traffic on the fire-ground (cf. Bearman et al. 2023). Like drills, there is limited research published on the effectiveness of emergency management centre exercises. The studies located relied on self-report measures and do not evaluate changes to decision-making skills (e.g. Perry 2004).

Field exercises

Field exercises have a long history of use for training personnel and are the main vehicle for training staff in multi-agency responses. Berlin and Carlstrom (2014) evaluated 19 Swedish multi-agency (police, ambulance, fire and rescue) collaborative field exercises and found only limited evidence that the exercises improved inter-agency collaboration. Many of those interviewed reported learning little from the exercises. Following these findings, Berlin and Carlstrom (2015) developed a Three-Level Collaboration Exercise model. The model has 6 activities as shown in Table 2. The model was evaluated over 7

Table 2: Berlin and Carlstrom (2015) Three-Level Collaboration Exercise.

(1) Seminar I	(2) Exercise I	(3) Seminar II	(4) Exercise II	(5) Seminar III
Information about the purpose of the exercise. Focus on collaboration. Information about assembly areas, radio channels. Safety and mode of transport. Departure to the assembly area.	Full-scale exercise. The exercise is stopped when a common organisation has been established and all participants have started their operations.	All participants are gathered together. Two questions are presented: • What did you do when you arrived at the incident site? • Was there something that you could have done differently? Presentation of time durations for different activities.	Full-scale exercise. Repetition of the same scenario as Exercise I. The exercise is stopped when a common organisation has been established and all participants have started their operations.	All participants are gathered together. Two questions are presented: • Did you do anything different compared to the first time? • What improvements were made? Presentation of time differences for activities between Exercise I and Exercise II.
(6)	Report is compiled and distributed to all participants within 7 days. Record details of the exercise conditions, scenario, time differences, chosen strategies and their effects.			

Source: Berlin and Carlstrom (2015), p.260.

exercises involving 178 personnel. Data were returned by 147 participants who rated the levels of collaboration, learning and usefulness positively overall.

Resources for operations-based exercises

The US Federal Emergency Management Agency (FEMA) published a Preparedness Toolkit that provides detailed guidance and templates to assist in the planning, conduct and evaluation of disaster preparedness exercises (FEMA n.d.). While these are tailored specifically to the US situation they could be adapted for use by Australasian emergency management organisations. The Australian Institute for Disaster Resilience released an updated version of its *Managing Exercises* handbook (AIDR 2023). The handbook provides an overview of exercising, exercise types, exercise documentation, conducting exercises and exercise evaluation.

E-based training and exercises

Computer-supported simulation exercises

A training platform used widely by law enforcement agencies but also by some fire, military and humanitarian agencies is the Hydra Foundation Critical Incident training and debriefing (Alison et al. 2013; Eyre et al. 2011; Hydra Foundation 2022). The only research that could be located about Hydra and training was a PhD thesis (Davies 2013) that examined the effects of simulation-based training on decision-making by New South Wales Police recruits. Davies (2013) found that, in terms of aiding transfer of learning, the most important element of the simulation for experienced police officers was the nature of the task. However, for novice police students, perceived realism was the most important element.

XVR is another computer simulation platform that is widely used for incident management training in the emergency management sector. Over 80 mainly emergency management organisations in 50 countries use XVR to train their personnel (LearnPro 2022). Lamb et al. (2014) outlined how a fire and rescue service in the United Kingdom uses XVR in conjunction with Hydra to develop and maintain incident command skills. No evaluation studies of XVR could be located in this study.

Virtual reality (VR) simulation exercises

Several VR systems have been developed for use in emergency management. The On-Line Virtual Environment (OLIVE) allows users to create persistent virtual worlds where participants can collaborate over networks to train in strategic response to complex emergency scenarios (Chen 2014). However, in an evaluation of OLIVE following an exercise involving responses to a flood emergency, the majority of participants reported that they did not learn as much as they did during traditional field simulation exercises. Prasolova-Forland et al. (2017) provided a detailed account of the development of a VR system for operational-level emergency management training (tasks and judgements). Participants reported satisfaction with the experience; novices more so than experienced practitioners. Tena-Chollet et al. (2017) conducted a survey of VR systems providing training in emergency management at tactical and operational levels in several countries. They concluded that a major advantage of using virtual environments was the repeatability of scenarios allowing participants to see the consequences of alternative courses of action.

In a review of evidence for training effectiveness using VR technology, Abich et al. (2021) evaluated research spanning domains of safety and emergency response (although research from the medical field dominated the review). VR was defined as a system that presented 3D computer-generated graphics requiring the user to fully interact with a virtual environment. Three forms of VR technology were distinguished: head-worn display (HWD), head-mounted display (HMD), and cave automatic virtual environment (CAVE). Training effectiveness was assessed across 3 learning domains of psycho-motor skills, spatial ability and knowledge acquisition. Across all 3 domains, use of VR technology was found to be generally more effective than alternative training methods such as manuals and multimedia presentations. Potential limitations included individual vulnerability to motion sickness, time required for trainees to become familiar with the technology and the limited number of scenarios available because of the development costs.

Khanal et al. (2022) reviewed the literature on VR, augmented reality (AR) and mixed reality (MR) technology used in emergency management. The review covered applications including hazard modelling, intelligence gathering and training. The literature on VR-related platforms for emergency management decision-making training is limited, but the overall conclusion is that successful current applications have been aimed at developing individual skills in particular operational settings (e.g. railway operations) and familiarising novices with visual aspects of hazards in emergency settings (e.g. mining hazards). No examples of use of the technologies to develop emergency management decision-making skills at the tactical or strategic levels were cited apart from the OLIVE platform discussed by Chen (2014).

General principles for simulations

Crichton (2017) distilled 5 principles for using simulation-based training exercises to improve team effectiveness based on extensive experience in simulation-based training to improve operational safety in emergencies. These principles are:

- develop appropriate learning objectives and expected performance standards
- train the team as a whole
- develop and use appropriate structured observation tools
- use the observation tools to provide feedback during a structured debrief
- repeat the simulation-based training exercise regularly to enhance expertise and retain performance standards.

The Australasian National Council for Fire and Emergency Services (AFAC) published 'Building capability through simulation: Research insights into good practice' that outlines some of the key issues to be considered in planning, designing and evaluating simulation-based exercises for training incident management personnel (Hayes 2015).

A review of simulation-based training in the US Army by Strauss et al. (2019) concluded that the Army's training emphasis was on simulation equipment and platforms rather than on learning design. Strauss et al. (2014) observed that this issue has continued for over 20 years. Salas et al. (2012, p.199) concluded that:

> *…challenge to training developers and simulator designers is to develop systems that use technology to promote learning. To achieve this goal, there will need to be a shift in focus from the designing of simulation for realism (and hope that learning occurs) to the design of human-centred training systems that support the acquisition of complex skills.*

Recent analyses of the US Army's use of simulation and virtual training shows that these issues continue to be a problem. While the Army continues to increase its use of simulation, it has not developed the performance measures required to understand the right mixture of training methods not to ascertain the return on investment for this type of training (Strauss et al. 2019; GAO 2013, 2016).

Post-incident learning activities—debriefs and reviews

Debriefs are a type of work meeting in which teams discuss, interpret, and learn from a recent event during which they collaborated (Allen et al. 2018). Debriefs provide a mechanism by which individuals and teams use post-incident discussion to learn and improve future performance. Across a range of work domains there is compelling evidence that well-conducted debriefs can improve team performance significantly (Owen et al. 2015). In relation to fire, rescue and other emergency response services, (Allen et al. 2019, p.507) indicated that an important goal of debriefs is to promote a positive safety climate:

> *The debrief allows teams to reduce ambiguity about an event when proper response to an incident is critical. This retrospective sensemaking is needed in order for team members who may have been physically distributed during an incident to develop a consensus about why and how the incident was managed more or less effectively, and how individual and collective action contributed to its success, failure or near failure.*

Allen et al. (2018) cautioned that debriefs do not necessarily occur automatically nor in a well-designed fashion and the conditions that make team debriefs effective are not easy to achieve. They summarised evidence-based practices for effective debriefing in medical teams, which they deemed likely to be applicable for debriefing in most work domains. Similar points were covered by Owen et al. (2015) in the AFAC handbook summarising the evidence for effectiveness of debriefings and after-action reviews. The handbook also provides a checklist and recommended structure for conducting them. In their review of sensemaking and critical decision research, Penney et al. (2022) concluded that the relevant literature supports the usefulness of debriefing and subsequent coaching in developing decision-making expertise. Feedback and self-reflection '…appear vital to the development and maintenance of expertise by facilitating the restructuring of knowledge as experiences and outcomes are appraised and measured against outcomes' (p.10).

Evaluation of training

It is clear that while some evaluation of training is performed, this is often quite limited. In a review of the literature reporting evaluations of disaster preparedness exercises (the majority of which was concerned with public health emergency preparedness), Beerens and Tehler (2016) identified that there was often a narrow focus on the reactions of participants (favourable/unfavourable) rather than on demonstrable improvements in the capability of the agencies.

To improve the evaluation of emergency management training, a number of tools are proposed. Thielsch and Hadzihalilovic (2020) reported the development of an evaluation survey tool to assess the effectiveness of tactical and strategic command unit training exercises for fire service personnel in Germany. The authors based their approach on the work of Kirkpatrick (1979) who proposed 4 levels of evaluation of workplace training programs:

- Level I: Reactions of trainees (favourable/unfavourable).
- Level II: Learnings by trainees.
- Level III: Changes in trainees' subsequent on-the-job behaviours.

- Level IV: The impact of training on the organisation's level of performance.

Thielsch and Hadzihalilovic (2020) proposed that a positive outcome at each level was a prerequisite for a positive outcome at the next level. They also noted that while evaluations at Levels I and II should be carried out as soon as practicable after conclusion of the training activity, evaluations at Levels III and IV could only be undertaken 'down the track' sometime after the training activity had concluded. They developed a 25-item evaluation tool focused on Levels I and II: the FIRE-CPX (Feedback Instrument for Rescue forces Education – Command Post eXercise scale).

Working in the Netherlands, van der Haar et al. (2013) developed a 21-item scale for members of on-scene incident management teams to self-assess their performance effectiveness on 5 dimensions of (i) situation assessment, (ii) decision-making, (iii) quality of actions, (iv) goal achievement and (v) errors. Also, Janssen and Vreugdenhil (2015) described an observers rating scheme based on behavioural markers as an evaluation tool for emergency response training exercises (TARCK-it). The rating scheme has 5 aspects of observed team performance during the exercise:

- T - Timeliness – whether activities are completed timely enough to be successful.
- A - Accuracy – whether activities are completed correctly to be successful.
- R - Relevance – whether the activities are relevant for completing one's task.
- C - Completeness – whether activities are completed to a sufficient extent.
- K - Kosteneffectiviteit (cost effectiveness) – whether the cost of activities that are carried out are in proportion to the gain.

Important points made about training

Salas et al. (2012) make 2 important points about training. The first is that appropriate training works. The second is that the design, delivery and implementation of training programs are all-important. Training program design will be critical to develop expertise in the complex task of decision-making. To develop an effective training program, it is important for organisations to consider how to systematically provide a suitable range of experiences that will enable a practitioner or team to develop (and maintain) a sound understanding of their capabilities and a strong appreciation of the contexts in which they are likely to operate. Salas et al. (2012) emphasised that training should be a systematic process and that organisations need to pay close attention to what happens before, during and after training.

Large-scale emergencies occur infrequently so emergency management personnel are not required to manage them very often (Lamb et al. 2014; Skryabina et al. 2017). This leads to 2 main challenges: retention and generalisation (Ford and Schmidt 2000). Retention issues stem from the deterioration of knowledge and skills over time if they are not used or practised (Woodman et al. 2021). Generalisation issues come from the necessarily limited scope of training exercises that are unlikely to encompass all the demands likely to be posed by actual emergencies. Ways organisations could counter these threats to decision effectiveness have been proposed including (a) providing staff with a range of self-directed and other learning opportunities to maintain knowledge and (b) structuring post-exercise debriefings in ways that encourage development of self-reflective appraisal (metacognitive) skills (e.g. Lamb et al. 2014).

It is clear that organisations need to have systematic approaches to training that includes an understanding of skill retention and generalisation. Woodman et al. (2021) have argued that a systematic approach to training needs to include a robust analysis of what skills need to be trained, based on task decomposition methods and training needs analysis. Part of the analysis includes the rate at which existing skills decay and appropriate skills maintenance schedules.

Discussion

This study examined the practices used in the delivery of emergency management decision-making training and focused on the learning methods used to develop procedural/tacit knowledge and skills. It considered the literature concerned with enabling learning post-incident though debriefing and reviews. The review covered the use of evaluation of decision-making training and exercises.

An important finding of this study was that there were very few published studies that evaluated emergency management decision-making learning activities. For almost all the learning activities reviewed, there was little, if any, published evaluation of the effectiveness of the intervention. In a few cases there was participant self-report data or suggestions on how the specific training or exercise activity could be enhanced. This is not to say that the current training and exercise activities do not support learning. However, without robust evaluation of training and exercise activities it is more difficult for emergency management organisations to justify their decisions on the training systems and technologies they invest in and continue to use. This finding is consistent with the evaluation literature that recognised the significant organisational barriers that undermine the adoption and implementation of robust evaluation practices (e.g. Phillips and Phillips 2016; Russ-Eft and Preskill 2009).

Developments in new technology have enabled the rapid adoption of simulation and VR platforms for training and exercising. These platforms offer advantages for emergency management settings and various emergency management organisations have invested in these. A particular strength of these platforms is the repeatability of scenarios providing the opportunity for participants to see the consequences of alternative courses of action. These technologies provide training for high-risk, low-frequency events, and access to training for regionally located personnel (e.g. Victoria Ambulance online triage simulations and FLAIM fire trainer). However, there appears to be preoccupation with simulation fidelity and limited investment in the learning design to help the acquisition of complex skills such as decision-making. Crichton (2017) provided helpful guidance on the use of simulations and Hayes (2015) highlighted important points for planning, designing and evaluating simulations. However, there is little literature that assesses the effectiveness of simulation and VR and no real guidance on how to best integrate these with other learning methods (see Marlow et al. 2018).

Post-incident debriefing has received significant interest from the emergency management sector over the last 15 years. There is clear evidence that well-conducted debriefs can improve team performance but also an acknowledgment that debriefs do not automatically occur and that enabling an effective debrief can be difficult. Penney et al. (2002) emphasised the usefulness of debriefing and subsequent coaching. Their observation of the importance of debriefing, its links to coaching and the value of reflective practice highlight a further issue. Evidence from Hayes (2018) suggests that the majority of Australian emergency management organisations may not have a formal coaching or mentoring program. Of the 26 emergency management organisations surveyed, Hayes (2018) reported that only 13.5% had a formal coaching program and 26% had a formal mentoring program.

This study found that the published research focused on a particular type of learning activity. Literature that studied the learning system or the effectiveness of integrating different learning activities to support decision-making capabilities could not be located. Training is a systematic process and there is a need to link the various training activities, exercises and experiences to a coherent and planned program to support effective learning. This approach is certainly not new and Ford (2021) noted the foundations for a systematic approach to enabling learning goes back over 90 years to Viteles (1932). There is evidence that emergency management organisations use some tools to support a systematic approach. Hayes (2018) found that 90% of the 26 Australian emergency management organisations surveyed used individual development plans. Emergency management organisations varied as to whether both staff and volunteers (30%) or only paid staff used these plans (35%). A limitation of development plans is that they can be quite general and not necessarily focused on developing specific decision-making capability. Maintaining a robust instructional system requires ongoing evaluation and refinement and this can present a challenge to many emergency management organisations.

Developing capability should be a systematic process that integrates various forms of learning. Developing complex capabilities such as judgement and decision-making needs to be built over time using various forms of learning, requires exposure and practice in a variety of situations and will be strengthened by reflective practice. Thus, it is unlikely that any single learning method will equip an individual with the requisite broad set of declarative/explicit and procedural/tacit knowledge. The dynamic and challenging nature of many incidents makes it very difficult to formulate a fixed set of training protocols for training decision-makers (Cesta et al. 2014). From a human resource development perspective, this could be framed as learning the requisite knowledge, skills, abilities and other personal characteristics (i.e. KSAOs). The acquisition of KSAOs will be enabled through a curated, coherent and integrated development journey using various forms of learning and work experiences.

Based on this review some important points for organisations to consider can be made:

- A range of options for training emergency management decision-making is available using discussions, operational exercises, intermediate methods (E-based exercises, including hybrid computer-supported exercises and virtual/augmented reality exercises) and post-incident learning.
- It cannot be assumed that participation in emergency management decision-making training will result in improved performance. That can only be determined by appropriate training outcomes evaluations.
- Training activities will not, of themselves, result in improved emergency management decision-making: that will only occur if the activity results in learning. Practice does not necessarily make perfect; it may merely make the imperfect permanent.
- The endeavours of trainers and facilitators are crucial to promote learning through stimulating and guiding trainees' self-reflections on the quality of situation assessments, decisions and actions during an exercise and how these might be improved.
- Decision-making competence is a depreciating asset. It needs to be maintained by opportunities to use it through exercises and sustained by an organisational culture that values and supports learning.
- Emergency management activities will require the involvement of other organisations and appropriately

planned and conducted training activities that involve participants from other agencies.

The most constructive action for emergency management organisations to improve decision-making effectiveness is to undertake critical reviews of current arrangements for decision-making training to ascertain:

- Is there an organisation-wide program of emergency management decision-making training, development and maintenance covering all the 4 levels of emergency management decision-making?
- Is the emergency management decision-making program adequately resourced in terms of training staff expertise and material resources?
- Does the emergency management decision-making training program match the operational emergency management decision-making responsibilities?

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Abstract

The increasing use of cordons after major seismic events necessitates an improved understanding of how post-earthquake cordons work in practice. The use of cordons in 3 case study countries (New Zealand, Italy and Nepal) were examined following damaging earthquakes to understand decision-making by emergency management authorities related to cordon implementation and management during the response and recovery. A qualitative research approach included 44 interviews with expert knowledge holders. This paper provides a synthesis of the results of these case studies and proposes a new working definition for cordons that addresses their dynamic temporal and spatial nature. The paper presents a model that captures the practical implications and recommendations of this research, Cordon Operations and management and Decision-making following Earthquakes (CODE), to support emergency managers and relevant authorities to be better prepared, make informed decisions and aid in operational activities in future seismic events.

Cordon operations and decision-making following earthquakes: a model for understanding cordons in practice

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Introduction

In recent decades, major seismic events around the world have resulted in the use of cordons as a response approach immediately post-earthquake. Following the 2011 Christchurch earthquake in New Zealand and the 2009 L'Aquila earthquake in Italy, cordons remained in the respective central city areas for years (Underwood et al. 2020). These cordoned-off areas were colloquially known as 'red zones' (in Christchurch) and 'zona rossa' (in L'Aquila). Post-earthquake cordons can have significant effects on response and recovery of a city (Hulsey et al. 2022; Chang et al. 2014). However, there has been limited research to understand post-earthquake cordons in practice to support emergency managers and relevant authorities to make informed decisions on the implementation and management of operational cordon activities over time.

To this end, 3 research papers (Shrestha et al. 2021; Shrestha et al. 2022; Shrestha and Orchiston 2023) are summarised to investigate the use of post-earthquake cordons in 4 different cities and an updated working definition for cordons is proposed. In the papers, case studies were conducted of Christchurch (2011 Christchurch earthquake), Wellington (2016 Kaikōura earthquake), L'Aquila (2009 L'Aquila earthquake) and Kathmandu Valley (2015 Gorkha earthquake). The research used qualitative research methodology involving 44 expert interview participants who had varying backgrounds, roles and responsibilities during the earthquakes. This paper uses the empirical data from these interviews, presented in detail in the 3 papers, to propose a practical model to guide the use of post-earthquake cordons to support preparedness for future seismic events.

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).

The 3 research papers synthesised in this article were approved by the University of Otago Human Ethics Committee under category 'A' or 'B'.

Post-earthquake cordons

According to Underwood et al. (2020, p.2) a cordon is '…a barrier established by an authority to temporarily exclude the public from a defined area'. The main purpose of a cordon is to protect the life safety of people from potential risks during critical situations, which can include fire hazards, active shooter situations, riots, etc. After damaging earthquakes, the criticality of the situation and safety concerns arise from the potential collapse of buildings and/or falling debris. Unlike for other uses of cordons, this criticality persists for an extended period of time because large earthquakes are usually followed by a sequence of aftershocks. Aftershocks make it difficult to assess the structural damage caused by the mainshock. As time goes by, it becomes increasingly uncertain whether the structural capacity of the built structures has been further compromised by aftershock activity. In many cases, damage may not be visibly apparent, requiring detailed engineering assessments to ascertain the structural integrity of buildings. These assessments may be necessary for numerous buildings depending on the scale of damage. Thus, it is important to restrict access to the public until authorities have completed these tasks and deemed the area safe.

While the primary purpose of establishing cordons is life safety, post-earthquake cordons also serve additional purposes. By creating a restricted zone, cordons form a secure area within which it may be necessary to protect against theft, looting and vandalism. Experts from Christchurch and L'Aquila pointed towards acts of theft and looting that reinforced the justification for maintaining cordons. In Kathmandu Valley, it was suggested that one of the reasons for cordon placement around temples was to protect them against theft of heritage artefacts. It should be noted that crimes may increase (Leitner and Helbich 2011; Prelog 2016) or decrease/remain stagnant (Barsky et al. 2006; Hombrados 2019) after disasters, so it is difficult to justify establishing cordons based on security considerations alone. Imperiale and Vanclay (2019) documented that the extent of cases of lootings in L'Aquila may have been overstated.

It is interesting to note that concerns regarding looting were not noted in the Wellington case study. This difference is explained by the relative level of damage and devastation caused by the earthquakes. In Christchurch, L'Aquila and Kathmandu Valley, the damage and destruction to properties and lives lost was much more significant compared to the Wellington case. Additionally, the effects of the earthquake were also more spatially and logistically localised in Wellington such that it was sufficient for authorities to manage the risk by placing smaller cordons around individual buildings or streets for a shorter time. This meant that the resources required were significantly lower in Wellington. In large and complex city environments, establishing and maintaining cordons are significantly more resource intensive and logistically challenging.

As the response phase moves into recovery, a number of challenges emerge. People who have been evacuated from buildings need to retrieve their belongings and other items needed for day to day lives, wellbeing and work. To support this, large-scale cordon access programs were established in Christchurch and L'Aquila by local authorities. A smaller scale operation was also observed in Wellington. These cordon access programs followed similar procedures to enable members of the public to enter the cordon, accompanied by emergency services personnel (often firefighters) to access their premises to retrieve essential items. The duration of stay within the cordons ranged from 5 minutes up to several hours depending on life safety risk assessments by the authorities.

Technical tasks were also required by engineers, contractors, labourers and insurers who required access to assess building damage, inspect services and undertake repair and demolition work. As such, when cordons are placed for lengthy periods of time, there are usually conditionally authorised people (journalists, service people etc.) who can enter the cordons. The results of this research showed that cordons are typically porous because absolute exclusion of the public is not tenable. The case studies showed that cordons are unpopular with the public when maintained for long periods of time, which in part, led to public protests in Christchurch and L'Aquila.

This study revealed legal and ethical challenges surrounding the use of cordons. According to Underwood et al. (2020), the statutory powers within a country determine the permissible authoritative actions after an earthquake, including the establishment of post-earthquake cordons. In New Zealand, the *Civil Defence Emergency Management Act 2002* allows Civil Defence to enforce exclusion of the public from a given area when a state of emergency is declared. As observed in Wellington, cordons can also be established through the Chief Executive of the Local Territorial Authority. In this approach, senior council executives must justify the cordon placement and seek approval from the Chief Executive. In L'Aquila, cordons were placed in the city centre for more than a decade through the use of ordinances. The lengthy

duration of cordon placement highlights the myriads of ethical challenges involved in cordon management. Post-earthquake cordons halt and/or limit many of the rights of citizens such as freedom of movement, access to resident and business premises, they affect livelihoods and, broadly, the rights to the city.

There was a desire to provide access to the so-called 'red zone' cordon in both Christchurch and L'Aquila. In Christchurch, the authorities prioritised the demolition of houses and reduction of cordons around access routes to facilitate the opening of the temporary Re:START mall. Additionally, there were red zone bus tours into Christchurch city centre for the public. These initiatives highlight some of the ethical considerations that authorities employed to enable the public to regain some degree of control. Similarly, in L'Aquila to encourage some degree of social life in the city, a few businesses and bars were given temporary permits to open within the cordons. Furthermore, residential reconstructions were prioritised over public buildings to enable people back into the historic city centre. This is in part due to the pressure from the public, but also a response to people's desire to return to their homes, their streets, their neighbourhood and to contribute to the economic recovery of the city.

Post earthquake cordons can also be used as a tool to support recovery. Cordons reduce bureaucratic 'red tape', for example, expediting demolition/reconstruction, traffic management and storage of materials and equipment. In Christchurch, because the access points into the cordons were controlled and records kept with regular monitoring, it became easier to keep track of demolition and construction works. This was useful to avoid health and safety issues and other potential hazards, such as asbestos poisoning. Cordons presented an opportunity for businesses and residents to undertake repair, retrofit or redesign work on their buildings even if there was limited or no damage due to the reduced cost of operating within the cordon (i.e. cost of permits and approvals from the council). Similarly, in L'Aquila, reconstruction projects were supported financially through fee waivers of large sums of money for occupying public land necessary to set up a construction site.

Over time, the space within a cordon becomes a transitional space for recovery. In Christchurch, the demolition process was fast-tracked because the space within the cordon, in essence, became a giant construction site where contractors could work faster without worrying about risk to bystanders. The low vehicular traffic allowed for ease of movement and storing demolition debris, construction materials and large vehicles. Similar experiences were observed in L'Aquila and, to a lesser extent, in Wellington.

Updated definition of cordons

The proposed definition of cordons provides a complete account of the characteristics of cordons and their use and updates the previous definition provided by Underwood et al. (2020). There are 2 main points of departure from the earlier definition. First, it highlights that the criticality of the situation is a prerequisite for establishing a cordon. Due to their restrictive nature, cordons should not be established if the situation is not risk sensitive. Authorities should have the discretion to decide whether the level of risk warrants establishing a cordon, similar to the discretion authorities have in declaring states of emergency (bearing in mind there is often a high degree of uncertainty). However, if risk is not apparent, then the risks must be communicated effectively to the public. This will reduce the potential for dissatisfaction from the public while encouraging compliance with cordon rules. Figure 1 shows that even though cordon boundaries are monitored by authorities, it is highly likely people will trespass the cordon boundaries, particularly when cordons are established for a long time over a wide area.

Second, the proposed definition also alludes to the dynamic scope of cordons such that their use goes beyond life safety of the public. As demonstrated by the case studies, when cordons are established for a long time, they evolve from an initial life safety response tool into a transitional function that enables and facilitates operational activities that support recovery.

Practical model for post-earthquake cordons

We present a conceptual model to support and guide practical consideration for post-earthquake cordons. It is anticipated that this Cordon Operations and Decision-making following Earthquakes (CODE) model (shown in Figure 2) will support emergency managers and relevant authorities to understand the complex and dynamic factors that emerge during the implementation and management of post-earthquake cordons. The 3 fundamental notions of risk, law and ethics are nested within the decision-making dimension of the model for understanding post-earthquake cordons. The notion of risk is the first thing that is discussed in the context of understanding disasters. However, the idea of 'risk' is complex, multifaceted, nuanced and requires a broader understanding of additional elements such as risk tolerance, risk acceptance and risk perception. Additionally, there are a myriad of legal and ethical challenges that need to be considered when post-earthquake cordons are used. This is because cordons are complex and multi-dimensional with a potential for significant consequences for the response and recovery of the city and its citizens after a major seismic event. When cordons are maintained for a long time, the

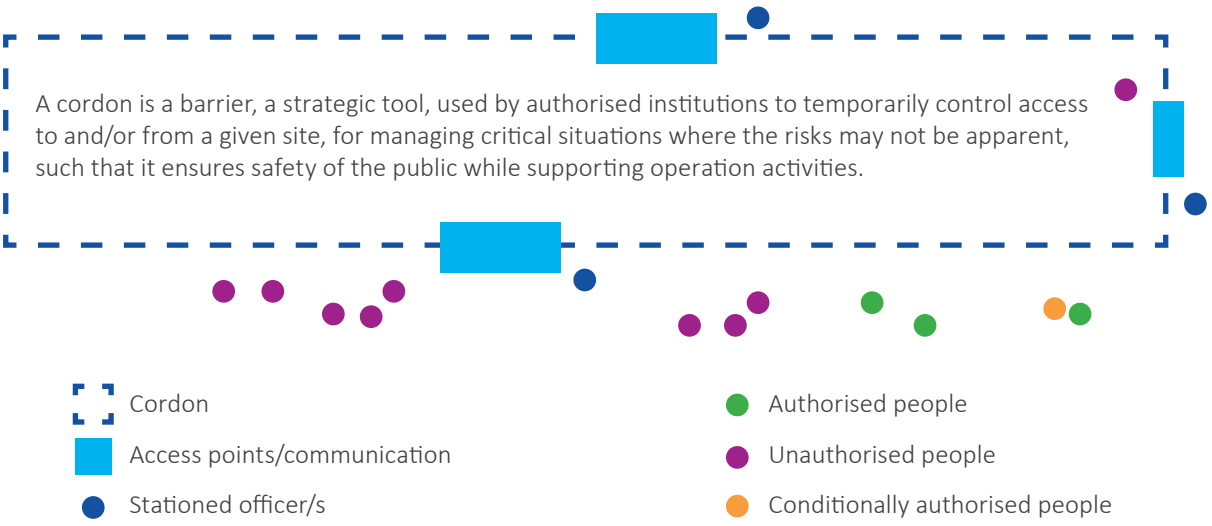

Figure 1: Proposed cordon definition and illustration of its function.

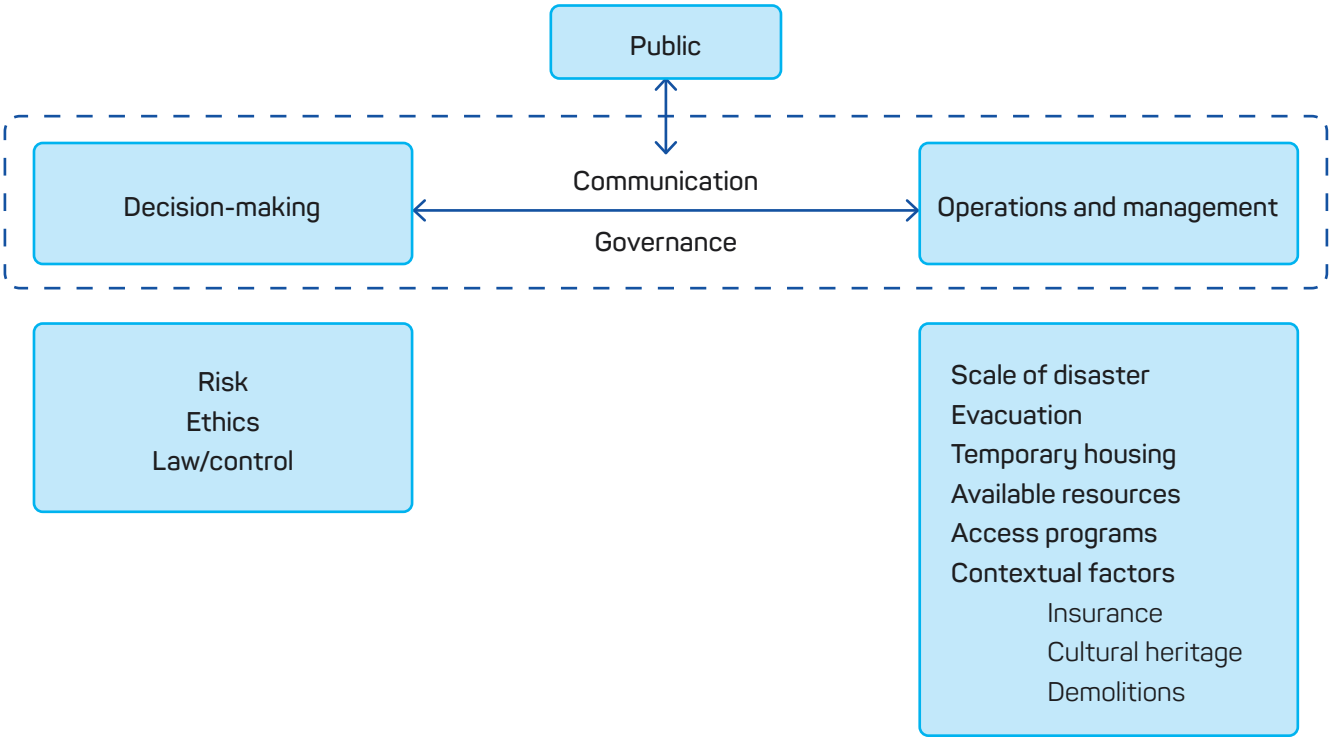

Figure 2: Model to guide practical considerations of Cordon Operations and management and Decision-making following Earthquakes (CODE).

inherent restrictive and top-down management of cordons can lead to other challenges particularly on the democratic principles of freedom of movement and people's autonomy to choose their risks.

The practical considerations for establishing and maintaining post-earthquake cordons can be synthesised through 2 key dimensions: decision-making and operations and management. These dimensions continuously interact as part of a complex system. This model is primarily based on case studies of Christchurch and L'Aquila due to the extended spatial and temporal scale of cordon use in each case. However, references to Wellington and Kathmandu Valley are made where appropriate.

Authorities need to consider whether establishing a cordon is necessary. As shown in the case studies, the initial establishment of post-earthquake cordons is mainly determined by the scale of the disaster, specifically the degree of damage to buildings and potential risks to

life safety. Although this is the main criteria, as noted in Kathmandu Valley, there may be nuanced reasons why the establishment of post-earthquake cordons is avoided (e.g. due to legal uncertainty, cultural nuances and lack of available resources). In Nepal, government official participants in this study noted that establishment of cordons is not specifically provisioned in the law. However, they indicated that post-earthquake cordons were legally tenable because they protect life safety, which is the major objective of Nepal's emergency legislation. Additional concerns relate to the availability of resources to actualise post-earthquake cordons, such as physical barriers and personnel to patrol the boundary. When cordons cover a large area, it leads to inaccessibility of many businesses (restaurant, shops and services), which greatly reduces commercial activity and directly effects social and economic recovery.

Once the decision has been made to establish a cordon, the next decision relates to defining their spatial extent. The spatial positioning and extent of post-earthquake cordons is directly related to building damage. In a study conducted by Hulsey et al. (2022), who modelled the effects of post-earthquake cordons on recovery of downtown San Francisco area following a Mw 7.2 earthquake, they found that cordons accounted for loss of around one-third (219 days) of expected functional use of office spaces.

If the scale of damage is too great, post-earthquake cordons need to encompass wider areas to account for practical considerations of operational ease and available resources (human, economic, physical). This was observed in L'Aquila as well as in Christchurch where the initial cordon extents exceeded the boundaries of damaged areas. For Christchurch, 4 avenues around the central business area offered a simple and practical demarcation of the damage zone in the early stages, whereas in L'Aquila the existing historic walls provided an existing barrier to control access to the city centre.

When post-earthquake cordons are established, immediate evacuation of the public within the cordon boundary is required (Underwood et al. 2020). Subsequently, shelter and temporary housing needs to be provided and managed for evacuees. The case studies showed that this can create significant challenges depending on the number of people affected. Evacuation and temporary housing challenges were significant in L'Aquila, highlighted by the substantial number of residents still in temporary housing after a decade (Imperiale and Vanclay 2019). This points to the potential emergence of unintended risks to the public and demands ethical consideration to mitigate such challenges. For example, removing residents from within a cordon will displace them from their livelihoods and social networks, which may lead to negative outcomes for their wellbeing.

Once the immediate emergency response phase passes (~1–2 weeks) and recovery becomes established, the reduction of cordon extent is heavily dependent on the approach chosen by authorities. In Christchurch, elimination of risk through demolition of damaged structures was the driver to reduce cordon extent (MCDEM 2015). In contrast, L'Aquila prioritised conserving cultural heritage. This led to a focus on shoring of buildings and emphasis on structural strengthening. Similarly, in Kathmandu Valley, the limited cordons used after the earthquake were intended to protect temples and heritage monuments. The differences observed in institutional approaches and ethical values in all 3 countries emphasise the highly context-specific nature of post-earthquake cordon use.

In Christchurch and L'Aquila, the massive cordon access programs required significant communication and collaboration between the various government authorities such as police, fire, emergency management, service providers, local and central government and consultants, among others. This was a challenging task due to the scale of the disasters, which consequently led to involvement of large numbers of stakeholders, agencies and organisations. In Christchurch, the formation of Christchurch Earthquake Recovery Authority (CERA) was established through a rapidly developed Act of Parliament that set a precedent for disaster recovery in New Zealand. According to a report by the Auditor General, the authority achieved a lot during its initial phase, but faltered due to tensions between Christchurch City Council and CERA during the recovery phase (Controller and Auditor-General 2017). Additionally, the high uptake of insurance in New Zealand led to increased governance and communication challenges as insurers had issues getting access into the cordon and carrying out damage assessments. This meant that demolitions of buildings could not occur or materialise quickly enough and slowed the reduction in cordon extent over time.

The value of cultural heritage is an important determinant of post-earthquake recovery decision-making and can influence operationalisation of cordons. In the case of L'Aquila, significant resources were invested to conserve heritage buildings and to preserve the cultural integrity of the old part of the city. In Kathmandu Valley, the importance of cultural and religious practices such as celebrations and daily worship meant that cordons placed around temples were frequently breached by priests and members of the local community. In stark contrast, to expedite the recovery of the Christchurch CBD, 1,240 demolitions had been carried out within the 4 avenues by 2015, 20% of which were heritage buildings (Gates 2015).

Similarly, in L'Aquila agencies such as Civil Protection, universities and the Ministry of Cultural and Architectural Heritage collaborated with firefighters to design, develop

and implement an alternative urban shoring system. However, there were difficulties in coordinating these agencies (Grimaz 2011). Alexander (2010) provided a detailed account of the governance challenges across various institutions observed after the L'Aquila earthquake. Negative issues with governance and inter-institutional communications and collaboration are not surprising when they are established against the backdrop of a major disaster, as evident from Christchurch and L'Aquila. It can be reasonably assumed that there will be political manoeuvring when a new governance structure is developed with significant executive power and influence. This suggests that there are significant challenges that authorities face in their attempt to control the response and recovery following a major disaster.

The challenges of communication and governance are not limited to institutional systems, but also for public risk communication. Regular communication about post-earthquake cordons was necessary in Christchurch, Wellington and L'Aquila, especially in relation to the respective access programs. Honest, regular and 2-way communication is necessary to reduce distrust from the public, avoid protests, increase compliance of rules and foster the values of reciprocity.

In the absence of appropriate ethical and transparent decision-making, political pressure in relation to post-earthquake cordons is increasingly likely to be exerted by the public. This was evident in Christchurch and L'Aquila, where individuals or groups exerted political pressure explicitly through public protests (Dines 2015; McLean et al. 2012) as well as privately through various channels. Wellington suffered from political pressure although to a lesser degree, but enough to influence decisions regarding post-earthquake cordons following the Kaikōura earthquake. The heightened politics around post-earthquake cordons is evidenced by the fact that the then Mayor of Wellington had to defend his decision not to establish more extensive cordons (RNZ News 2016).

The interaction between the public and the authorities was somewhat different in Kathmandu Valley. For example, cordons around an apartment complex were removed by the public, but the authorities remained silent as they were not able to provide alternative solutions, such as temporary housing or alternative transport routes. The range of communication and governance challenges that emerged in each case study highlight the contextual nature of post-earthquake cordon decision-making and operations.

Conclusion

There is a growing need to understand the practical aspects of using post-earthquake cordons due to their increasing use after seismic events. To this end, this paper summarised 3 research papers that investigated post-earthquake cordon used in 4 different post-earthquake case studies that applied cordons as a response tool at varying spatial and temporal scales. It is clear that the purpose of post-earthquake cordons evolves from the initial need for a safe and secure area into a transitional space focused on reconstruction to support recovery of the city. An updated definition has captured the broader characteristics of cordons and the dynamic decision-making and management required for their effective use, from initial response to long-term recovery. The CODE model for post-earthquake cordons can guide emergency managers and relevant authorities to understand the range of practical considerations involved with cordons. The CODE model could be used by the authorities to make informed decisions for effective response and recovery following future seismic events.

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Urban design and wildfire engineering at the wildland-urban interface: a review of international urban planning and building requirements

Peer reviewed

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Abstract

It has been almost a decade since Gonzalez-Mathiesen and March (2014) completed their international analysis that identified 9 design features for wildfire risk reduction via urban planning. Despite their recommendations and subsequent global attempts to enhance and improve resilience from an urban design perspective, wildfires[1] remain one of the costliest hazards globally, both from a financial and a human perspective. This continued devastation raises the question as to whether urban design and wildfire engineering practices have either been adopted or changed since Gonzalez-Mathiesen and March (2014). To consider this, this paper presents a review and comparison of contemporary international wildland-urban-interface-related urban design legislation, policy and frameworks. Inconsistent approaches to addressing wildfire-related risk, and at times competing standards required between planning and building approaches were identified. These only serve to further reduce the potential effectiveness of measures intended to improve wildfire resilience at the national and international scales. Future work should focus on establishing evidence-based performance standards that emphasise the practical application of the findings of the best available current research to be incorporated into planning and construction. At the same time, it may be necessary to review policy approaches to clearly align key definitions of tolerable risk as well as provide clarification about how performance standards can be demonstrated.

Introduction

In recent years, large and severe wildfires have increased in occurrence, duration and intensity (Jolly et al. 2015). Recent mega-fires provide evidence of their scale and effects (Filkov et al. 2020; Lie and Banerjee 2021; Bonilla-Aldana et al. 2019). As part of the efforts to increase community preparedness for and resilience to wildfire, international jurisdictions have adopted guiding principles (ABCB 2014, 2022a, 2022b; WAPC 2023; QFES 2019; NFPA 2013) and prescriptive codes and standards (Miller et al. 2016; SAI Global 2018; NFPA 2017) that apply to both urban planning and fire engineering design of buildings within the wildland-urban interface (WUI) (also known as the rural-urban interface, or RUI). In addition, common urban planning design elements across jurisdictions (e.g. asset protection zones, road access standards, firefighting water access and enhanced construction standards) attempt to reduce the effects of wildfire and to assist fire services successfully defend life, property and the environment (NFPA 2013). Collectively, these requirements aim to increase the preparedness of communities to withstand wildfire, which is an essential component of the emergency management model of prevention, preparedness, response and recovery.

It has been almost a decade since Gonzalez-Mathiesen and March (2014) completed an international analysis that identified 9 design features for bushfire risk reduction via urban planning. These principles (summarised in Table 1) aimed to either reduce

1. The term 'bushfire' is used in Australia and 'wildfire' is used in other countries. Wildfire and its plural are used throughout this paper and are synonymous with other terminology such as 'wildland fire' and 'bushfire'.

Table 1: Nine design principles for bushfire risk reduction via urban planning.

Reducing vulnerability	Coordinating and improving response
Consideration of the overall context and landscape impacts on exposure from overall fire likely behaviour.	Consideration of the availability, capacity, location and travel times of emergency services, if available.
Determination of adequate separation from heat and flame sources, given topography, vegetation, likely weather and any other relevant factors.	Facilitation of the efficient access and egress of emergency services, including integration of separation spaces as spaces for active defence or evacuation locations.
Management or modification of vegetation, landscaping or other fuel sources such as outbuildings.	Ensure water availability for firefighting, including appropriate location, supply, connectivity and signage.
Management of the density, location, and design of structures, including reducing vulnerability to ember attack, and integration of building and planning standards appropriate to context and siting.	Deal with civilian response actions, including the range of possible actions such as finding refuge, actively defending or evacuating properties.
Protection of infrastructure, and care for land uses with greater vulnerability, for example, kindergartens.	

Source: Gonzalez-Mathiesen and March (2014)

community vulnerability (largely relying on the physical design of a settlement) or to improve firefighting and emergency response. Despite these findings and subsequent global attempts to enhance wildfire resilience (Intini et al. 2020; Penney and Richardson 2019; Penney et al. 2020a; Syphard et al. 2013, 2017), wildfires continue to be among the costliest disaster events both from a financial and a human perspective (Intini et al. 2020; Penney et al. 2019a; Blanchi et al. 2012; Cova et al. 2011; Haynes et al. 2008). Such destruction leads to the question as to whether urban design and wildfire engineering practices have been adopted or have changed since the work by Gonzalez-Mathiesen and March (2014). This study addresses this question with a review and comparison of contemporary international WUI-related urban design legislation, policy and frameworks. This study is significant in that it provides a contemporary review of international urban design and wildfire engineering guidelines, extends the breadth of international WUI building and planning requirements and provides a review of strategic governance, regulatory and engineering approaches that Gonzalez-Mathiesen and March (2014) considered as being required. Applications of the findings of this study facilitate improved practice in each of the themes examined, provides a basis to assist future research and contributes to the literature exploring wildfire engineering and increased resilience.

International planning and building approaches

Australia

In Australia, bushfire-resistant construction standards are incorporated into the National Construction Code via the Building Code of Australia through the adoption of Australian Standard AS 3959:2018 Construction of Buildings in Bushfire-Prone Areas (SAI Global 2018) (referred to as AS 3959). The applicability of AS 3959 is triggered by the identification of land being susceptible to bushfire or being 'bushfire-prone'. This identification essentially captures all land within 100 metres from the development containing vegetation greater than one hectare[2] in area, could burn (Penney et al. 2020a). AS 3959 details the methodology to calculate radiant heat flux as a result of worse-case fire on structures and provides associated Deem-to-Satisfy[3] and limited performance-based enhanced construction standards to increase the resilience of structures.

Notwithstanding several important technical limitations as described in Penney and Richardson (2019); Penney et al. (2020a), the use of AS 3959 has extended into jurisdictional planning provisions (WAPC 2021; NSWRFS 2019; Tasmanian Government 2020; DPCD 2011; State of Queensland 2019; Victorian Government 2024) as a method for determining whether land use is appropriate from bushfire exposure. Design requirements for urban development in areas prone to bushfire vary between jurisdictions, however, they ultimately focus on 4 aspects:

- Location as determined by a hazard level known as the Bushfire Attack Level (BAL), which is derived from the worst-case calculated radiant heat flux in accordance with AS 3959.
- Asset Protection Zone as being the separation area between flammable vegetation and the structures to be protected.
- Access and egress that includes road construction standards, access design considerations and fire service access routes.
- Firefighting water sources.

2. A hectare is 10,000 metres^2 or 0.01 kilometres^2.

3. Deemed-to-Satisfy provisions are the required design factors, materials, components and construction methods that, if used, meet the performance requirements of the associated code or policy. Performance-based solutions (also known as performance solutions) don't follow the 'recipe' of Deemed-to-Satisfy and provide an equivalent or higher level of safety measured against the performance requirement.

Table 2 summarises these requirements as well as some of the design limitations identified in this study.

While various bushfire planning provisions provide limited consideration for performance-based solutions, there is a dearth of quantitative performance requirements and verification methods identified and an almost total reliance on the approval authority's qualitative assessment (Penney et al. 2020a) of proposed performance-based alternative solutions. In comparison, since the adoption of the 2022 version of the Building Code of Australia in 2023, there are now quantified probabilistic performance requirements that apply to construction in bushfire-prone areas. There is also considerable variation between jurisdictions within Australia, with some states (including Victoria) enforcing bushfire requirements in joint planning and construction legislation, while other states such as Western Australia and New South Wales rely on separate planning legislation and construction legislation. Combined with the current state of bushfire engineering practice being unregulated (in other words, no certification or license is required to practice), the result can be inappropriate design decisions leading to inappropriate development, difficulty in enforcing compliance, excessive land use restriction, costly over-engineering and development delays (Penney and Richardson 2019). The design requirements also fail to directly consider firefighter tenability or operational feasibility limits (Penney et al. 2019a, 2019b, 2020a, 2020b, 2020c).

Canada

Bénichou et al. (2021) provides a significant and recent contribution to urban design and life safety guidance for developments in wildfire-prone areas. In this Canadian guide, an introductory explanation of wildfire fuels and behaviour is provided as well as a comprehensive

Table 2: Summary of urban design bushfire considerations and identified limitations across Australia.

Category	Requirement	Limitations
Location	Development appropriate in areas subject to radiant heat flux not greater than 29kW/m^2 (BAL-29) with high-risk or vulnerable land use not permitted in areas exceeding 12.5kW/m^2 (BAL-12.5). Development conditional on construction standards in accordance with AS 3959. Developments classified as either vulnerable land use (for example schools, hospitals and aged care facilities) or hazardous land use (industrial developments) are subject to additional measures that vary between jurisdictions. Typically, lower radiant heat thresholds (10kW/m^2) are tolerated from a planning perspective while additional performance-based solutions are required under the Building Code of Australia for Class 9 development (equivalent to vulnerable land use classification under planning approaches).	AS 3959 provides deemed-to-satisfy construction standards for developments exposed to a radiant heat flux greater than 40kW/m^2, however, from a planning perspective, only developments facing a maximum 29kW/m^2 are considered inappropriate. This creates conflict between planning and building codes and guidelines. Planning guidelines still rely on active firefighting intervention but do not consider human tenability and firefighter operational effectiveness thresholds are less than 3kW/m^2 (Penney et al. 2019a), Construction in accordance with AS 3959 is a deemed-to-satisfy approach in the Building Code of Australia meaning that irrespective of actual BAL rating, if AS 3959 is followed, the safety and risk standards of the Building Code are deemed to have been met. Building Code provisions introduced in May 2023 provide additional performance requirements with few deemed-to-satisfy provisions and approved verification methods for Class 9 buildings (health care, assembly and residential-care buildings). If correctly approached, the fire safety design of the development can address these requirements through a single approach. Conversely, if planning and building approaches are siloed and independent of each other, the potential for costly and lengthy disputes to resolve conflicts is a real possibility.
Asset Protection Zone	Landscape to include a defendable space that ensures a maximum radiant heat flux of 29kW/m^2 on the structure and is designed as an area for firefighters to conduct wildfire suppression operations. In most jurisdictions, the asset protection zone must be retained entirely within the individual land parcel, preventing adjoining properties combining to satisfy the Asset Protection Zone requirements.	
Access and egress	The primary requirement is for 2 different access routes connecting to a public road network and providing 2 different destinations. It also details design standards for internal road networks and fire service access routes.	Some major points are not considered: • Position of egress routes in relation to bushfire. • Urban density and road usage. • Time required to safely evacuate vs. available time until fire arrives (known as RSET vs. ASET).
Firefighting water supply	Requires either a reticulated or water tank supply. Where water tank supply is used, a nominal volume of water is typically required (e.g. one 50,000L tank per 25 lots or one 10,000L tank for lots greater than 500m^2).	Some major points are not considered: • Whether fire suppression operations are possible on the site. • Firefighting water flow rates and volumes required are based on credible worst-case scenarios for the sites in question.

Source: Information is summarised from WAPC (2021), NSWRFS (2019), Tasmanian Government (2020), State of Queensland (2019) and Government of South Australia (2020).

summary of National Fire Protection Association codes and research from Canada and the United States. Capturing a combination of hazard assessment criteria and methodologies, in addition to qualitative and prescriptive design standards in a similar fashion to those in the Australian Building Code and planning guides, the *National guide for wildland-urban-interface fires* (Bénichou et al. 2021) stops short of providing fire engineering approaches, verification methodologies or performance-based solutions. Bénichou et al. (2021) provide additional commentary and guidance for community utilities, public transportation and firefighting response qualifications, capabilities and legislative powers.

United States

Increasing the resilience of urban design at the WUI remains a priority for large areas within the United States. California is often perceived and portrayed as having the greatest risk due to wildland fire, with recent research (Mowery and Punchard 2021) reporting '32% of all housing units are in the WUI'. This has had a devastating effect in the event of wildfire. Conditions influencing fire behaviour (e.g. fuel, weather and topography) along with public policy, including land use, have created a history of destructive fires and has led to the development of building codes and a culture of reducing the effects of the next disaster.

The focus on resilience ranges from fire codes, building codes and reference standards, to public resources, government codes and operating principles for firefighters. In California, this is developed and implemented across numerous agencies from the state's executive and legislative branches through several agencies including the Department of General Services and Department of Forestry to local jurisdictions including cities and towns. The California Fire Code Chapter 49 *Requirements for Wildland-Urban Fire Interface Areas* (2022) covers the mitigation of conditions where wildfire burning in vegetative fuels may affect the built environment (e.g. ignite buildings, pose a threat to life, overwhelm suppression or result in large property losses).

The Director of the California Department of Forestry is empowered to classify lands and establish a Fire Hazard Severity Zone (FHSZ) that considers wildfire history, updated fuels data and potential hazard to the built environment. The California Building Code Chapter 7A *Materials and Construction Methods for Exterior Wildfire Exposure* (2019) specifies the types of building materials and construction methods that should be used for construction within the WUI. These requirements apply to all (moderate, high and very high) FHSZ areas in state responsibility and (currently) in very high FHSZs of local responsibility.

The California Building Code has numerous sections that each address building components and often have multiple prescriptive options for complying with the requirements. Within the California Fire Code, statutes, codes and regulations address road standards for fire equipment access and standards for identifying streets, roads and buildings. Defensible space requirements (analogous to Asset Protection Zone in Australia) are given for 2 zones, 0–30 feet (0–9 metres) and 30–100 feet (9–30 metres), with recent legislative changes acknowledging the importance of the 0–5 feet (0–2 metres) sub zone to be ember resistant.

Firefighters and emergency responders come from a multitude of organisations including local, state, and federal resources (volunteer and professional). The state firefighting resource, CAL FIRE, publishes a document on operating principles for the WUI incidents (CDFFP 2014).

Table 3 is a summary of the FHSZ, defensible space, access and egress and firefighting water supply considerations in California.

Beyond California, wildfire considerations for urban design vary across state and local jurisdictions (Mowery and Punchard 2021). Colorado has a large and growing population within the WUI but has few requirements in terms of land use (new developments) and lacks adoption of statewide building codes for wildfire hazards. Some states like Montana and Washington have taken steps to addressing WUI design considerations through regulation and offer tools for local jurisdictions to use and adopt. Some states and local jurisdictions have adopted the *International Wildland-Urban Interface Code* (ICCI 2020). Additionally, the National Fire Protection Association publishes consensus standards NFPA 1140: Standard on Wildland Fire Protection and NFPA 1142: *Standard on Water Supplies for Suburban and Rural Firefighting* that may be referenced by other codes.

New Zealand

In contrast to both Australia, Canada and the United States, the community perception in New Zealand is that wildfires are not prevalent enough to need planning. The prevailing view is represented in Kornakova and Glavovic (2018):

> *Most people in New Zealand are not prepared at all. People are very prepared for earthquakes and tsunamis and volcanic activity, but I don't think most people would have thought about fire as a threat. People have always seen it as something that happens in Australia or California or parts of the Mediterranean basin, and not something we need to worry about so much.*
> (Kornakova and Glavovic 2018)

In the absence of designated wildfire planning or construction requirements, Fire and Emergency New Zealand (FENZ) offers guidance to rural property owners on its website, including a rural property checklist (FENZ 2021a) and guidance on landscaping for fire safety (FENZ

Table 3: Summary of wildfire considerations for urban design in California.

Category	Requirement	Limitation
Fire Hazard Severity Zone	Considers wildfire history, fuel loading, slope, weather and other relevant factors including areas where winds have been identified as a major cause of wildfire spread.	For local responsibility areas, maps are only published by the state for very high FHSZ.
Defensible space	Fuel modification and maintenance in a condition so that a wildfire burning under average weather conditions would be unlikely to ignite the structure.	Depending on lot size and setback distances, the 5–30 feet (2–9 metres) zone may be on a neighbour's property.
Access and egress	Roads and driveways that provide for safe access for firefighting equipment and civilian evacuation concurrently.	Fails to consider: • Position of egress routes in relation to wildfire. • Urban density and road usage. • Time required to safely evacuate vs. available time until fire arrives.
Firefighting water supply	Emergency water is available, accessible and maintained in quantities and locations to attack a wildfire or defend property.	Fails to consider: • Whether fire suppression operations are possible on the site. • Firefighting water flow rates and volumes required are based on credible worst-case scenarios for the sites in question.

Source: California Fire Code (2022)

2021b). The checklist introduces the concept of creating a safety zone around rural dwellings consisting of an inner and outer zone. It is suggested the inner zone (0–10 metres from the home) consists of lawn and fire-resistant plants and trees, while the outer zone (10–30 metres from the home) includes removal of scrub and thinning existing trees, even spacing of remaining trees so that the foliage is not touching that of adjacent trees, pruning of large trees and removal of all branches within 2 metres of the ground, removal of dead or dying trees and the removal of overhanging trees near power lines. No other fire-based urban design requirements are considered.

Other countries

In France, the Forest Fire Risk Prevention Plan (Cerema 2022) relies on physical separation between 50–200 metres of buildings from vegetation that could burn. Applying a similar approach, Spain relies on 50 metres separation between vegetation and dwellings in certain areas as well as the provision of dedicated firefighting water sources (Xunta de Galicia 2007; Junta de Extremadura 2006). In contrast, neither Portugal nor Chile mandate any specific urban design or construction provisions to address the threat of wildfire. However, recent research suggests that such approaches are required (Castillo Soto et al. 2022; Samora-Arvela et al. 2023).

Discussion

While there is evidence of the 9 design principles established by Gonzalez-Mathiesen and March (2014) being partially applied in contemporary urban design and wildfire engineering requirements, the acceptance of enhanced resilience measures into urban design solutions remains varied. Australia adopts the strictest governance model from a building perspective, embedding construction standards through Standard AS 3959 being identified as a deemed-to-satisfy solution to the performance criteria of enhanced construction standards required in bushfire-prone areas. The Standard also requires WUI measures within state- and territory-specific legislation. However, the Australian regulatory mechanism for application of urban design planning requirements varies between states and territories, which may lead to irregular application. Critically, none of the Australian planning guidelines or policies reviewed referenced evidence to support design criteria beyond the qualitative principles set by Gonzalez-Mathiesen and March (2014) and few referenced verification methods beyond the calculation of radiant heat using AS 3959.

A similar situation exists within the United States, with California adopting a stricter approach to enforcing urban design requirements at the WUI compared to Colorado, Montana or Washington. Canada and New Zealand are less strict in the application of construction and urban design provisions and provide guiding (non-mandatory) provisions only. Spain, Chile and Portugal provide little, if any, risk mitigation measures to be applied. While this situation might be considered reasonable in New Zealand due to its perceived low risk of WUI fires occurring, this is not the case in Canada, Spain, Chile and Portugal, which all have a significant history of wildfire events.

The combined planning, building, fire service and community environment is a complex system with competing elements. It is challenging to identify competition across different elements and the introduction of an apparent solution in one area can result in suboptimal outcomes in another area. For example, the requirement to have specified exit routes (one of the original 9 principles) without consideration for traffic density, traffic flow rates, fire behaviours or safe evacuation times could lead people to be overrun by the fire front while trying to evacuate. When considered alongside the ongoing destruction caused by wildfires, these findings suggest that urban design and wildfire engineering at the WUI needs significant improvement. The solution lies in the adoption of formal fire engineering approaches like those already adopted within the built environment for fire safety within the Building Code of Australia, inclusive of defined performance criteria and verification methods that facilitate an evidence-based approach to urban design as opposed to the largely qualitative judgement approaches currently applied globally.

Conclusions

This paper presented a review of contemporary international WUI-related urban design legislation, policy and frameworks with a comparison to original work by Gonzalez-Mathiesen and March (2014). This study extended the breadth of international WUI building and planning requirements and reviewed strategic governance, regulatory and engineering approaches that Gonzalez-Mathiesen and March (2014) deemed as being required.

We found that the acceptance of enhanced wildfire resilience measures into urban design solutions remains varied globally. The inconsistent approaches to wildfire-related risk and, at times, competing standards required between planning and building approaches serves to further reduce the potential effectiveness of measures intended to improve resilience at a national and international scale. While there is a requirement for increased adoption of appropriate governance frameworks and regulation in areas subject to wildfire, there is also a need for robust research to develop evidence-based urban design solutions.

Ultimately, attempting to solve the wildfire issue through isolated planning and building solutions will be ineffective and result in unnecessary financial costs and bureaucratic processes. Future work should focus on the establishing evidence-based performance standards emphasising the practical application research into the combined planning and construction approach to the wildfire problem. It may be necessary to reconsider policy approaches to more clearly align key definitions of tolerable risk, as well as providing clarification as to how performance standards can be demonstrated.

Disclaimer

All statements expressed in this article are those of the authors and do not necessarily reflect the official opinion nor policies of their affiliated institutions, civilian, military, government or other.

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Analysing institutional responses towards disaster risk reduction: challenges and antecedents

Abstract

Globally, the frequency and magnitude of weather-related hazards poses significant challenges for governments and the private and the not-for-profit sectors. This paper provides exploratory insight into the challenges that hinder institutional responses to risk reduction. This study specifically considered public sector organisations within disaster risk reduction (DRR) organisational fields. The paper identifies 3 major constraints, which include fragmentation, difficulties in using risk information and cultural identities that affect public sector organisations and community responses. To analyse these issues, an institutional theory lens was used to explain the antecedents under which institutional actors may respond based on events and stakeholder expectations and demands. The findings suggest that challenges hindering response to risks and emergencies are strategic, institutional or operational in nature. A selection of public sector organisations response initiatives is presented within an Australian context with analysis of the *Sendai Framework for Disaster Risk Reduction 2015-2023* Priority 4. Recommendations and further research to identify and address other institutional constraints and sectors are recommended.

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Background

Globally, the frequency and magnitude of hazards arising from climate change pose significant challenges for governments and the private and the not-for-profit sectors. Australia has had its fair share of floods, bushfires, earthquakes, cyclones and drought and the role of the public sector in responding to emergencies and reduce disaster risks is vitally important. This is because public sector organisations are significant institutional pillars that guide societal actions. Public sector organisation functions include substantial investment in critical and social infrastructure, regulatory enforcement and providing channels for collective public action including education, training and communication (Wilkinson 2012; Twigg 2015; Abunyewah et al. 2020). Australia's second National Action Plan (Commonwealth of Australia 2023) for the implementation of the *Sendai Framework for Disaster Risk Reduction 2015-2023* (the Sendai Framework) (UNDRR 2015) indicates that the complexities associated with climate change, emergency management and risk governance architecture often makes coordination efforts difficult. Other institutional challenges associated with risk prioritisation, public awareness and engagement as well as social vulnerabilities (Paton 2019; Paton and Buergelt 2019) have been identified.

Given the complexities and uncertainties associated with risk reduction and response, this paper uses a 2-stage literature review to identify institutional challenges that influence public sector organisations and community responses as well institutional theory concepts associated with disaster risk governance. To enhance institutional responses, government reports were analysed to identify response-based interventions from an Australian perspective. The Sendai Framework Priority 4 was deconstructed as a prescriptive guide to simplify rudiments for enhancing disaster preparedness for effective response pre- and post-disaster.

Methodological approach: data search, screening and synthesis

The use of a qualitative method as a mode of inquiry into the meaning individuals or groups ascribe to social problems is one akin to research involving constructivism and the use of theoretical lenses (Creswell and Poth 2016). It involves the collection of data through examining documents, observing behaviours, interviewing participants or reviewing literature using books, journal articles and reports (Creswell and Poth 2016). This study involved traditional and critical literature reviews, which explored institutional response challenges and interventions in pre- and post-disaster stages. The rationale was to provide theoretical underpinnings that explain the antecedent factors that may influence response.

Document analysis is a valuable approach that has been underused (Merriam and Tisdell 2016). Document analysis of government reports was conducted to understand how response in Australia has been approached. The rationale was to integrate aspects of authoritative and credible sources that were peer reviewed and based on a royal commission inquiry into past disaster events including consensus contributions and agreements among government entities and stakeholders. Guiding the document analysis was the intent to identify response-based initiatives and interventions that have shaped the emergency management discourse in Australia. As Australia is a signatory to the Sendai Framework (Paton 2019), Priority 4 was deconstructed to develop a conceptual framework for public sector organisations responses.

Scopus and Google Scholar were used to obtain quality and credible peer reviewed papers published in English. A phrase-specific search on Google Scholar used the search string 'institutional challenges hindering response to disaster risks and emergencies' to identify common barriers of public sector organisation response outcomes. An initial search generated 142 documents, which were filtered based on title, abstract, keywords, body text and relevance to the discourse. There were 8 duplicates that were removed using Endnote software and 37 documents were inaccessible. This left 97 documents for scrutiny. In addition, an internet search using Google yielded 25 documents from Australian governments on the Australian Institute for Disaster Resilience Knowledge Hub, the National Emergency Management Agency website and other open source platforms.

Response-based challenges within DRR organisational fields

The term 'institution' has been widely used in disciplines to mean different things. According to Scott (2013), the generally accepted view is that institutions are social structures characterised by a high level of resilience comprising of cultural-cognitive, normative and regulative elements that provide meaning to social life. Disasters often necessitate institutional reforms and a shift in the manner with which communities manage or respond to risks. These shifts may take the form of creating new ways of adapting or responding to disasters or even totally transforming the social, economic or environmental aspects of a community. Marlowe and Lou (2013) identified a 2-way response approach (community-based and public sector-based response) to the magnitude 7.1 earthquake of September 2010 in Christchurch, New Zealand. Community members from culturally and linguistically diverse backgrounds shared valuable information for mobilising community members and organisations to identify safe shelters amidst other challenges of limited linguistic competencies, social capital networks and the awareness of local hazards (Ward et al. 2018; Marlowe et al. 2022). Table 1 provides some context to the response-based challenges in DRR organisational fields.

Fragmented nature of DRR organisational fields

In DRR organisational fields, teams are drawn from diverse disciplines and bring together personnel with varying backgrounds, experiences and skillsets. Challenges can

Table 1: Some response-based challenges in DRR organisational fields.

Contexts	Response constraints	Authors
Contested logics across disciplines. Environmental policies and power dynamics. Complexities of competing demands and expectations.	Fragmentation	Bertels and Lawrence 2016; Kissinger et al. (2021); Hagelsteen and Becker (2019)
Influence of risk communications on intentions to prepare. Relationships between municipal risk communication approaches and development priorities. Design and implementation of early warning systems.	Information access	Abunyewah et al. (2020); Agrawal et al. (2022); Goerlandt et al. (2020); Satizabal et al. (2022)
Indigenous knowledge, worldviews and inclusivity. Risk, transformation and adaptation. Design and implementation of disaster management interventions.	Cultural identities	Ali et al. (2021); Paton and Buergelt (2019); Paton (2019); Cannon (2016); Imperiale and Vanclay (2020)

arise from limited shared understanding of how issues may be assessed and resolved (Renn et al. 2011). This issue is attributed to mindsets and views of fields as fragmented with contesting logics, which influence organisational actions (Bertels and Lawrence 2016; Lounsbury 2007). Given the variance in standards of operations, the manner with which personnel execute plans would differ, which leads to information asymmetry and operational or evaluative disconnects under field conditions. Twigg (2015) suggested that partnering organisations may have different mandates, value systems and ideologies as well as funding streams and may use and interpret terminologies differently. During coordination, organisations are required to make decisions under high degrees of uncertainty and in complex situations due to competing demands from multiple stakeholders. This could lead to ambiguity (Hagelsteen and Becker 2019). Kissinger et al. (2021) also identify fragmentation as a challenge in the environmental policy area indicating conflicting sector goals, disconnects between global and local action and ambition as well as imbalances in power dynamics.

Access to information difficult to use

Communication plays a crucial role in organisations as it sets the pace for decision-making and organisational or community actions. It also has a central role in managing disaster risks. The challenge is that communication can take a one-way dimension (mostly in a scientific or quantifiable manner). Hence, it can be difficult to simplify information for diverse populations with varying learning and interpretative needs. DRR personnel also deal with multiple channels of communication to improve responsiveness. A challenge is to identify ways to minimise language barriers for tourists and residents (Teo et al. 2019; Véliz-Ojeda et al. 2020) who may have limited understanding of the dominant language in communities where they dwell. As such, public sector organisations must develop mechanisms through symbols or language translations that can be integrated into information sharing platforms. Abunyewah et al. (2020) suggested that elements of effective risk communication such as trust, information sufficiency, efficacy, message clarity and source credibility are crucial for a community's participation and receptiveness (see Figure 1). The literature review indicates that for knowledge to be effectively created and disseminated, the transformation or conversion of tacit and explicit knowledge should be considered (Toinpre et al. 2018; UNDRR 2015; Twigg 2015). While this may be a daunting task, communities can use dialogical approaches involving cross-cultural communication mechanisms.

Cultural identities impeding risk management

Culture plays a critical role in risk management and influences the manner with which societies perceive and respond to disaster events. People interpret information differently based on their cultural identity manifested through lived experiences, beliefs, traditions, geographic location and gender orientation (Hewitt 2009; Lai 2022; Odiase et al. 2020). This means cultural aspects would determine the choices people make to adapt, avoid or cope with a particular situation. Culture shapes people's perceptions and responses to a given event (Hewit 2009). For example, response would differ for people residing in mountainous regions experiencing volcanic eruptions or glacial activity compared to people residing in riverine areas experiencing flooding (Bird et al. 2011). This implies that geographic location also influences people's risk knowledge and behaviours. According to Blaikie et al. (2014), the lack of access to power, structures and resources exacerbates vulnerability and unsafe conditions. Therefore, understanding power positions and the influence on responses to risks is crucial. Also, the representation of vulnerable communities and their inclusion in critical and social infrastructure (i.e. schools,

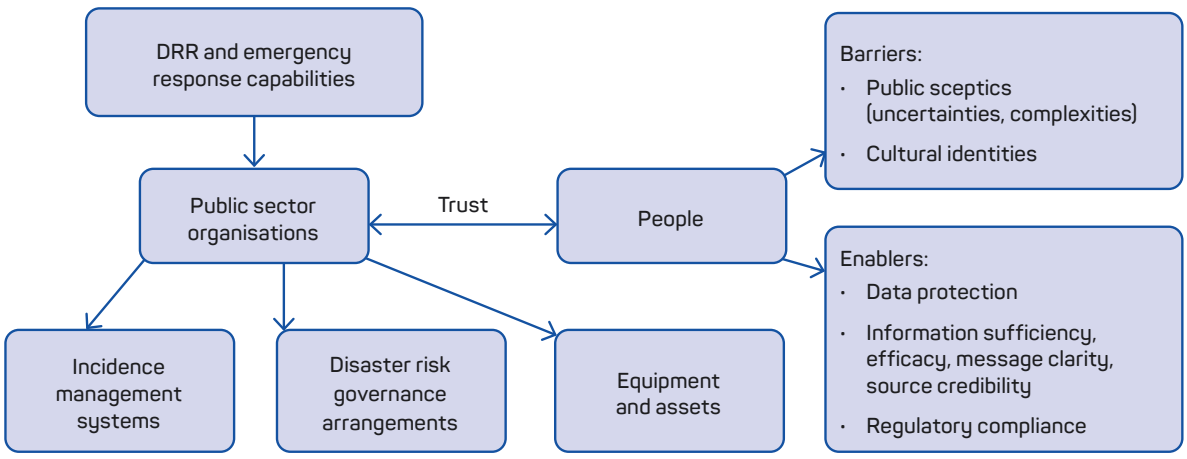

Figure 1: Institutional antecedents for disaster risk reduction and response.

hospitals, recreational spaces, bridges, etc.) investment is of paramount significance (Tierney 2012). Political will to address this can influence wealth distribution and risk reduction investment in exposed communities. While people living in communities with access to amenities and resources are better able to relocate to safer locations, others living in areas with minimal investment in critical infrastructure may find it challenging to safely relocate. Another consideration is that of trust, loyalty and sense of attachment to the land. Hewitt (2009) described this as a dilemma between remaining as 'environmental refugees' and 'perceptions of safety'.

Institutional pressures and antecedents for public sector organisation responses

Understanding institutions and how they work is beneficial to identifying response mechanisms that address stakeholder expectations and demands to reduce risks within communities. The lack of organisational analysis presents a challenge to DRR organisational field actors especially for those involved in designing and implementing projects, informing policy dialogue and coordinating development efforts across various levels of governance. For example, in the wake of the summer bushfires 2019–20, some states responded by declaring a state of emergency (Commonwealth of Australia 2020). Table 2 lists examples of events that activated institutional and operational responses to DRR in Australia.

Public sector organisations are subject to 3 forms of institutional pressures (coercive, normative and mimetic) both internally and externally. Coercive pressures manifest through an organisation's adoption of practices or processes prescribed by a dominant organisation. Normative pressures stem from meeting requirements such as certifications, protocols and standards of operations. Mimetic pressures involve imitating organisational processes or practices that have proven to be successful (DiMaggio and Powell 1983; Scott 2013; Toinpre et al. 2018). Various stakeholder groups, including public sector organisations officials, and the public can exert these pressures. Table 3 categorises some institutional responses to constraints based on event-triggered activations listed in Table 2.

Exploring antecedent factors through which public sector organisations respond to pressures provides a rationale to analyse organisational behaviour under varying circumstances (Oliver 1991). The willingness and commitment of organisations to conform or resist coercive, normative or mimetic pressures depends on:

- why the pressures are being exerted (cause)
- what entities are that exert the pressures (constituents)
- what sort of pressures are being exerted (content)
- where the pressures are emanating from (context)
- by what means the pressures are being exerted (control).

An understanding of these conditions may assist public services organisations effectively respond to disaster risks under varying conditions. These antecedents often shape DRR and emergency response capabilities.

Table 2: Examples of response-based activations in Australia 2003–2019.

Events	Year	Response initiatives / activations
Bushfires in the Australian Capital Territory	2003	Restructured emergency management arrangements Developed a Strategic Bushfire Management Plan (SBMP)
Indian Ocean tsunami	2004	Quad partnerships between Australia, the United States, Japan and India
Tropical Cyclone Oswald	2013	Betterment funding under Category D
North and Far North Queensland monsoon trough	2019	
2019-20 bushfire season	2019	National Bushfire Recovery Agency Queensland State of Emergency New South Wales State of Emergency
	2020	Victoria State of Disaster Australian Capital Territory State of Alert
Queensland flooding	2019	National Drought and North Queensland Flood Response and Recovery Agency
Tropical Cyclone Kirrily	2024	Disaster Recovery Funding Arrangements[1]
COVID-19 pandemic	2019	Partners in the Blue Pacific – an initiative between Australia, Japan, New Zealand, United Kingdom and the United States of America

Source: Commonwealth of Australia (2020)

1. Queensland Government Reconstruction Authority: www.qra.qld.gov.au/sites/default/files/2024-01/v1_activation_summary_tropical_cyclone_kirrily_commencing_25_january_2024_v1_0.pdf

Table 3: Categorising some institutional responses to pressures emanating from constraints.

Institutional constraints	Coercive	Normative	Mimetic
Fragmentation	Political commitment	Institutional efficiency	Inter-organisational collaboration
Information access	Public sector financing	Information sharing and engagement	Externally institutionalised norms
Cultural identities	Regulations	Attitudinal change	Adopting new practices

Exploring Australia's institutional responses to DRR

Australia's DRR organisational field has experienced change. In 2023, the National Emergency Management Agency (NEMA) was established through a merger between the previous National Recovery and Resilience Agency and Emergency Management Australia. This change came with the need for organisational advisory support so that decision-makers are provided with the necessary tools, equipment/assets to respond to demands and expectations from institutional constituents while ensuring incident management systems and governance arrangements are inclusive. As identified in the mid-term review of the Sendai Framework implementation, Australia has agencies and committees such as the Australia-New Zealand Emergency Management Committee[2] and Australia and New Zealand Council for Fire and Emergency Services (AFAC)[3] to meet its obligations to improve resilience of communities (Commonwealth of Australia 2022). Figure 2 provides examples of multilevel institutional frameworks that complement existing arrangements between Australia's states, territories and local governments.

Various organisations deal with fragmentation differently. For example, homogenising the National Recovery and Resilience Agency and Emergency Management Australia to establish NEMA has unified operations in terms of reducing duplication and improving coordination and management of emergencies and disasters. However, the challenge remains in synergising operations across disciplines within the field. Using an inter- and intra-organisational approach through the formation of collaborative partnerships such as the Northern Rivers Resilience Initiative[4] (a partnership between NEMA and CSIRO in New South Wales) has prioritised flood resilience through the development of a community-supported solution (see Figure 3 for Australia's early warning arrangements). Another initiative to address fragmentation has been the Regional Collaborations Program[5] that builds linkages in the Indo-Pacific Region to facilitate research and innovation.

2. Australia-New Zealand Emergency Management Committee, https://nema.gov.au/index.php/about-us/governance-and-reporting/committees-and-councils/national-emergency-management-meetings-and-committees#anzmc.
3. AFAC, www.afac.com.au.
4. Northern Rivers Resilience Initiative, www.csiro.au/en/research/disasters/floods/Northern-NSW-Resilience-Initiative.
5. Regional Collaborations Program, www.education.gov.au/regional-research-collaboration-program.

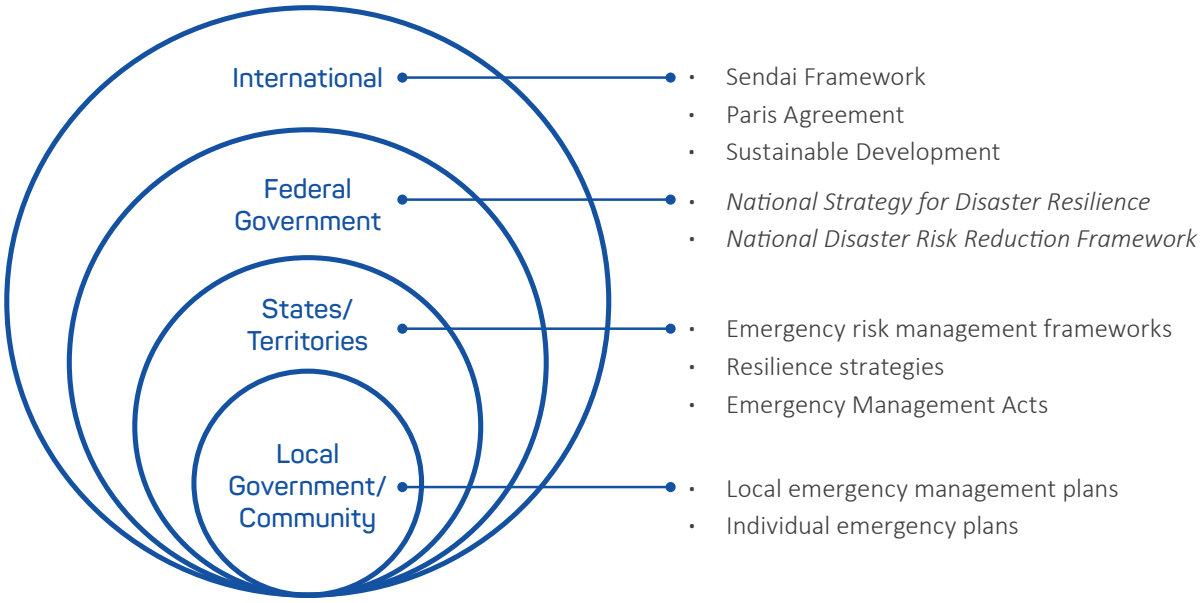

Figure 2: Examples of multi-level institutional frameworks and arrangements for DRR in Australia.
Source: Adapted from Commonwealth of Australia (2020), p.112.

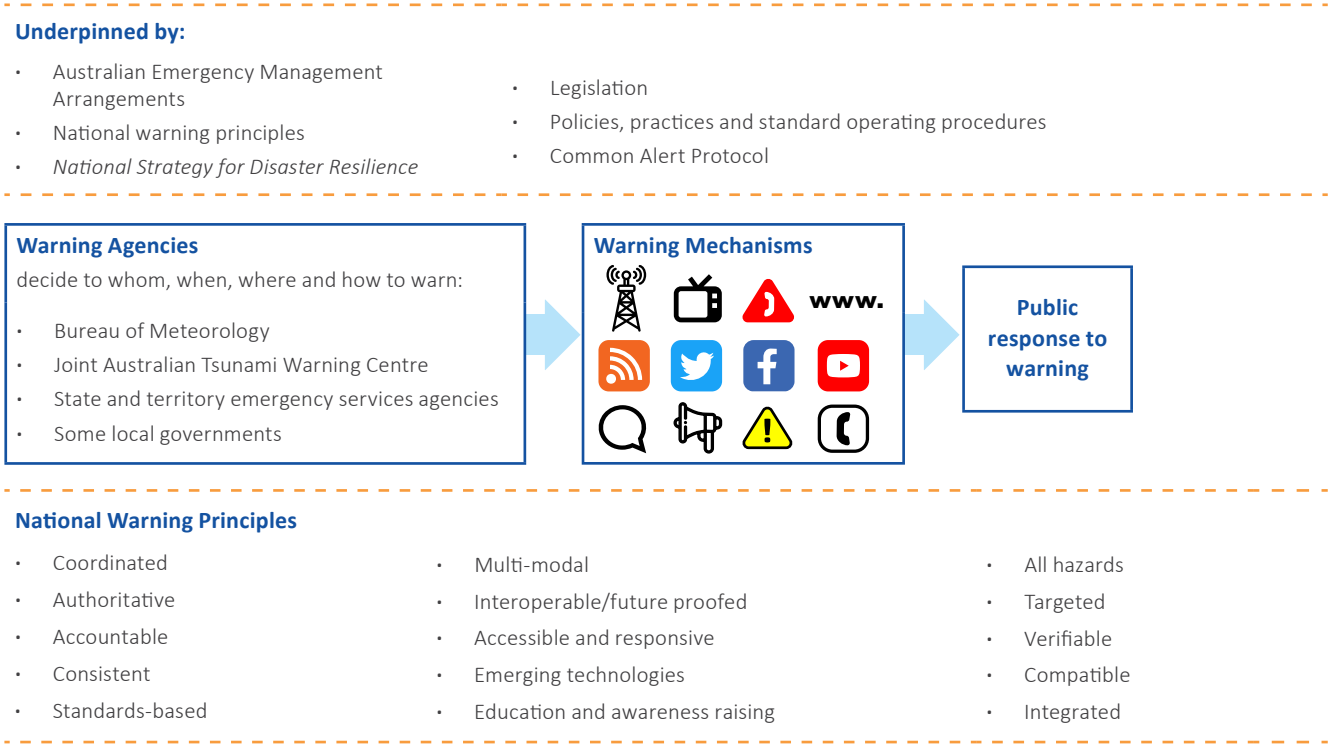

Figure 3: Australia's emergency warning arrangements.

Source: Commonwealth of Australia (2020), p.289.

In terms of access to information, the Australian Institute for Disaster Resilience Knowledge Hub supports and informs policy, planning, decision-making and contemporary practice in risk resilience. Another initiative is the Trusted Information Sharing Network[6] that works with industry on critical infrastructure resilience. AFAC is also a trusted source of advice for the field through sharing knowledge, lessons learnt and challenges. Finally, considering the issue of integrating cultural inclusivity into resilience initiatives, the Australian Government through the National Indigenous Australian Agency[7] funds the Indigenous Ranger Program[8] and Indigenous Protected Areas Program[9] to support Aboriginal and Torres Strait Islander peoples to combine their knowledge with conservation training to protect land, sea and culture including cultural fire management activities. Other initiatives are Aboriginal Communities Emergency Management Program and the Australian Institute for Disaster Resilience Education for Young People Program[10] to improve preparedness and response at a community level.

DRR efforts often depend on complex governance arrangements (Tierney 2012). The regulative and normative institutional pillars are based on defining institutional norms that guide emergency management policies and DRR strategies, plans and program implementation. However, in the Australian context, there are attributes that define emergency management systems that include existing arrangements, hierarchies, symbolic systems, routines and artefacts (Rosell and Saz-Carranza 2020; Albris et al. 2020) for national coordination (see Figure 2). There are 3 mechanisms that facilitate a whole-of-government approach; the National Coordination Mechanism, the Crisis and Recovery Committee and the Inter-Departmental Emergency Taskforce. These mechanisms provide situational awareness, advice and data to support decision-making, communication and strategic coordination (Figure 4).

Institutional responses to disaster risk: integrating the Sendai Framework priority

Dealing with each phase of the emergency management cycle presents intra- and inter-organisational challenges that require experience and the right skills and competencies (von Meding et al. 2011; Ahmed and Charlesworth 2015; Seddiky et al. 2020). Responding to pressures may manifest through policy reforms, investment in critical infrastructure, capability

6. Trusted Information Sharing Network, www.cisc.gov.au/how-we-support-industry/partnership-and-collaboration/trusted-information-sharing-network.
7. National Indigenous Australian Agency, www.niaa.gov.au/.
8. Indigenous Ranger Program, www.niaa.gov.au/our-work/environment-and-land/indigenous-rangers.
9. Indigenous Protected Areas Program, www.niaa.gov.au/our-work/environment-and-land/indigenous-protected-areas-ipa.
10. Education for Young People Program, www.aidr.org.au/programs/education-for-young-people-program.

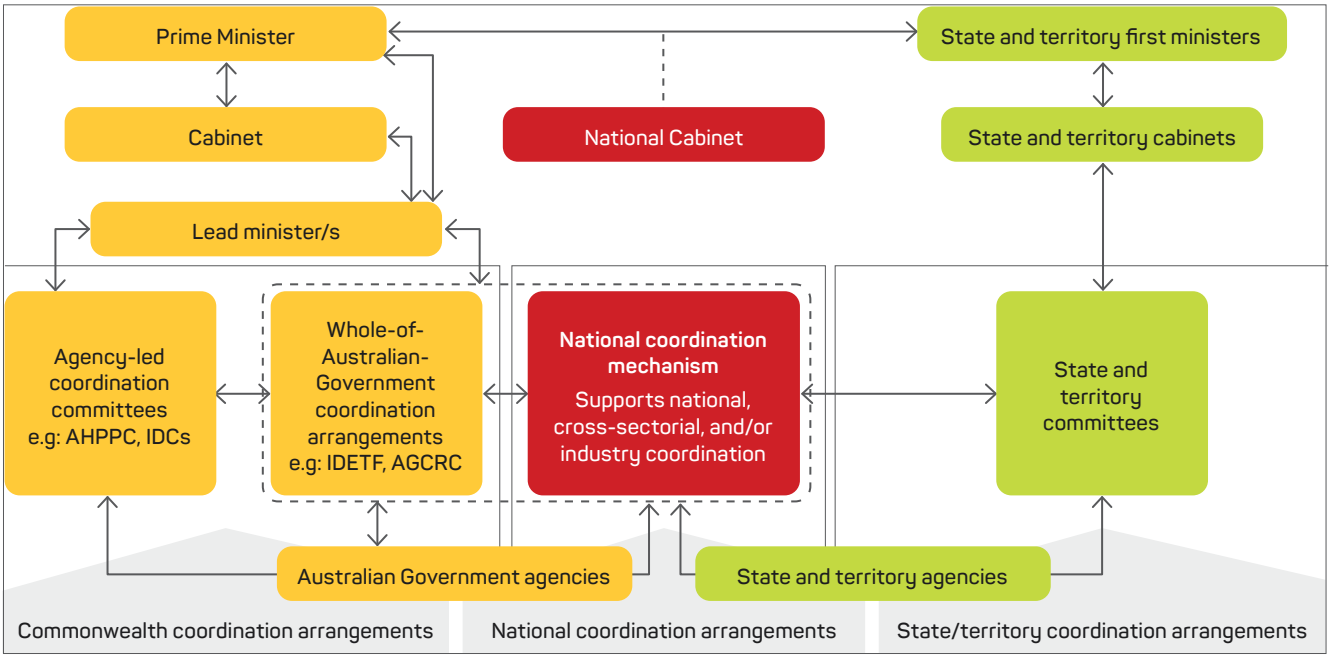

Figure 4: Australia's emergency management coordination arrangements.

Source: Commonwealth of Australia (2023), p.31.

enhancement through education and training or review of pre-existing institutional arrangements. The Sendai Framework Priority 4 - Enhancing disaster preparedness for effective response and to build back better in recovery, rehabilitation and reconstruction, emphasises the need to strengthen preparedness for response and taking action to anticipate while ensuring capacities are in place at all levels. Figure 5 shows that Priority 4 is sectioned across pre- and post-disaster actions to include planning (Section A) and response (Section B). Planning involves disaster preparedness policies and plans that include climate change and impact involving relevant institutions required to facilitate DRR participation and engagement. Response deals with harnessing human resources to facilitate participation and engagement. Multi-sector forecasting and early warning (33b, 34c) were identified as stimulants for investment in critical infrastructure (33c) especially those relevant for community evacuation. In addition, the development of codes for coordinated action in response and preparedness (34b) were noted as significant aspects to strengthen laws and procedures on national and international cooperation (33p). These will further yield initiatives for response involving the adoption of policies for coordination and funding mechanisms for relief assistance and recovery/reconstruction (33e). Priority 4 also emphasises on training and enhancing capabilities for response and recovery. This involves conducting drills (33h, 34f), simulations and stockpiling (33d, 34h) to aid rescue and recovery and to strengthen the capacity of local authorities for evacuation. By engaging community stakeholders, public sector organisations can bring continuity of planning and operations (33g) to the post-disaster phase.

This study was not exhaustive; however, it illustrates paths through which the Sendai Framework can be visualised. As public sector organisations responses may be either passive or active, Norman et al. (2014) suggest that, generally, such responses need to be continuously updated to reflect the latest scientific and technical knowledge. This is viable to help decision-makers within DRR organisational fields to consider areas given less attention. Traditions, beliefs and risk perceptions can determine community willingness and capacity to influence response in reconstruction and recovery (as was the case of Mostar, Bosnia and Herzegovina and Christchurch, New Zealand). Although in the case of Mostar, the concept of 'building back better' after a disaster did not override the role of cultural awareness and heritage preservation as they demonstrated a strong sense of place and cultural identity. For them, reconstructing a bridge and retaining its initial features using the same local materials symbolised the restoration of desecrated values and the re-established a structure of cultural significance.

Conclusions and recommendations

This study considered challenges that hinder response to risks and emergencies that are strategic, institutional and operational. Responses can be passive or active depending on the nature of antecedents. These aspects are often guided by the nature of pressures (coercive, normative or mimetic) exerted on institutional constituents. The

study drew on relationships between institutional theory concepts and aspects of public sector organisation responses to understand institutional dynamics within DRR organisational fields. Given the complexities and uncertainties of disasters, DRR organisational fields are often multi-disciplinary and offer opportunities for different disciplines to work together. Yet, a fundamental challenge to unifying unique elements of varying logics, perspectives and values remains daunting across preparedness, prevention, response, mitigation, reconstruction and recovery. Effective responses are often characterised by trust, information sufficiency, efficacy, message clarity and source credibility. While risk information may be transmitted differently, diversifying information sharing is viable to foster multi-stakeholder responses. In addition, cultural identity issues manifest in difficulties associated with stakeholder characteristics, normative and cultural-cognitive attributes, varying values, cultures and traditions that influence community and organisational response.

Practical steps that can be taken to bridge institutional gaps are provided in the literature. However, these appear scarce in DRR organisational field discourse using institutional theory. Practically, face-to-face communication by field workers, community mobilisers, extension workers, local meetings and workshops have proven to be effective for knowledge sharing, learning and dialogue that facilitate response. In Australia, constitutional and operational responsibility lies with the states and territories and the autonomous nature of risk management across jurisdictions differs making operationalising arrangements complex. The Royal Commission into Natural Disaster Arrangements (2020) detailed stakeholder challenges associated with understanding and using information. This causes inefficiencies, siloing and duplication of effort and calls for nationally consistent multi-hazard mechanisms for communicating risks. This approach helps to avoid confusion for states and territories using similar mechanisms but conveying different information across each jurisdiction. These gaps are being addressed. For example, the Australian Warning System[11] was updated to bring consistency to actions for multi-hazard warning levels. These were the same nationally but had varying symbols and corresponding actions required under each alert level. This issue was also similar for terminologies used for fire danger ratings. Power dynamics is a major factor influencing actions and may emerge from socio-economic status of participating organisations, formal authority, social capital, specialist knowledge and expertise. Efficient accountability mechanisms may resolve some of these issues and propel receptiveness towards adopting practices that are more inclusive and holistic. A limitation of this paper is that it focuses on public sector organisations. Further contributions using other sectors will improve the knowledge base within DRR organisational fields.

11. Australian Warning System: www.australianwarningsystem.com.au

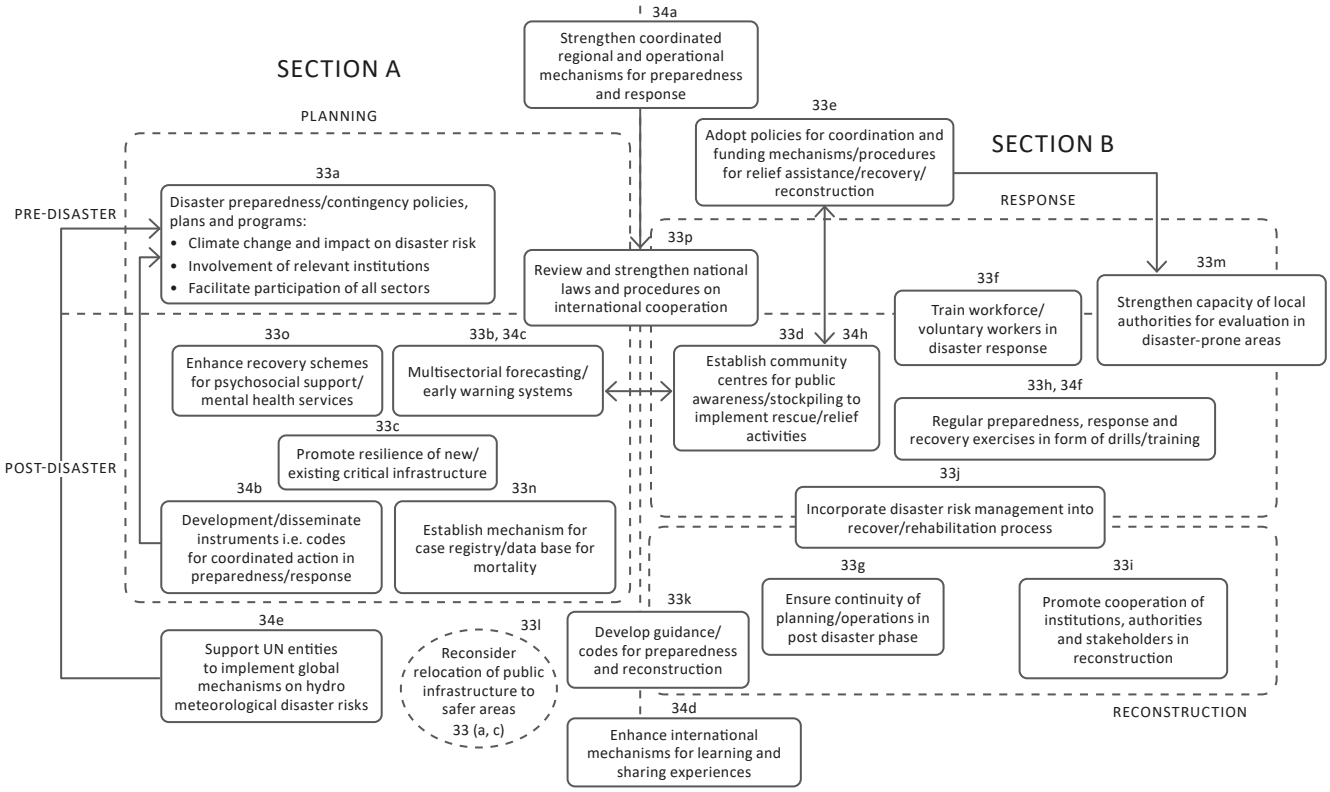

Figure 5: Deconstructing the Sendai Framework Priority 4 - Enhancing disaster preparedness for effective response and to build back better in recovery, rehabilitation and reconstruction.

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The South Australian Department of Health and Wellbeing approach to emergency management during the COVID-19 pandemic

Abstract

This paper summarises the strategic and operational approaches to emergency management taken by the South Australian Department of Health and Wellbeing (better known as SA Health) during the COVID-19 pandemic State of Emergency declaration between 22 March 2020 and 24 May 2022. It identifies several lessons that may be useful for future responses to similar types of emergencies. It is concluded that SA Health's response was highly effective, with all of the response's strategic objectives achieved; however, activities in some areas could nevertheless have been more efficient.

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Introduction

COVID-19 was first detected in China in December 2019 (Graham and Baric 2020:734). The subsequent global pandemic is now in its fifth year, with the response including community lockdowns, social distancing, mandatory mask wearing, imposition of travel restrictions, and mandatory quarantine (Piret and Boivin 2021:10). These measures were widespread in Australia during the first two years of the pandemic, but have since ceased. In their place, Australia has transitioned to ongoing pandemic management as a part of routine business, and now takes a predominantly clinical as opposed to a public health approach. The third year of the COVID-19 pandemic was characterised by its progressive disappearance from media prominence, and by increased speculation as to when the disease would be declared endemic, formally ending its pandemic status (Klobucista 2022).

As Huremović (2019:22) observed about the 1918 Spanish Flu pandemic, 'societies deal with such rapidly spreading pandemics … at first with great interest, horror, and panic, and then, as soon as they start to subside, with dispassionate disinterest'. The COVID-19 pandemic is now well into the latter part of this process. Perhaps because of the rapidity with which the pandemic response rose and then fell from prominence, there has been limited exploration of potential lessons it may yield. In Australia, the COVID-19 pandemic was treated as a public health emergency for over two years at both the national and state levels (Evans 2022). In addition to its more prominent epidemiological aspects, several aspects of the response fit within the field of emergency management.

This paper seeks to fill a gap by identifying lessons from the state-level COVID-19 pandemic emergency response in South Australia (SA). First, it summarises SA's emergency management arrangements and how these were applied during the COVID-19 pandemic. Second, it summarises the pandemic's progression within SA and the Control Agency's emergency management strategies. The Control Agency was the SA Department of Health and Wellbeing, which along with its affiliated health networks and services is more often referred to as SA Health (SA Health 2022a). Third, this paper examines how these strategies were implemented operationally, and several lessons are identified. Lessons mostly relate to the application of the Australasian Interservice Incident Management System (AIIMS) (AFAC 2017), as this was used to organise State Control Centre – Health (SCC-H), which was established to coordinate SA Health's pandemic response operations. Overall, SA Health's COVID-19 pandemic emergency response was one of the most effective in the country; however, as the lessons identified show, its activities in some areas could have been more efficient.

Emergency management in South Australia

Emergency management in SA is governed by the *Emergency Management Act 2004* (SA) (hereinafter 'The Act') (Government of South Australia 2021). The Act establishes a State Emergency Management Committee and State Emergency Management Plan (SEMP), with the former responsible for preparing and updating the latter, as well as for providing strategic oversight of a range of emergency management functions. The Act appoints the Police Commissioner as the State Coordinator and South Australia Police (SAPOL) as the Coordinating Agency, with responsibility for interagency coordination and for facilitating Control Agency functions.

A Control Agency is appointed under The Act and has responsibilities for the management of a specific type of emergency. Control Agency responsibilities are detailed in the SEMP rather than in The Act (Government of South Australia 2022b:16–17). Of the 22 types of emergencies for which the SEMP specifies a Control Agency, this role is delegated to SAPOL 11 times; the SA Metropolitan Fire Service (SAMFS), SA Country Fire Service (SACFS) or SA State Emergency Service (SASES) twice each; and to one of five State Government departments for the remaining six types of emergencies. SA Health is the only department designated as the Control Agency for two types of emergencies: food or drinking water contamination, and human epidemics. Four other departments are each specified as the Control Agency for a single type of emergency (Government of South Australia 2022b:18).

When not the Control Agency, the other agencies mentioned in the SEMP have defined roles as Supporting Agencies. These roles may also be delegated by the State Coordinator to government departments not mentioned in the SEMP. An interagency list of nine functional support groups is also given, along with a lead agency for each group. Functional support groups focus on areas including logistics, communications, public information, emergency accommodation, engineering, and ambulance and Australian Defence Force (ADF) support (Government of South Australia 2022b:19–20). Additionally, SA is geographically divided into 11 'zones', with a Zone Emergency Support Team (ZEST) able to be activated by the Control Agency to respond to emergencies locally within the zone. A ZEST is coordinated by the Local Police Commander (Government of South Australia 2022b:9,20).

South Australia's COVID-19 pandemic State of Emergency arrangements

The first two cases of COVID-19 in SA were diagnosed on 1 February 2020 (ABC News 2020a). Amid growing case numbers originating in returning overseas travellers, a public health emergency was declared on 15 March (Keane 2020). This was followed on 22 March by Police Commissioner Grant Stevens declaring a state-wide State of Emergency under The Act (ABC News 2020c). The State of Emergency was extended several times, ultimately remaining in place for a record 793 days, until 24 May 2022 (Malinauskas, 2022).[1] The Chief Public Health Officer, Professor Nicola Spurrier, was appointed as State Controller – Health, and SA Health became the Control Agency (SA Health, 2020:15).

In accordance with SEMP requirements, the State Emergency Centre was stood up following the State of Emergency declaration to provide support to the Police Commissioner in his role as State Coordinator (ABC News 2020c). SA Health had stood up SCC-H on 2 February, prior to the State of Emergency declaration and as part of its response to detection of the state's first positive cases. Initially staffed by four people who held substantive appointments elsewhere in the department, SCC-H staffing rapidly expanded and other agency representatives were embedded within it following the declaration of the public health emergency (Parliament of Australia 2020:Table 8). These early measures ensured that SCC-H was already functioning when the State of Emergency was declared, at which time it commenced fulfilling the emergency response control and coordination roles of the Control Agency (Government of South Australia 2022b:21).

1. For context, the second-longest declared State of Emergency in SA history lasted for 11 days, following flooding in the state's north (Nine News Staff, 2022).

Progress of the pandemic and SA Health's emergency response strategies

With hindsight, three distinct stages of SA's COVID-19 pandemic response can be identified. The nature of response strategies and the associated operational approaches, organisational structures, missions, main effort and key tasks varied considerably between these stages. It is therefore useful to address each stage separately.

Elimination stage

The first stage ran from the first case diagnosis on 1 February 2020 until 22 November 2021, which was the day before the state's borders were opened. This can be referred to as the elimination stage. The state's emergency response strategy implemented during this stage aimed to minimise risk to vulnerable community members, as little was known about COVID-19 during the early months of the pandemic and no vaccine was yet available (Spurrier 2020). To achieve this aim, the strategic objectives were to 'flatten the curve', prepare hospitals for an influx of COVID-19 positive admissions, and 'take the public on the journey' by keeping them informed of the approach and the reasons it was being taken. As this stage progressed, efforts to flatten the curve were so successful that the first of these objectives evolved into achieving zero COVID-19 cases within the state.

There were four community outbreaks within the state during this stage, with all being contained within days-to-weeks. These outbreaks were interspersed by lengthy periods when the only COVID-19 cases in the state were among the capped number of returning international or interstate travellers who were required to isolate in specialised medi-hotels for a 14-day period following arrival. The four outbreaks were the initial outbreak at the start of the pandemic (March to May 2020), the Thebarton Cluster (August 2020), the Parafield Cluster (November 2020) and the Modbury Cluster (July to August 2021) (InDaily Staff 2020; Richards 2020; ABC News 2020b; ABC News 2021). Of these, the initial outbreak was the most extensive, eventually including 438 positive cases (InDaily Staff 2020). The other three outbreaks were quickly and effectively contained, with each peaking at less than 50 active cases following short periods of strict lockdown implemented under The Act. Key indicators of the success of this approach are that, as at 22 November 2021, SA had the lowest total number of cases for any mainland Australian state and the lowest number of COVID-19-positive fatalities (COVID Live 2022).

Seeding and suppression stage

The second stage started when state borders were opened on 23 November 2021 and ran until the end of the State of Emergency declaration on 24 May 2022. This can be referred to as the seeding and suppression stage. During this stage, the state opened its borders to other states with active COVID-19 outbreaks and, shortly afterwards, to international arrivals. The intent at its outset was to introduce COVID-19 into the community in a manageable way (Spurrier 2021). Modelling conducted prior to the border opening was based on data pertaining to the Delta variant, an 80 percent community double vaccination rate, and the continuation of then-extant public health measures such as mandated mask wearing in public. This modelling showed a 27 percent chance of an 'outbreak', which was defined as over 100 cases per day for three or more days (Richardson 2021). It also predicted that case numbers would peak in mid-February 2022. Preparations for this stage, including the numbers of hospital beds expected to be required and the anticipated extent of the out-of-hospital response, were based on this modelling.

Four days after the state's borders opened, the World Health Organization recognised the newly-emergent Omicron variant as a 'variant of concern' (Nebehay and Winning 2021). This variant, which is much more infectious than Delta, was first detected in SA on 9 December 2021 (Lal 2021). Its presence rendered the Delta-based modelling outdated. In particular, its increased infectiousness caused greatly increased case numbers above those the modelling anticipated. This infectiousness necessitated expansions in both the hospital and out-of-hospital components of the response. New modelling occurred as soon as sufficient data on the Omicron variant became available, though this was not until a month after its detection (Spurrier 2022). The initial Omicron outbreak in SA peaked on 20 January 2022, about a month earlier than the Delta-based modelling had predicted, with 35,525 active cases including 290 people hospitalised (SA Health 2022b). After this, case numbers decreased until, by 22 February 2022, there were only 13,161 active cases (SA Health 2022c). Since that time, case numbers have oscillated, with a second peak in mid-April 2022 caused by the BA.2 sub-variant (Esterman 2022). This was the final significant wave of infections prior to the cessation of the State of Emergency.

Living with COVID-19 stage

The third stage commenced when the State of Emergency ended on 24 May 2022, and continues at the time of publication. This can be referred to as the living with COVID-19 stage. The response during this stage has occurred under the *South Australian Public Health Act 2011* (SA), which was amended in May 2022 to enable

an ongoing public health response without requiring continued use of the *Emergency Management Act 2004* (SA) (Malinauskas 2022). This stage has been defined by the integration of ongoing but reduced-scale response capabilities into SA Health's routine business practices. Part of this reduction included SCC-H ceasing operations in mid-June and disbanding on 30 June 2022. After this, some SCC-H functions ceased while others were transferred to different parts of SA Health. Although some of the ceased functions seem to have been temporarily reinstated at the peak of various waves of cases (see Harmsen, Boisvert and Opie 2022), such occurrences also seem to have decreased over time as response activities have become increasingly routinised.

Cases have continued to oscillate during this stage, and periodic peaks and troughs in case numbers are likely to continue indefinitely now that COVID-19 is within the community. It is also likely that this stage will continue until COVID-19 is declared to have transitioned to being endemic. Though speculation about the likelihood of this declaration is growing, it may still be several years away (Klobucista 2022). Regardless of timeframe, SA Health's COVID-19 response is already sufficiently integrated into routine business that this declaration is unlikely to have any noticeable operational impact.

Operational approach, effectiveness and lessons identified

The COVID-19 pandemic was the first time SA Health had been appointed as the Control Agency during a State of Emergency declaration. Though it had previously been a Supporting Agency, this required little organic emergency response capability. This meant that almost all of SA Health's capacity to conduct emergency response operations had to be built from scratch as the pandemic progressed. This included establishing and consolidating SCC-H, as well as several task-organised entities that became known as 'workstreams' by mid-2020.

From its establishment, SCC-H was organised in accordance with the AIIMS guidelines (AFAC 2017). This was due to the extensive assistance SA Health received from state and national-level emergency management agencies during the first year of the pandemic. Most notably these agencies were SACFS, SAMFS, SASES, SAPOL, and the ADF. The first three of these agencies use AIIMS, while the others instead use a similar staff structure in their own headquarters (ADF 2019:Annex 1B).[2] Embedded SACFS officers in particular assisted SA Health to implement AIIMS guidelines as it developed its own emergency response capabilities.

The AIIMS guidelines were adapted to meet the unique requirements of the first two stages of SA Health's pandemic response. Table 1 summarises these adaptions and lists the overarching functional areas within the SCC-H organisational structure. The greyed-out boxes within Table 1 indicate where the SCC-H and AIIMS structures deviated from each other. Furthermore, Table 1 does not list sub-structures nor constituent components within each SCC-H functional area. Both of these aspects are discussed separately below.

2. There is a very strong case to be made that the organisational structure contained in AIIMS is derived from the ADF staff structure, which is much older, having its roots in the North Atlantic Treaty Organization Common Staff System. This has its own antecedents dating to the Napoleonic Wars (Zabecki 2008a:1–22; Zabecki 2008b:1–20).

Table 1: SCC-H adaptions to the AIIMS framework.

AIIMS structure (source: AFAC 2017:46)	SCC-H structure (elimination stage)	SCC-H structure (seeding and suppression stage)
Incident Control	Commander	Commander
Deputy Incident Control	Deputy Commander	Deputy Commander / Duty Commanders
Liaison	Liaison Officers	Liaison Officers
Safety		
Planning	Planning	Planning
Intelligence	Intelligence	Intelligence
Public Information	Public Information	Public Information
Operations	Operations	Operations and Logistics
Logistics	Logistics	
Investigation		
Finance	Finance and Business Support	Finance and Business Support
	SA COVID-19 Information Line	SA COVID-19 Information Line
	Exemptions	Clinical Support

As indicated by grey boxes in Table 1, SCC-H did not include separate functional areas for Safety or Investigation. Instead, safety considerations were factored into routine business across all functional areas, similarly to how the ADF integrates them into its operational planning and conduct (ADF 2019:Annex 1C). Due to the nature of the pandemic response, contact tracing occurred instead of more traditional forms of investigation. This was done within a workstream that was outside of SCC-H's structure. Additionally, when a breach of Emergency Declarations was suspected, investigation was undertaken by SAPOL.

Table 1 also shows two functional areas established within SCC-H to meet unique pandemic response requirements. The first was the SA COVID-19 Information Line, which provided a whole-of-state-government call centre service for members of the public seeking information about any aspect of the pandemic response. The second was a clinical capability. In the elimination stage, this capability was exemptions-focused, assessing applications for people seeking to enter the state or to exit quarantine on compassionate grounds. In the seeding and suppression stage, the opening of the state's borders resulted in a reduced number of exemptions requests and an increased need for clinicians to be embedded in Health Rapid Response Teams (HRRTs) (these are discussed below). As a result of this change in focus, processing of exemptions was rolled into an expanded Clinical Support functional area.

Within the other functional areas, precise roles sometimes varied from those specified within AIIMS. For example, during the seeding and suppression stage, SCC-H's Intelligence function developed an online booking system for close contacts of COVID-19-positive people. This enabled the orderly collection of rapid antigen test kits and reporting of test results. On the other hand, the Intelligence function had ongoing difficulties providing the analysis and forecasting required to enable intelligence-led operations. In terms of 'traditional' intelligence outputs, this functional area provided data collection, statistical reporting, and imagery support. This enabled historical and trend analysis but lacked a predictive element. Predictive analysis was instead achieved through mathematical modelling completed under contract by Adelaide University, the results of which were reported directly to the Chief Public Health Officer (Spurrier 2021). Modelling tended to be completed very close to predicted events, allowing insufficient time for preparedness activities to occur. A notable exception was modelling conducted in preparation for the state's border opening on 23 November 2021. This was completed several weeks before the scheduled event and enabled detailed planning and preparation to occur (Richardson 2021; Spurrier 2021).

Another example is the Finance functional area, which became Finance and Business Support through the addition of a dedicated human resources staff. This was important as SCC-H staff numbers needed to surge during high-tempo periods. Most staff were on short-term contracts with options to renew. This was a reasonable employment model in light of sustained uncertainty regarding how long SCC-H's emergency response capabilities would be required. Several SA Government human resources functions are centralised within Shared Services SA (Shared Services SA 2022). The need for interagency coordination to resolve almost all human resources matters often involved ongoing business-as-usual rates of responsiveness when the pace of dynamic emergency response operations required a much-faster-than-usual timeframe. SCC-H's organic human resources capability helped address this issue by facilitating consistent interagency coordination and by enabling rapid turnaround of the components of human resources processes that could be undertaken within SCC-H.

The roles of some functional areas closely aligned to those specified in AIIMS, but lessons can nevertheless be identified. For example, Public Information was excellent at distributing data including daily case numbers, and at informing the public about changes to Emergency Directions. However, the volume of work required to publish this data left no time for other public relations-type activities. As a result, Public Information published almost no human-interest stories about the pandemic response or responders. Public awareness of a wide range of commendable response activities was therefore limited to people directly affected. This contributed to a general feeling among SA Heath staff that their pandemic response activities were never fully understood nor recognised.

By the end of the elimination stage, SA Health had established nine workstreams outside of SCC-H to manage aspects of its pandemic response. These are summarised in Table 2. Some of these workstreams began as sub-functional capabilities within SCC-H, such as medi-hotel administration and testing site establishment. Both of these activities began within SCC-H's Operations function and were moved into their own workstreams once it was identified that the required scale needed to be much larger than initially anticipated. Other workstreams always existed separately from SCC-H, for example, the Acute Healthcare Readiness and Contact Tracing and Outbreak Investigations workstreams. All nine workstreams continued to exist during the seeding and suppression stage, though their roles changed to align with the changed strategic situation. At the end of this stage the workstreams were disestablished and, as occurred with SCC-H, their roles either ceased or were transferred to ongoing parts of SA Health to continue as a part of routine business operations.

The existence of these workstreams outside of and in addition to SCC-H helped to keep the Commander's span of control manageable (AFAC 2017:15–18). However, this came at the cost of unity of command (AFAC 2017:18–19),

intra-agency coordination, and efficiency. It also created some duplication as well as dual areas of responsibility and reporting. A key cause of these issues was that each of the workstreams was headed by a senior executive who was senior to Commander SCC-H. In other words, this aspect of the command structure was upside down. Instead of being empowered with the traditional scope of command authority, Commander SCC-H had to rely heavily on methods such as consensus building and negotiation. Furthermore, workstreams did not organise using the AIIMS structure. Rather, they were organised according to routine business practices, which complicated required coordination arrangements. In a future pandemic response, this situation should be rectified through the appointment of Commander SCC-H at a more senior level within SA Health.

While some of SCC-H's sub-functional level capabilities were broken out into their own workstreams, others remained within SCC-H. These were mostly within the Operations and Logistics functions. During the elimination stage, key sub-functional level capabilities included establishing quarantine areas ('red zones') in high-risk locations such as Adelaide Airport arrivals hall, and the safe transport of people needing to enter quarantine. During the four community outbreaks that occurred in this stage, SCC-H supported several high-risk facilities and communities. Support measures included providing personal protective equipment, conducting training on COVID-19 prevention measures and, rarely, deploying a single HRRT to an outbreak site for up to several days to establish forward incident control and provide localised SA Health support during outbreak management. Operations and Logistics functions were separate and their roles well-defined; however, neither function had dedicated staff to deploy during outbreaks. Instead, SCC-H could only conduct outbreak response operations by deploying operations room staff to an incident site, effectively 'robbing Peter to pay Paul'. This approach was feasible during the elimination stage because of the limited scale and duration of response operations.

The scope and scale of SCC-H operations dramatically increased during the seeding and suppression stage, when multiple HRRTs were deployed and sustained for weeks-to-months at high-risk locations across the state. To maintain this increased response effort, SCC-H established three new sub-functional areas with dedicated staff. Two of these were dedicated teams to support residential aged care facilities and remote Aboriginal communities. Each of these teams had a core of dedicated SCC-H staff, which was supplemented during HRRT deployments by other agency staff (primarily SAMFS and SASES), and by testers, contact tracers and clinicians from across SA Health. The third area was a Transfer Coordination Centre, which arranged safe movement of COVID-19 positive patients to or between medical facilities, and the operational movement of HRRT members. All three sub-functional capabilities were subordinate to a combined Operations and Logistics functional area. The combination of these two functions within the SCC-H operations room was due to staff shortages brought on by the need to transition from 15/7 to 24/7 operations. Although an unconventional and possibly unprecedented arrangement, the combination of these two function areas was workable due to cross-training of staff.

A final observation relates to command and control arrangements. Table 1 shows that SCC-H replaced Incident Control with a Commander, and Deputy Incident Control with Deputy and Duty Commanders. This is because SCC-H, while interagency, was formed within SA Health and its primary role was to coordinate the Control Agency's (SA Health's) response. Incident Controllers were appointed to manage interagency coordination at key locations when required, in accordance with the AIIMS principles (AFAC 2017:18–19). For example, in the elimination stage, Incident

Table 2: SA Health COVID-19 response workstreams.

Workstream	Role summary
Borders and Exemptions	Coordinated exemption requests processing.
Vaccine Rollout	Distributed vaccines to eligible community members.
Quarantine and Isolation	Administered medi-hotels to facilitate safe quarantining.
COVID-Safe Planning and Compliance	Coordinated monitoring of Emergency Directions implementation and compliance.
Contact Tracing and Outbreak Investigations	Identified, assessed and managed individual exposure information including contact tracing.
Testing and Surveillance	Ensured testing was available to identify positive cases.
Enablers	Provided human resources, procurement, and other supports to all workstreams.
Acute Healthcare Readiness	Ensured the hospital system was able to meet the demands of COVID outbreaks.
Coordination and Implementation Support	Coordinated expertise and data-sharing across workstreams.

Controllers were appointed to manage 'red zones' at Adelaide Airport and in medi-hotels during periods when passengers were transferred to quarantine. In both the elimination and seeding and suppression stages, HRRT commanders were appointed as Incident Controllers. Most of these personnel held substantive positions with SCC-H's Operations and Logistics functional areas or their sub-functional specialist teams; however, in a few remote locations, Incident Controllers were appointed from either SAPOL or a Local Health Network due to their extensive local knowledge. This arrangement had the additional benefit of relieving pressure on over-tasked SCC-H personnel and is an example of the benefits of interagency cooperation.

Conclusion

This paper examined the SA Health-led COVID-19 pandemic response during the State of Emergency declaration in place in SA from 22 March 2020 to 24 March 2022, summarising SA Health's emergency management strategies and operational approaches, and identifying several lessons. With hindsight, it is possible to identify three separate response stages, referred to herein as elimination, seeding and suppression, and living with COVID-19. The first two stages had their own strategic objectives, operational missions, main efforts and key tasks. The third stage has seen the pandemic response transition to being part of SA Health's routine business, with reduced-scale ongoing response functions occurring outside of an emergency management setting and after the cessation of the State of Emergency declaration.

Taking a holistic view, it can be concluded that SA Health's COVID-19 pandemic emergency response was one of the most effective in the country; however, its activities in some areas could nevertheless have been more efficient. This was especially the case regarding intra-agency command arrangements and coordination, which were affected by the concurrent existence of both SCC-H and workstreams that operated independently of it. Coordination was further complicated by the use of routine business-type organisational structures within the workstreams, which did not align with the AIIMS framework. While the application and adaption of the AIIMS framework within SCC-H was vital to its operational success, there was nevertheless room to improve within several functional areas, as highlighted by the lessons identified above.

These possible improvements are relatively minor when compared to the number of lessons that were identified and actioned during the period of the emergency response itself. Indeed, it must be borne in mind that SA Health started the pandemic with no prior experience of emergency management aside from that obtained through peripheral roles as a Supporting Agency. Every aspect of its COVID-19 pandemic emergency response had to be built almost from scratch as the emergency progressed. That this occurred and that SA Health achieved one of the most effective responses in Australia, and arguably globally, is testament to the hard work and ingenuity of several hundred people from a range of agencies who were involved in the response.

Disclaimer

The views expressed in this article are exclusively the author's own and do not reflect those of any organisation with which he is or was previously affiliated.

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Tsunami emergency risk management in Australia: maintaining the momentum

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Scenario

Imagine that, early in the morning of 4 March 2044, the pressures from the plate boundaries along the Tonga-Kermadec trench reach their tipping point and release a powerful magnitude 9.4 earthquake. Advanced atmospheric analysis, courtesy of the global satellite system, captures the details of the rupture in near real-time. These details are transmitted to the 24/7 operations centre of the Joint Australian Warning Centre for automatic input into a fast tsunami propagation model implemented on a quantum computer. Within 15 minutes of the rupture, a first-pass inundation model is created of the Australian eastern seaboard and digitally disseminated to all registered users. Meanwhile, you wake to an alarm on your wearable device that alerts you of a tsunami warning for your location. You don't panic. You know what to do. Just a few months ago, during the 2043 World Tsunami Awareness Day, your local community exercised a tsunami evacuation. You know where to go, what to take and you also know who in your neighbourhood will need help. Gone are the days when you need to take insurance papers as they are saved to your wearable device. You don't even need a phone charger because wireless charging has become widely available. But you take your medication and a change of clothes and your beloved pets and exit. You knock on your neighbour's door and leave on foot to the agreed marshalling point beyond the tsunami evacuation zone. There you convene with your neighbours and check on who isn't there and let the emergency services personnel know.

This future is one the emergency management sector is working towards. We have the components in place, we know the gaps and we need to maintain momentum. At a high level, we are developing faster and more accurate warnings as well as evidence-based information to underpin effective community awareness and prepared communities.

It has been 20 years since the Indian Ocean Tsunami in 2004 and its devastating consequences. Since then, Australia has observed over 25 tsunamis. Of these events, 6 exceeded the warning level and the Joint Australian Tsunami Warning Centre issued appropriate warnings for 5 of these events excluding the 2006 Java event. There were 5 instances when the centre issued a tsunami warning but the tsunami either did not eventuate or was below the threat. For the remaining 14 events, the centre issued national No Threat bulletins, which were verified by observing only below marine warning level waves. Some key events are listed (a full event list is provided in the Appendix):

- 2006 Java event of 17 July from a M7.7 earthquake. It resulted in the largest run-up recorded in Australia at Steep Point in Western Australia (Prendergast and Brown 2011). There was no warning due to the Australian Tsunami Warning System not yet being operational.
- 2007 Solomon Islands event of 1 April from a M8.1 earthquake. It received a strong reaction among residents in Cairns with significant media interest and coverage (King 2008). Tsunami warnings were issued for Queensland but only below-warning tsunami waves up to 25cm were observed.
- 2010 Chile event of 27 February from a M8.8 earthquake. A marine warning was issued for the eastern states and offshore islands. Norfolk Island observed 61cm tsunami waves but other locations along the eastern seaboard only registered below-threat wave observations of up to 36cm.

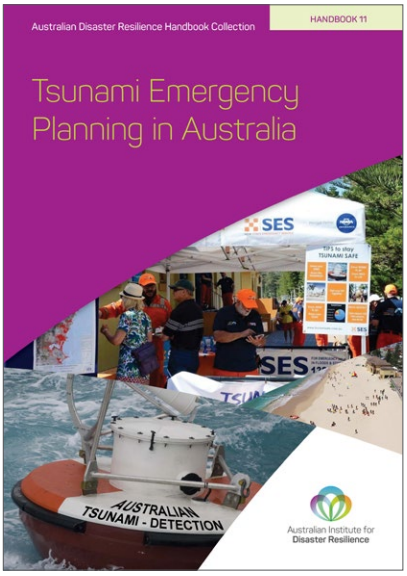
- 2022 Hunga Tonga-Hunga Ha'apai event of 15 January from a major volcanic eruption. This challenged the eastern seaboard's warning and response systems due to the complex nature in how the tsunami was generated. Marine warnings were issued for all eastern states and land warnings were issued for Norfolk Island and Lord Howe Island, all verified by observations.

This paper summarises the current state of tsunami risk management capability in Australia as well as current challenges and emerging opportunities.

Current capability

Following the Indian Ocean Tsunami, the Australian Government committed $68.9 million for the Australian Tsunami Warning System. This program commenced in 2005 and resulted in a major expansion of the seismic network and sea-level monitoring network, establishing the Joint Australian Tsunami Warning Centre and developing a national emergency management capability to manage tsunami risk. The latter is implemented through the Australian Tsunami Advisory Group whose members consist of all Australian jurisdictions, including offshore territories and New Zealand. Key achievements of the group include the roll-out of a tsunami education program for emergency managers (Introduction to Tsunami for Emergency Managers), the development of the Tsunami Emergency Planning Handbook and its companion Tsunami Hazard Modelling Guidelines and the award-winning online educational tool, Tsunami: The Ultimate Guide. The Australian Tsunami Advisory Group provides knowledge sharing with the aim to improve tsunami risk management in the Oceania region.

Australia is at the forefront of international efforts to develop a comprehensive Indian Ocean Tsunami Warning and Mitigation System (IOTWMS). It also supports the Pacific Tsunami Warning and Mitigation System (PTWS) under the auspices of the UNESCO Intergovernmental Oceanographic Commission (UNESCO-IOC). The Joint Australian Tsunami Warning Centre is one of 3 tsunami service providers for the IOTWMS and provides real-time threat advice to 27 tsunami warning centres across the Indian Ocean. Australia has funded and hosted the Secretariat Office to coordinate the IOTWMS development and sustainment. For the PTWS, the Australia Government provided ongoing support to the seismic and sea-level observation networks in the southwest Pacific region. Such a coordinated international development also helped improve the end-to-end Australian Tsunami Warning System from risk assessment, detection and warning, emergency response to community response. The system benefited from accessing the global monitoring networks and international best practice. It is regularly tested in the biennial tsunami exercises of IOWave and PacWave.



The Tsunami Emergency Planning in Australia handbook covers the scientific information and principles of risk assessment, warning systems, planning, education, response and recovery in the context of tsunami.

Since 2004, effort has been invested into tsunami modelling to improve warning systems and disaster management. The warning system is underpinned by a database of modelled tsunami scenarios (Greenslade et al. 2011). Once an earthquake has been assessed as having potential to generate a tsunami, relevant scenarios are selected to inform the warnings. As sea-level information comes to hand, the scenario selection is refined and warnings are updated. The warning centre is designed to provide emergency managers with a minimum of 90 minutes of warning time.

There have been great advances in hazard modelling for emergency management purposes—methodological and computational. The earlier hazard modelling projects were restricted to a limited number of scenarios and a limited extent of the coastline with coarser resolution elevation data than is available today. With the access to greater high-resolution nearshore elevation data, many modelling projects can capture broad extents of the coastline and apply sophisticated sampling of probabilistic scenarios to support local decision-making. This approach is being implemented in locations in Western Australia (Kendall et al. 2024) and in New South Wales and Queensland. Similar projects have been conducted in Tasmania involving Hobart port authorities and there have been numerous tsunami projects in Queensland.[1] These site-specific projects are possible through the offshore probabilistic tsunami hazard assessment (PTHA18) developed by Geoscience Australia. First developed in 2008 and

1. Tsunami Modelling along the East Queensland Coast and Meteotsunami in Queensland www.publications.qld.gov.au/dataset/tsunami-modelling-east-queensland-coast.

subsequently updated in 2018, PTHA18 is a step-change from the earlier version and benefits from new knowledge formed after the Tohuku event in 2011 (Davies and Griffin 2018). This knowledge challenged assumptions about the maximum magnitude possible on subduction zones around the world.

It is projects such as these that build understandings of risk at the local level and provide the evidence to develop evacuation plans, community communications and other risk-management activities. Where detailed inundation modelling is not available to inform evacuation plans, disaster managers can apply the general advice of 1km from the coast or 10m in elevation. Both Queensland and New South Wales have mapped this general advice and made it publicly available.[2]

Current challenges

The development of the Australian Warning System recognised that over 75% of tsunamis worldwide are generated by earthquake. Tsunamis are generated by mechanisms that result in a significant displacement of water and include submarine landslides, volcanic eruptions and meteorological driven events.

During the initial tsunami warning system program, bathymetric surveys were conducted along the New South Wales coast to develop an understanding of submarine landslides and their potential to generate a tsunami (Glenn et al. 2008). Tsunami generated by submarine landslides present a major challenge for Australia's coastline populations given the proximity to the coastline and the general lack of warning. This is a continuing area of research in Australia in collaboration with New Zealand counterparts.

The Hunga Tonga-Hunga Ha'apai event in 2023 reminded the world of volcanoes as sources of tsunami. This was not the first time that Australia had experienced tsunami from this source. Observations had been recorded at Onslow on the northwest of Western Australia following the 1883 Krakatau event (Simpson et al. 2007). There are a host of volcanic sources in the Oceania region, the obvious ones being along the Pacific Rim from Indonesia, Papua New Guinea into the Pacific but also in Australia's southwest and Heard Island.

The Hunga Tonga-Hunga Ha'apai event presented a major challenge to the Joint Australian Warning Centre and in the response by emergency managers. The event reinvigorated discussions about the need for an intermediary warning level between the 'Marine' and 'Land' threat levels. This is driven in part by the implications of evacuating large populations in the dense Gold Coast and northern New South Wales regions. Evacuation is informed by the general advice of 1 km inland or 10 m elevation in the absence of detailed modelling. Issuing emergency alerts also raises the considerations of prioritisation given the limitations of the system. Further complicating this situation is that the detailed modelling is generally based on earthquake-generated tsunami.

The rarity of the hazard means that communities may not be well prepared. In addition, the response system is rarely stress-tested. There remains high uncertainty about the tsunami hazard, especially over longer return periods. Pleasingly, some emergency management agencies test aspects of their tsunami management capability through scenarios (e.g. Indian Ocean-wide tsunami exercise (IOWave) and Pacific-wide tsunami exercise (PacWave)). This has yielded useful information about existing capability such as the importance of developing evidence-based tsunami evacuation maps. These findings are important to adapt practice and procedure as well as emergency management effectiveness. However, they are contingent on highly detailed, time consuming and expensive data acquisition, complex modelling and is reliant on significant state and federal investment and collaboration. Community awareness of tsunami risk in Australia is low as identified by Paton et al. (2017) who concluded that taking a multi-hazard view to community engagement would be most effective to include tsunami in the understanding of risk in the community. Focusing on tsunami alone in an environment with increasing frequency and intensity of storms, floods and fires might be politically unsound.

As community awareness of tsunami hazard is low, developing a good understanding of community and institutional exposure and vulnerability to this low-likelihood but potentially catastrophic event remains the cornerstone of effective emergency management. For example, in metropolitan Perth, following the Joint Australian Warning Centre issuing of a land warning, marine effects on coastlines can occur within 2.5 hours and land inundation in 3 hours. Tens of thousands of residents, workers and visitors as well as schools, hospitals, businesses and aged care facilities would need to be safely evacuated. This is an enormous, complex and challenging task and success would be reliant on people understanding the hazard, where the risks are, what areas are safe and what to do if a tsunami occurs.

The Western Australian Tsunami Inundation Modelling Project used extensive computer modelling of earthquake-generated tsunami to understand potential inundation and produce evidence-informed community evacuation maps covering Perth to Western Australia's southwest. Importantly, this has allowed emergency managers to understand the quantum of exposure and vulnerability and to discuss tsunami risk with local government. This understanding enables the emergency management sector to communicate risk to communities and address gaps

2. Tsunami evacuation areas of Queensland, at www.fire.qld.gov.au/prepare/tsunami/evacuation-areas.

in emergency management plans, communications plans and evacuation plans. With ambitions to continue this project along the Western Australian coastline, including the northwest (the most tsunami-prone area of Australia (Davies and Griffin 2018), knowledge and hazard awareness will improve.

With few events and no detailed modelling conducted in northern Queensland, there is an assumption that the Great Barrier Reef protects coastal communities. The Solomon Island's event in 2007 showed otherwise. This event was recorded on the tide gauges in northern Queensland in mainland communities 'behind' the Great Barrier Reef. Modelling of this event confirmed that tsunami can propagate through the reef (Baba et al. 2008). Expanding this evidence base will inform future community awareness activities in northern Queensland.

Low-frequency hazards like tsunami will inherently have a high level of uncertainty. Research through archives of newspapers, ship journals, port logs and entries in marine journals contribute to an event catalogue, as do palaeotsunami studies (including in Australia and the surrounding region). This provides evidence of events over the last tens to hundreds of thousand years. Clark et al. (2011) identified 5 deposits considered likely to have resulted from tsunamis in southeastern Tasmania. Given the urban development on the eastern seaboard of the Australian mainland, it is highly unlikely that studies similar to the Tasmanian study could be undertaken. Conducting palaeotsunami studies are important as they can constrain the likelihood of tsunami for sources that are important for Australia. One example is the research in Thailand (Jankaew et al. 2008) that identified a probable precedent for the 2004 Indian Ocean Tsunami.

Emerging opportunities

History of First Nations peoples offers intriguing insights about tsunamis in the Kimberley Region of Western Australia. Bryant et al. (2007) reported that, across parts of this region, place naming, art and oral history of a cosmogenic mega-tsunami were supported with geomorphic evidence of such an event at 2 locations. There is significant opportunity to learn from and understand this oral history, legends and experience with coastal hazards as a basis to better understand them.

Coastal systems such as mangroves have been shown to have a mitigating effect on coastal hazards, including tsunamis. These nature-based solutions are identified in the guidelines for the Australian Government's flagship initiative for disaster resilience and risk reduction. The Disaster Ready Fund is administered by the National Emergency Management Agency and funds eligible projects under either Stream One - Systemic risk reduction or Stream Two - Infrastructure. Stream Two includes investment in green-blue infrastructure, or nature-based solutions.[3] These solutions often involve local communities and help raise risk awareness as well as the value of these structures.

Advances in technology present exciting opportunities to progress risk management of tsunami in Australia. With quantum computing on the horizon, coupled with new sensors, we could have the ability to better characterise an earthquake rupture to input to fast tsunami models in near real-time that could result in targeted warnings. The rapid emergence of machine learning models presents vast opportunities for development in the modelling space (see an example by Mulia et al. 2022). There remains the question as to whether such investment is viable in the absence of not knowing the risk. Are efforts better spent elsewhere, at least in the short term, to improve inundation modelling for key parts of the Australian coastline so we can understand the risk, be better prepared and take mitigating steps?

Tsunami risk management will benefit from other advancements such as an improved emergency alert system. With spatial systems rapidly advancing, it is reasonable to envision a future where location-specific warnings can be received on a personal device for those who have them.

Conclusion

There has been significant investment in tsunami risk management over the last 20 years and there are challenges yet to overcome. The Australian Tsunami Advisory Group is implementing a faster and more accurate warning system to everyone as well as understanding and communicating risk so that people know what to do when they receive a warning. This progress will be achieved with collaboration with First Nations peoples and internationally to embrace ideas from other areas of knowledge and expertise. However, raising and sustaining risk awareness for a low-frequency hazard will always be challenge and will require ongoing effort.

3. Disaster Ready Fund, at https://nema.gov.au/disaster-ready-fund.

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Appendix

Tsunami events recorded in Australia since 2004

2006 Java event of 17 July from a M7.7 earthquake. It resulted in the largest run-up recorded in Australia at Steep Point in Western Australia (Prendergast and Brown 2011). There was no warning due to the Australian Tsunami Warning System still being established.

2007 Solomon Islands event of 1 April from a M8.1 earthquake. It received a strong reaction among residents in Cairns with significant media interest and coverage (King 2008). Tsunami warnings were issued for Queensland but only below-warning tsunami waves up to 25cm were observed.

2007 Sumatra event of 12 September from a M8.5 earthquake. Marine warning issued for Cocos Island and Christmas Island. No tsunami waves observed.

2009 New Zealand event of 15 July from a M7.8 earthquake. Land warning issued for Lord Howe Island, marine warning issued for Norfolk Island, New South Wales, Victoria and Tasmania. Below-threat waves were observed along the eastern seaboard and the named offshore islands.

2009 Samoa event of 28 September from a M8.1 earthquake. A national No Threat Bulletin issued and the below-threat level tsunami waves of up to 40cm were observed along the eastern seaboard.

2009 Sumatra event of 30 September from a M7.6 earthquake. Marine warning issued for Cocos Islands and cancelled 2 hours later. No noticeable tsunami waves were observed.

2009 Vanuatu event of 7 October from a M7.8 earthquake. National watch issued for potential tsunami threat to Queensland and cancelled 45 minutes later. Below-threat level tsunami waves of up to 10cm were observed along the Queensland coast.

2010 Chile event of 27 February from a M8.8 earthquake. Marine warning issued for eastern states and offshore islands. Norfolk Island observed 61cm tsunami waves and other locations along the eastern seaboard registered below-threat wave observations of up to 36cm.

2010 Sumatra event of 6 April from a M7.8 earthquake. A national No Threat Bulletin issued and below-threat tsunami waves were observed at some locations of the western seaboard.

2010 Vanuatu event of 10 August from a M7.3 earthquake. A national No Threat Bulletin issued and below-threat tsunami waves were observed at some locations of the eastern seaboard.

2010 Mentawai event of 25 October from a M7.7 earthquake. A national No Threat Bulletin issued and below-threat tsunami waves were observed along the western seaboard.

2010 Vanuatu event of 25 December from a M7.3 earthquake. A national No Threat Bulletin issued and below-threat tsunami waves were observed at some location of eastern seaboard.

2011 Tohuku event of 11 March from a M9.0 earthquake. A national No Threat Bulletin issued and below-threat waves were recorded along the eastern seaboard. Anecdotal report of several swimmers being washed into a lagoon at Merimbula in New South Wales.

2012 North Sumatra event of 11 April from a M8.6 earthquake. A national No Threat Bulletin issued and below-threat tsunami waves were observed along the western seaboard.

2013 Santa Cruz Islands event of 6 February from a M8.0 earthquake. A national No Threat Bulletin issued and below-threat waves were recorded along the eastern seaboard.

2016 Sumatra event of 2 March from a M7.8 earthquake. Marine warnings were issued for Cocos Island and Christmas Island and watch alert issued for most of the Western Australia coast. Below-threat waves of up to 10cm were observed on the mentioned islands and parts of the Western Australia coast.

2016 Solomon Islands event of 8 December from a M7.8 earthquake. A national No Threat Bulletin issued and below-threat waves were recorded at some locations of the eastern seaboard.

2017 Kermadec Islands event of 8 December from a M6.3 earthquake. There were no alerts issued due to the earthquake magnitude being below the criteria of M6.5. Below-threat tsunami waves of up to 14cm were observed at Norfolk Island.

2018 Loyalty Islands event of 5 December from a M7.6 earthquake. A national No Threat Bulletin issued and below-threat waves were recorded at some locations of the eastern seaboard.

2021 Loyalty Islands event of 11 February from a M7.6 earthquake. Marine warning issued and verified for Lord Howe Island and below-threat level waves observed along the eastern seaboard.

2021 Kermadec Islands event of 5 March from a M7.9 earthquake. Marine warning issued and verified for Norfolk Island and below-threat level waves observed along the eastern seaboard.

2021 South Sandwich Islands event of 12 August from a M8.1 earthquake. A national No Threat Bulletin issued and below-threat tsunami waves were observed along the western seaboard.

2022 Hunga Tonga-Hunga Ha'apai event of 15 January from a major volcanic eruption. It challenged the warning and response systems due to the complex nature of how the tsunami was generated. Marine warnings were issued for all eastern states and land warnings were issued for Norfolk Island and Lord Howe Island, all verified by observations.

2022 Loyalty Islands event of 30 March from a M7.0 earthquake. A national No Threat Bulletin issued and below-threat waves of up to 10cm were observed at Norfolk Island.

2023 Loyalty Islands event of 19 May from a M7.7 earthquake. Marine warning issued for Lord Howe Island, confirmed by waves observed on the island. Below-threat waves of up to 24cm were observed in some locations of the eastern seaboard.

Reflections on the Newcastle earthquake: the next 35 years

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Abstract

Earthquakes remain a rare yet constant risk to communities around the world. In Australia, these have the potential for significant consequences such as the Newcastle earthquake in 1989, the Meckering earthquake in 1968 and the Adelaide earthquake in 1954, which was the most destructive earthquake recorded in Australian history until the Newcastle event. This year marks the 35th anniversary of the Newcastle earthquake and the 70th anniversary of the Adelaide earthquake. It provides an opportunity to reflect on the systems and processes available to emergency managers for prevention, preparedness, response and recovery from emergency events.

Introduction

On 28 December 1989, a 5.6 on the Richter Scale (now equivalent to a Moment Magnitude 5.3 as currently used across Australia) earthquake struck Newcastle, New South Wales. The city area of Newcastle was the centre of the earthquake and 13 people were killed, many were injured and 30,000 buildings within the city area were damaged (Newcastle (N.S.W.) Renewal Co-ordination Unit 1994). The earthquake was felt as far away as Batemans Bay to the south, Dubbo and Armidale in the northwest of the state with some reports coming from Melbourne (Coroners Court of New South Wales 1990, p.1). The earthquake was the first in Australia with a damage bill of $1 billion (1994) dollars (Newcastle (N.S.W.) Renewal Co-ordination Unit 1994, p.2).

The coronial inquest that followed made 3 recommendations and several observations (Coroners Court of New South Wales 1990). Recommendations included changes to the Australian Earthquake Loading Code AS 1170.4, a review of engineering and architecture training courses and formalisation of a procedure to have engineers attend emergency sites to provide advice on building structures. Observations included discussion on the importance of leadership, equipment that should be used, failures of telephone and radio equipment and communication in general and the use of engineers at the scene (Coroners Court of New South Wales 1990, pp.22–23).

Since that time, what keeps earthquake scientists and emergency management personnel alert is not knowing where and when the next big earthquake might occur. Many of us are unaware of these concerns and what it could mean for the homes we live in, the infrastructure we rely on for our way of life and consequences to society and the economy.

Risk

Past disaster events provide insights and lessons for the future. The Insurance Council of Australia commissioned an analysis of these past catastrophes to allow more direct comparison of the impact these events had on the community. The analysis adjusted for inflation and normalised the costs to present-day and found that the 1989 Newcastle earthquake is ranked the third most costly insurance catastrophe when normalised to present-day property numbers, values and building codes. The costliest is Cyclone Tracy in Darwin in 1994, followed by the hail storms in Sydney in 1999 (Insurance Council of Australia 2023, pp.8–9).

Since the Newcastle earthquake, there have been major advances in the emergency management sector. Development and improvements in the consideration of risk, through publications such as the Risk Management Standard (drafted in 2004 and updated) (International Organisation for Standardisation 2011) underpins the thinking applied for emergency management personnel. The application of risk to

emergency management is documented in national policies such as the *National Strategy for Disaster Resilience* (Attorney-General's Department 2013) and is supported with other strategies such as the *National Disaster Risk Reduction Framework* (Commonwealth of Australia 2018). These now frame the way risk and resilience are considered in Australia. Supporting these national policies are other materials such as those found on the Knowledge Hub website of the Australian Institute for Disaster Resilience. The Knowledge Hub contains historical information, a glossary of common terminology and a range of best-practice doctrinal handbooks that are freely available. These may promote best practice, whole-of-community and multi-jurisdictional management of emergency events prevention, preparedness, response and recovery.

Prevention

Building codes play a crucial role in community safety and are one of the prevention measures available to reduce risk. But Australia has a large legacy building stock developed prior to the current building standards. It took the Newcastle earthquake event for the earthquake loading standard to be established and to assure life safety (given this is a key objective of the National Construction Code (Australian Building Codes Board 2022)). Life safety is the key principle for emergency management, however, emergency management encompasses the critical recovery component, which is usually protracted and costly.

Prior to the Royal Commission into the National Natural Disaster Arrangements, a global initiative led by the International Code Council was established to improve the resilience of buildings and communities from weather-related hazards. This initiative was a collaboration between the code development organisations of Australia, Canada, New Zealand and the United States working towards shared outcomes (Australian Building Codes Board 2020). As part of this effort, the Australian Building Codes Board sought stakeholder views and opinions on the challenges and opportunities to enhance resilience in the building codes and standards (Australian Building Codes Board 2021). The findings were that stakeholders acknowledged the need to investigate how building codes and standards can reduce vulnerability risks to current and future building stock. This need was recognised during the royal commission and resulted in its Recommendation 19.4:

> *The Australian Building Codes Board, working with other bodies as appropriate, should: (1) assess the extent to which AS 3959:2018 Construction of buildings in bushfire-prone areas, and other relevant building standards, are effective in reducing risk from natural hazards to lives and property, and (2) conduct an evaluation as to whether the National Construction Code should be amended to specifically include, as an objective of the code, making buildings more resilient to natural hazards.*
> (Binskin et al. 2020, p.43)

To address this recommendation, government building ministers agreed in June 2024 to add climate resilience as an objective of the National Construction Code to withstand extreme weather events (Department of Industry Science and Resources 2024). What is not clear is the effect this new objective will provide for earthquake resilience. Until the outcome is implemented into the code, it is unknown if this objective will apply to all construction code standards. If so, what does this mean for earthquake loading and future earthquake resilience of all buildings?

Preparedness

The emergency management sector remains challenged to raise awareness of low-probability hazards such as earthquake especially when faced with situations created by higher-frequency hazard events. We also know that resilience gains can be undone with an event in a major town or city where there is concentrated infrastructure like roads, rail, power, water and communications infrastructure potentially damaged. What would mean for the broader economy?

The earthquake science and engineering community know the uncertainties in earthquake hazards and accommodating this uncertainty in construction. Dealing with uncertainty is part and parcel for the emergency management sector, however, these uncertainties are not well understood by the community. There remains large unknowns about the maximum earthquake that could occur in Australian and we don't know all the secrets that the landscape holds.

The National Seismic Hazard Assessment (updated in 2023) (Geoscience Australia 2024b) defines the expected level of ground shaking for defined return periods to inform building codes and emergency management. Among the outputs from this assessment is the Earthquake Scenario Selector Tool that contains credible earthquake scenarios for defined locations around Australia and that can be used for exercising, risk assessments and planning. The National Seismic Hazard Assessment is updated as new research and data becomes available and is typically updated to coincide with updates to the earthquake loading code.

Response and recovery

Emergency management agencies are increasingly working together to deliver consistency in their operations. The primary incident management systems used across Australia are the Australasian Interagency Incident Management System (AIIMS) (AFAC 2017) used by fire and emergency services and the Incident Command and Control System Plus (ICCS+) used by police agencies (Australia New Zealand Policing Advisory Agency 2022). These 2 management systems have more in common than ever before and the integration is constantly improving. Recent developments have increased the application of recovery considerations into the overall management of

emergencies with new units of competency developed for recovery practitioners (Commonwealth of Australia 2020).

There has also been specific parallel work to develop Australia's Urban Search and Rescue (USAR) capabilities. Two states now maintain internationally certified teams and other jurisdictions maintain smaller capabilities that can work together across borders (National Emergency Management Agency 2024). To develop Australia's USAR capabilities, Australia hosted the Asia Pacific Earthquake Response Exercise in August 2023 in collaboration with the United Nations International Search and Rescue Advisory Group (International Search and Rescue Advisory Group 2023).

Since the Newcastle earthquake, there has been continued investment and evolution in the monitoring and alerting of earthquakes with the establishment of the National Earthquake Alert Centre (NEAC) and many new products provide usable information to support response and recovery operations. Modern alerting uses the moment magnitude scale, replacing the Richter Scale. NEAC products such as the Felt Grids and ShakeMaps published through Earthquakes@GA provides valuable situational awareness about where the greatest earthquake ground shaking is predicted and where people have reported the effects (Geoscience Australia 2024a).

Opportunities

The emergency management community has advanced considerably since the 1989 Newcastle earthquake. Professionalisation of the emergency management field, including the people known as emergency managers is advancing (Dippy 2020, 2022). Emergency management is moving toward a full-time role for more and more practitioners. A greater collaborative effort is becoming evident as improvements in standards such as those relating risk have created a framework to support national progress towards resilient communities. However, unlike tsunami and tropical cyclone, there is no national forum to unify efforts in earthquake risk management. We need national leadership to acknowledge earthquake risk and convene a national forum under the auspices of the Australia-New Zealand Emergency Management Council (ANZEMC) governance arrangements to drive continuous improvement in emergency management for earthquake risk.

Such a forum could advocate for and support efforts to strengthen the seismic network that could reduce vulnerabilities and provide a better definition of earthquake hazard. The forum would support better knowledge sharing of earthquake projects and provide a chance to leverage efforts for broader national benefit. The forum could collectively seek to address the challenge of community perception of earthquakes. For example, the forum could develop ways to improve community awareness of earthquakes and of knowing what to do in an earthquake regardless of whether people are at home, work or are elsewhere. The forum could consider using the United States led annual Great ShakeOut exercise platform to raise awareness of earthquakes to practice what to do in an earthquake (Federal Emergency Management Agency 2023). There is already participation in such exercise from institutions in Australia (less than 100 in 2023) and that participation should grow in the future. In 2023, over 700,000 participants were registered from New Zealand institutions for its Great ShakeOut exercise.

There are a host of research and data gaps that are well known to the scientific and engineering community. A national forum could bridge the knowledge gaps through unified effort and support.

What does the future hold

The future holds a range of new and emerging processes and technologies that will enhance community resilience. The ongoing professionalisation of emergency management will lead to better educated and trained emergency managers who are able to influence policy and practice in an evidence-informed manner. The professionalisation of emergency management will provide greater research and practically validated lessons from which to train the artificial intelligence tools that are being developed. The use of artificial intelligence requires that research provides the source research validated information from which to train that artificial intelligence. Artificial intelligence may then provide an opportunity to identify and prevent emergency events.

Advances in remote sensing technologies such as low earth orbit satellites will provide a means to learn more about the world in which we live and communicate that knowledge in a timely and efficient manner. These processes and technologies support the technical and human responses to emergency events as we seek to prevent emergencies, prepare for, respond to and recover from future events. We can't prevent everything, but the aim must be to reduce the negative effects for communities.

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The challenges of research utilisation and the risks of collaborative research

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Abstract

Translating and using research in emergency management policy and practice is challenging. It requires time and collaboration between researchers and practitioners. While it is assumed that working together well will lead to better outcomes than working in silos, clear evidence and guidance on what it takes to achieve successful collaboration is lacking. This paper discusses the challenges of research translation and utilisation and considers the risks of collaboration. The paper reflects on how collaboration between researchers and practitioners can achieve robust scientific contributions, as well as relevant and useful practical outcomes.

The challenges of research

Scholars have argued for efforts to strengthen the links between science and practice to improve emergency management policy and practice (Spiekerman et al. 2015). However, there are challenges to research translation and utilisation (see Oliver and Boaz 2019).

These challenges include the tendency to simplify complex problems to enable robust and rigorous research methods and to produce generalised results. Also, competing priorities and timelines for research and practice, which result in limited incentives to collaborate, limit the involvement of end users in research (Oliver and Boaz 2019; Wilkens et al. 2016). This can create or exacerbate the gap between research and practice.

Scoping and conducting research without meaningful contributions from end users assumes that quality research can translate itself. Ideally, emergency management organisations would be able to take generic results and not only translate the relevance into their context, but also decipher the implications and solutions required to improve current practice. However, this assumption underestimates the amount of time, resources, negotiation and effort research translation and utilisation requires.

The benefits of collaboration

This paper uses the phrase 'collaborative research' to capture the shared intention of terms such as co-design, co-production or co-creation. These terms are being increasingly used across many academic disciplines and expected benefits include being able to solve complex or wicked problems that cannot be solved through silos or by singular disciplines Turner and Baker 2020; Wilkens et al. 2016). It is also argued that collaboration is more likely to result in research outputs that are useful, usable and used than if end users were not involved (Oliver and Boaz 2019).

Risks of collaborative research

Discussions of the challenges and risks of collaborative research are not new (Flinders et al. 2016; Cvianovic et al. 2016). However, because these approaches are used across a wide range of disciplines, lessons learnt about collaboration may not reach everyone who is conducting collaborative research (Oliver and Boaz 2019). Moreover, despite increasing demands to conduct collaborative and practically relevant research, there are few evaluations of whether such approaches lead to improvements in policy and practice (Oliver and Boaz 2019; Turner and Baker 2020). As a result, practical guidance to support effective collaboration is lacking (Reed et al. 2014; Cvianovic et al. 2016; Wilkens et al. 2016. Also, because there

are differences among stakeholders, in project scope, power dynamics and expected outcomes, a one-size-fits all approach to collaboration is unlikely to be successful (Wilkens et al. 2016).

There are risks involved in working collaboratively rather than within the safety of established disciplines and methods. Collaboration asks us to move out of this space of comfort and requires us to transform the way that we design and conduct research projects. Not acknowledging these risks when embarking on collaborative research projects could have implications not only for the translation and utilisation of research, but also the quality of scientific contributions. In other words, we run the risk of producing results that can neither be utilised in practice nor published as scholarship (Turner and Baker 2020).

Despite the increasing promotion of and positive rhetoric around participatory research projects, Flinders et al. 2016, p.266) state that such projects are:

> *time-consuming, ethically complex, emotionally demanding, inherently unstable, vulnerable to external shocks, subject to competing demands and expectations, and other scholars (journals, funders, and so on) may not even recognise its outputs as representing 'real' research.*

While collaborative action research is risky business, 'this is what makes it so fresh and innovative' (Flinders et al. 2016, p.261). If research for practice is risky business, what are the alternatives? If we continue to work in silos, nothing changes. Is it possible to design research so that it contributes to science and can inform and assist innovation in public policy and service? The Natural Hazards Research Australia funded the Predictions in Public project to achieve both aims.

Predictions in Public Research (PiP) project

Background

There have been many advances in scientific knowledge about fire behaviour and modelling, practice and agency capacity to deliver fire spread predictions to support operational decisions (Begg et al. 2021; Tolhurst 2018). Public demand for real-time data has increased (Wood et al. 2018). In addition, reviews, inquiries and royal commissions have repeatedly called for improvements in the timeliness and quality of warning products (United Nations Office for Disaster Risk Reduction 2022; Royal Commission into National Natural Disaster Arrangements 2020). The use of fire spread predictions has received increasing attention since the 2019–20 fire season when so-called 'Red Maps'' were released to the public in New South Wales and the Australian Capital Territory.

Yet, questions have arisen about the value of producing fire spread predictions during future fire seasons. Previous research in Victoria showed that while operational staff agree that providing the public with quality real-time information is important, concerns remain regarding how to effectively embed predictions into existing warning products and when and how to release them to the public (Begg et al. 2020).

Based on this and with the support of the AFAC Predictive Services Group and AFAC Warnings Group, the topic of public-facing predictions was identified as a research challenge.

Project aim and governance

The aim of the PiP project was to develop empirical evidence and collaborative processes to contribute to a national approach to the future use of public-facing fire spread prediction products during an emergency. The project team is made up of coordinators who have research and emergency management experience from 2 Victorian government agencies. The research team includes experts from 4 Australian universities. The team has expertise in risk communication, evacuation modelling, cartography, anthropology and organisational learning.

The project also has a steering committee made up of AFAC Predictive Services Group and AFAC Warnings Group with representatives from all Australian jurisdictions. This committee provides feedback on the research and assists with and approves decision-making related to the project's scope and practical outputs. The steering committee and the research team meet for 30 minutes each fortnight using Microsoft Teams. The project team also presents regularly at the AFAC groups meetings to provide project updates and seek endorsement for specific decisions.

Project design

The project had 3 phases. Phase 1 has been completed. The research conducted in Phase 1 aimed to better understand the status quo. This included current emergency management organisation practice as well as community comprehension and use of existing public-facing map-based products. Two local maps were tested with community members in each Australian jurisdiction. In most cases, the maps tested were incident warning maps but predictions were also tested where they had been previously released to the public (e.g. in New South Wales, the Australian Capital Territory and Victoria). The findings of the research were discussed with the project steering committee to identify the implications for current practice and the research in Phase 2.

Phase 2 is underway. A range of prediction map design concepts have and will be co-developed with the research team and the project steering committee and tested with

community members in 5 studies. Based on the findings of this research, 3 practical outputs for emergency management organisations to use will be delivered in Phase 3. Only one of the 3 outputs has currently been identified, which is a set of evidence-based principles for designing and disseminating prediction maps. The additional 2 outputs have been funded but not yet defined. These outputs will be co-developed together with the research team and the project steering committee.

Lessons for collaboration, research translation and utilisation

Complex problems require effective collaboration approaches to translate research into practice. Collaboration is risky. If not done well, there is a risk that projects produce not only poor-quality research and that the results will have little relevance for end users.

Lessons from the PiP project include that collaborative research takes time. To commence the project and to enable collaboration, incentives for researchers and practitioners are required. The time and resources that relationship- and trust-building requires is not often budgeted for in research projects. Also, to enable the adaptable approach that collaboration requires, there is a need for flexibility in project planning. On the one hand, a clear plan for collaboration that articulates how end users will be involved in the decision-making process is an important way to value everyone's input. On the other hand, flexibility and creativity are important to allow for changes in the project plan as needs arise.

Finally, having a facilitation role that sits between researchers and practitioners has been beneficial in the PiP project. It has meant that there is capacity within the project for researcher and practitioner inputs to be considered and that negotiations are guided and decisions are shared.

There is no one-size-fits-all approach to collaboration between researchers and end users. However, acknowledging the risk of collaboration and learning from previous research projects provides considerations for researchers and practitioners who want research to be practically relevant and to produce robust scientific evidence.

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Rural community resilience to natural hazards: promoting grassroots resilience in a coastal New Zealand community

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Introduction

Aotearoa New Zealand's vulnerable low-lying coastal communities face imminent threat from coastal hazards and the consequences of climate change. There is an urgent need to understand how community resilience, adopted in international and national policy, can enhance societal resilience across the emergency management cycle of risk reduction, preparedness, response and recovery. This report presents findings from a study of a coastal community in southern New Zealand that is exposed to a range of climate-related hazards. This paper brings together academic perspectives on community resilience theory and presents an adapted framework that considers the contextual factors (social, political, environmental, economic and physical domains) that are recognised as complex and interacting drivers of resilience.

Resilient communities

Communities have a range of attributes and resources, underpinned by the critical roles that individuals and community groups play to enhance their resilience. At the same time, external institutional or political factors shape the local community context and influence how they operate. Resilience often develops at the grassroots level through locally driven resilience-building actions. Here, a disparity emerges, where top-down institutional support through policy and resourcing can have significant influence on grassroots efforts to build community resilience.

The rationale behind this research is to understand how effective grassroots community resilience can be supported and enabled by local government emergency management and broader planning activities. Specifically, how local governments can support communities to be resilient given the interconnected and complex nature of community resilience.

Researching rural coastal communities

Research targeting hazard management, risk reduction and resilience in the rural context addresses gaps in the literature. Urban environments have larger populations, infrastructure and economic importance and are exposed to the greatest potential losses from future disasters. Thus, hazard management research has tended to focus on large towns and cities. According to Spector et al. (2019), rural communities are often more exposed to natural hazard events due to factors including geographic and social isolation, lower incomes, lack of resources and vulnerable infrastructure. A heightened focus on urban centres also exists in the application of formal planning processes that leave small coastal communities marginalised.

Recent hazard events, particularly the Kaikōura magnitude 7.8 earthquake in 2016 and Cyclone Gabrielle in 2023, revealed how important it is to focus on the resilience of rural communities (Spector et al. 2019). The Kaikōura earthquake and its wide-ranging economic and societal effects re-affirmed that rural events can have significant

consequences at the national scale. The New Zealand *National Disaster Resilience Strategy*[1] emphasises the need to implement effective hazard management, risk reduction and resilience-building initiatives across all communities. In addition, Spector et al. (2017) called for a greater focus on rural resilience research in the natural hazard context.

This study addresses this gap in rural resilience research by investigating how the support and facilitation of community resilience by local government and other planning arrangements can help rural coastal communities to prepare, respond and recover from hazard events. To achieve this, the rural coastal township of Waikouaiti was examined. It is located approximately 40 km north of Dunedin in the South Island. Waikouaiti is a low-lying community in the coastal zone and is vulnerable to risks associated with climate change.

Rural community resilience: the case study of Waikouaiti

This study received ethics approval from the University of Otago Ethics Committee (low risk human ethics, approval number D23/155 UOHEC).

Primary data for this study was collected between June and August 2023 using semi-structured interviews with community members in Waikouaiti and officials from local governments. Community participants were selected based on their local leadership roles and involvement with resilience focused initiatives. In particular, representatives from the Community Board and members of the Progress of Waikouaiti Area (POWA) community group. POWA initiates and facilitates community-led actions for the benefit of the community.

A snowball[2] method reached other community leaders and residents and a total of 9 interviews were conducted. Participant observation was undertaken at community meetings. This helped to build a picture of the attitudes and perceptions of local residents about emergency management in Waikouaiti as well as their views on building community resilience. Local government participants were selected based on their expertise in natural hazard planning, emergency management and community resilience initiatives.

This article heavily references the 'water scare event', which occurred in 2021 and involved the detection of high levels of lead in the Waikouaiti water supply. The high levels of lead were alerted to council, however, it took 3 months before this alert was detected and actioned. This event resulted in significant distress within the community and, anecdotally, affected the relationship between Waikouaiti residents and the Dunedin City Council. Subsequently, the water scare event is considered influential in shaping community perceptions and attitudes towards the local government and hazard preparation generally.

Thematic analysis of the interview data was coded into themes relating to social, economic, institutional, environmental and physical indicators following conceptual framings of community resilience by Twigg (2009) and Kwok et al. (2019). The findings from the themes, contextualised within existing community resilience studies, were used to develop a conceptualisation of community resilience called the Community Resilience Ecosystem. This framework is used to explore the inter-connected factors that contribute to and influence grassroots community resilience and is intended to support hazard management planning and resilience building in rural communities.

The complex, multi-layered notion of 'community'

Defining 'community' is complex and multi-layered (see Mulligan et al. (2016). This was acknowledged by community and local government participants in this study. Traditional emergency management approaches have tended to focus on communities in spatially defined areas, thus failing to consider the full range of social and temporal dimensions that play a role in determining resilience (Twigg 2009). For example, the detection of lead contamination in the local water supply in 2021 was not confined to the geographic boundaries of Waikouaiti, as residents from Hawksbury and Karitāne were also affected by the event. Additionally, due to the potential effects of the contamination over time, people who live permanently and have lived there for longer periods of time had greater exposure to the health risk as compared to other home owners or visitors. This event demonstrates how the complexities of community can affect the application of hazard management responses.

To support resilience initiatives through hazard management planning it is critical that a range of opinions, voices, experiences and resources within a community are acknowledged and considered. A community leader said, 'You need broad, overarching perspectives'.

In the aftermath of the water scare event, the community urged the district and regional councils to consider inclusive, accessible and collaborative engagement processes to avoid loss of trust and damage to community relationships with local government. Participants described having spaces for discussion and knowledge sharing between local residents and local government officials, to enable a range of voices and opinions to be considered in the resilience-building process. By appreciating the complexities that exist around the term 'community',

1. *National Disaster Resilience Strategy,* at www.civildefence.govt.nz/cdem-sector/plans-and-strategies/national-disaster-resilience-strategy.
2. Snowball sampling (also known as chain-referral sampling) is a non-random sampling method used when characteristics of samples are rare or difficult to find. It occurs when one participant recommends others who are then invited to take part in the research.

emergency management planners and practitioners can pay attention and care to the human, spatial and temporal factors that influence resilience in communities.

A holistic, interconnected approach

One of the most referenced and critical elements of this study, and many other academic contributions, is the holistic and interconnected nature of communities (Twigg 2009). The Community Resilience Ecosystem draws together these elements and demonstrates the importance of a holistic approach to hazard management that acknowledges the social, economic, institutional, environmental and physical factors of community resilience (Figure 1). The community ecosystem is represented with interlocking and interconnected arrows. There are 5 core factors that define the ecosystem and were selected based on their broad acceptance in the literature as the most commonly used indicators of community resilience. Within each of these factors, the results from the Waikouaiti case study revealed a number of context-specific variables that shape community resilience that can be applied to other rural townships. Thus, our framework provides guidance for emergency managers to determine, investigate and enhance community resilience.

A key benefit of adopting a holistic view of the relationship between hazard management and community resilience is that resilience is not shaped simply by physical resources and funding, which has often been the focus of local government policy. This study revealed that approaching community resilience in a holistic manner can guide perspectives away from a reliance on physical and economic aspects towards the social dimensions of resilience, such as community leadership and collective effort at the grassroots. The opportunities to improve community resilience are listed in Figure 1. These opportunities offer practical actions to help guide resilience building and emergency management activities within rural communities. They focus on relationships, knowledge sharing and building trust.

The important and influential role of governance in community resilience

The role of institutions, particularly the Dunedin City Council, Otago Regional Council and Emergency Management Otago in New Zealand is important to guide and support emergency management and community resilience in rural communities. These institutional relationships, processes and constraints (funding and

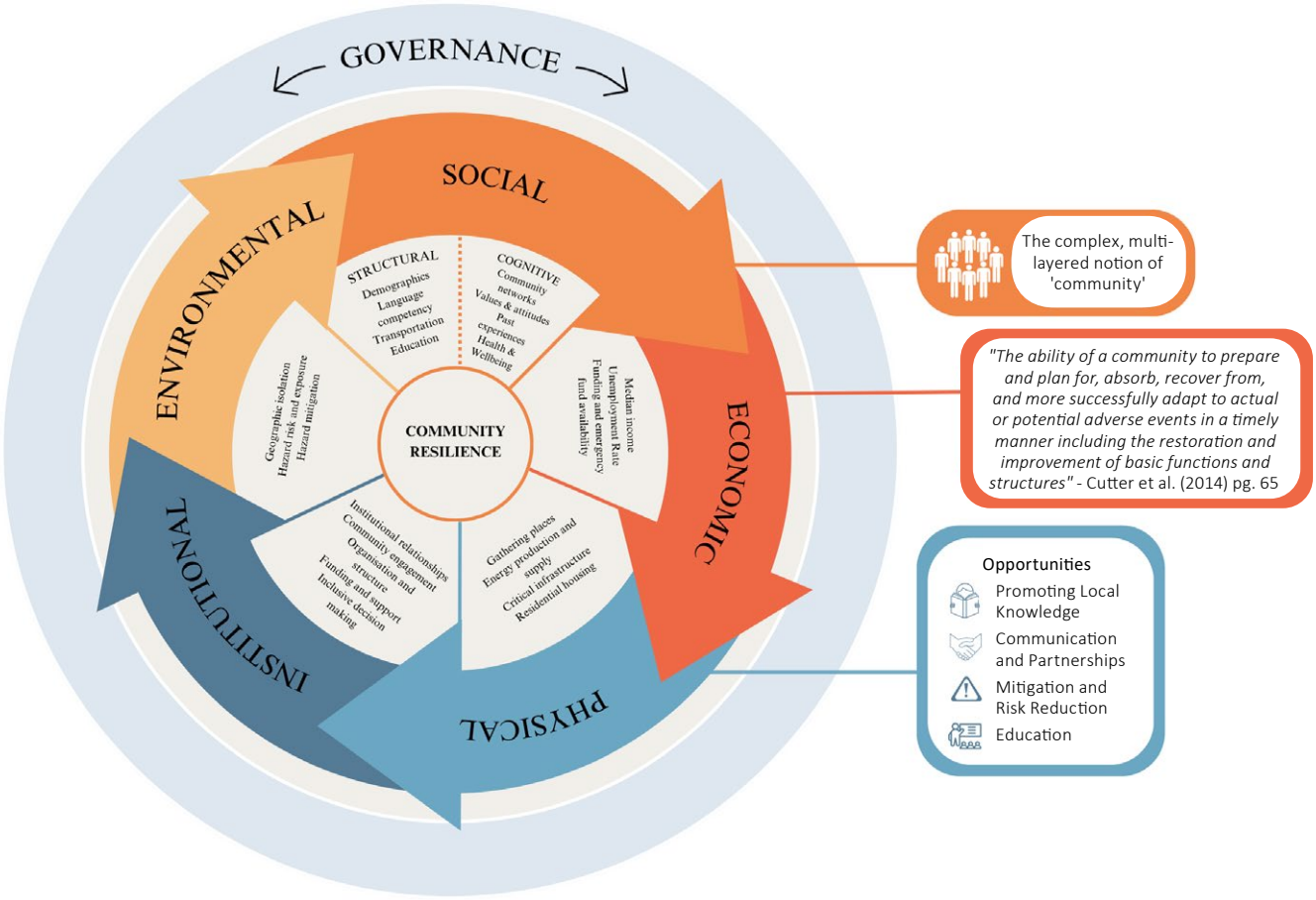

Figure 1: The Grassroots Community Resilience Ecosystem: Enhancing Hazard Management and Resilience in Rural New Zealand.

resource availability) are important influences on wider resilience building in community resilience studies. Kruse et al. (2017) and Twigg (2009) identify disaster risk governance and the associated laws, policies, responsibilities and relationships as significant factors that shape resilient communities. The notion that governance is a framing structure in which community resilience sits has been applied to the Community Resilience Ecosystem.

Findings from the Waikouaiti case study revealed the importance that participants placed on governance. Members of the Waikouaiti community disclosed negative perceptions of local council and emergency management that were driven by a lack of clarity about roles and responsibilities. A shared understanding of roles and strong relationships between communities and outside providers can create effective responses during hazard events and can result in improved resilience. Therefore, open and transparent communication between authorities and communities are needed to understand who, how and when resilience-building actions are implemented.

Academic literature and research findings show that people are more willing to take responsibility and contribute to local preparedness actions if they perceive their relationship with formal agencies as fair and empowering (Paton and McClure 2013). This supports international and national policy disaster risk reduction and resilience, including the *Sendai Framework for Disaster Risk Reduction 2015-2030*[3] and the National Disaster Resilience Strategy, that promote empowering communities to develop community-led resilience. Collective effort guided by local knowledge was evident in Waikouaiti as an opportunity to enhance community resilience through the empowerment of the community. Participants identified the co-production of knowledge and ideas between the community and emergency managers as an opportunity to enhance resilience. One participant said, 'coming up with better solutions together; that's how we are going to make better decisions'.

Participants were supportive of improving the roles and responsibilities of local government in hazard management for rural communities. Key informants, including from local government, emergency services organisations and community leaders, recognised the potential benefits from council adopting a supportive role in rural resilience. In particular, implementing resilience-building actions and initiatives at the grassroots level. A local resident participant spoke about the role that council should play in emergency management and resilience-building initiatives, 'I think the best thing to do is to support what we want to do locally'.The shift from a top-down management approach to the empowerment and support of grassroots, bottom-up management originates from the notion that local communities are often more successful to prepare, respond and recover from events.

Community resilience outlook

This research showed that approaching practical hazard planning with an understanding and appreciation for holistic community resilience can enable effective grassroots resilience building. The Community Resilience Ecosystem framework provides a summary of the elements and influencing factors that contribute to the complex and multi-layered notion of community resilience. It is also a framework for local government to encourage and support grassroots community resilience in communities.

3. *Sendai Framework for Disaster Risk Reduction 2015-2030,* at www.undrr.org/publication/sendai-framework-disaster-risk-reduction-2015-2030.

Acknowledgments

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Community-led disaster resilience initiatives: a case study

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Abstract

It is widely acknowledged that community-led initiatives can significantly improve community resilience to bushfires and other disasters. These initiatives can be particularly important in overcoming some of the challenges presented to emergency management organisations in moving towards the goal of community resilience and shared responsibility. This paper provides an overview of a case study of the roles and outcomes of community-led bushfire and disaster resilience initiatives in the region of Kangaroo Valley, New South Wales, Australia. Three initiatives are described: the establishment of a comprehensive network of bushfire-ready neighbourhood groups, the establishment of the Kangaroo Valley Bushfire Recovery Association and its recovery 'drop-in centre', and the genesis and evolution of a community resilience group known as 'Resilient KV'. These initiatives played significant roles before, during and after the disastrous passage of the Currowan bushfire through Kangaroo Valley in January 2020. This fire destroyed over 10% of homes in the region and had very severe impacts on people, infrastructure, animals and the environment. The findings of this study covered issues including household 'stay-and-defend' versus 'leave early' decision-making and the ways residents improved the bushfire resilience of their properties.

Background

During the southern hemisphere spring and summer of 2019–20 a bushfire crisis unfolded across several Australian states and territories that was unprecedented in terms of the number, size and intensity of the bushfires that occurred and their geographical extent. The catastrophic effects of these 'Black Summer' bushfires led to individuals, families, communities and resources being stretched as never before. This applied to the agencies responding during the fire emergency, to organisations assisting affected communities during their recovery and to the reconstruction industry that was responsible for the demolition of destroyed and damaged buildings and infrastructure and the eventual rebuilding of people's homes and other property.

This paper provides an overview of some of the outcomes of the study 'Building Community Resilience to Bushfires: A Case Study of Kangaroo Valley, Australia'. The aim was to understand the complex, multi-level, multi-disciplinary issues that influence the bushfire resilience of communities via a case study of the Kangaroo Valley community located in New South Wales, which was hit by the Currowan fire on the night of 4 January 2020.

We were interested to explore bushfire risk prevention, preparation, response and recovery approaches and activities in relation to the 3 societal levels as shown in Figure 1 (i.e. 'Households', 'Community', and 'Government and Industry'). Some of the specific issues covered in the study included:

- the roles that new community-led initiatives played in each phase of the event
- household preparation for, response to and recovery from the Currowan fire, including their leave or stay-and-defend decision-making and retrofitting of their homes
- how the reconstruction and supply chain ecosystem operated.

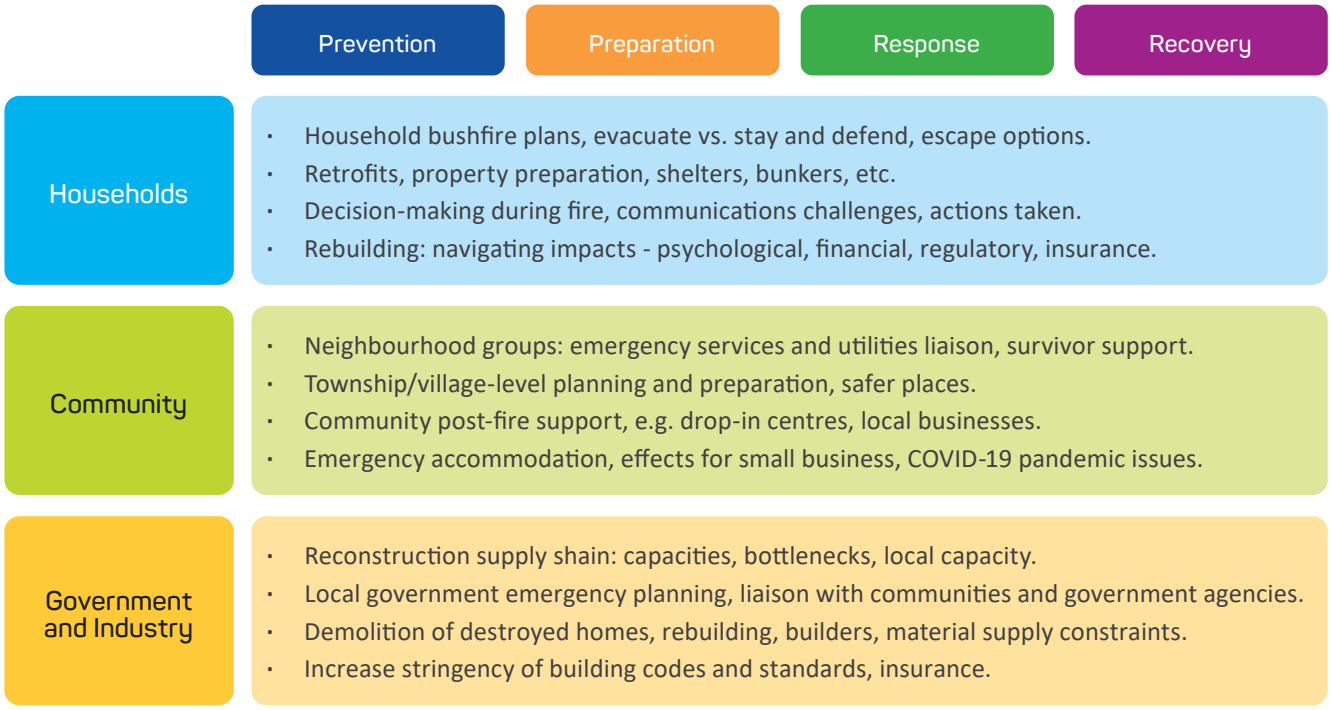

Figure 1: Schematic of societal layers influencing community bushfire resilience explored in this project.

From the overall study, we developed a number of information resources for community and practitioners, including a final report (McKinnon et al. 2022), a webinar and a series of 9 Bushfire Research Briefs that describe pertinent issues in detail (McKinnon et al. 2024).

Data collection was primarily through 70 semi-structured, in-depth interviews involving over 83 interviewees. These were supported by a review of written materials. Cohorts of interviewees included:

- residents and householders living in and around Kangaroo Valley
- community members involved in bushfire resilience initiatives
- local business owners
- volunteers and employees of emergency services and not-for-profit organisations
- employees of local government
- local professionals with relevant expertise, such as bushfire consultants
- people involved in the post-bushfire reconstruction program (e.g. peak body representatives, architects and designers, builders, tradespeople, demolition contractors).

In addition to data gathered through interviews, technical bushfire resilience assessments were made of 37 homes and other buildings to investigate the standard of construction of existing dwellings and retrofits undertaken by householders to increase the resistance of their property to bushfires. This aspect of the project was informed by previous research on the retrofitting of homes (e.g. Penman et al. 2017).

In this paper we focus on the genesis and evolution of local community-led bushfire resilience initiatives in the Kangaroo Valley. Research by Lucas et al. (2022) demonstrated the importance of developing '... social adaptation pathways using local communication interventions to build the neighbourhood knowledge, networks and capacities that enable community-led bushfire preparedness'. This can be achieved via a range of community strategies and approaches that provide stronger connections within the micro-level community of households and businesses, and to the macro-level of government, emergency services and the not-for-profit sector, as discussed by McLennan et al. (2021), Pope and Harms (2022) and Bloor et al. (2023).

Kangaroo Valley and the Currowan bushfire

Located 2 hours' drive southwest of Sydney, Kangaroo Valley is a semi-rural area of approximately 256 km^2 with a population of around 900 people in 500 households. It is a popular tourist destination and the population increases substantially during summer months. The region is bordered by national parks and nature reserves, particularly the Morton National Park to the south and west. This, together with the geography of the valley itself means that road access to the area is limited, which has important implications for residents and authorities in

Pyrocumulonimbus cloud looming over Kangaroo Valley on 4 January 2020.

Image: Maureen Bell

the event of a major incident such as a bushfire or other emergency. Evacuation may become difficult if any of the roads leading to the area become impassable.

The Currowan fire is believed to have been ignited by a lightning strike approximately 90 km southwest of the valley on 25 November 2019 (Adcock 2021). It eventually burned for 74 days across 320,385 hectares. The firefront reached Kangaroo Valley during the afternoon of 4 January 2020. The Nowra weather station, 24 km away, measured air temperatures over 43°C and wind speeds over 55 km/h that day, but participants we interviewed described much more intense local winds and temperatures.

The Kangaroo Valley community was significantly affected by the Currowan fire, which destroyed approximately 50 homes, representing 10% of all homes. In addition, many holiday cabins, sheds and other buildings were destroyed, along with equipment and extensive infrastructure. Many thousands of animals died, including livestock. The loss and damage to property, effects on mental health and wellbeing, economic effects for individuals, businesses and the community, the death of animals and significant damage to ecosystems have all presented long-lasting challenges for the community.

Local community-led initiatives prior to the Currowan fire

As with many bushfire-prone communities, members of the Kangaroo Valley Volunteer Rural Fire Brigade (KVVRFB) have provided support to their community in both bushfire fighting capabilities and community engagement over many decades. During the autumn and winter of 2018, it became clear that bushfire risks in Kangaroo Valley and surrounding regions were increasing beyond historical expectations due to low rainfall and high fuel loads. As a result of such concerns, the captain of the KVVRFB and others, including the local police officer, organised a Public Bushfire Awareness Community Meeting in September 2018, which was attended by approximately 150 people, including residents and members of NSW Rural Fire Service (NSWRFS). In addition to achieving heightened community awareness of these higher risks and the need to prepare for possible future bushfires, another key outcome of the meeting was a call by the KVVRFB for the community to '… take the lead in developing a Community Bushfire Survival Plan for Kangaroo Valley' (Smart 2018).

Kangaroo Valley Community Bushfire Committee

Following this public meeting, a new entity was established of the Kangaroo Valley Community Bushfire Committee (KVCBC), with members having a variety of backgrounds and experiences, including NSWRFS volunteers, local trades people, academics, logistics specialists and lawyers. A wide

The Bushfire-Ready Neighbourhood Planning information stall at the 2020 Kangaroo Valley Agricultural Show.
Image: Paul Cooper

range of issues and concerns were canvassed including a perceived lack of awareness, planning and preparation of many households regarding bushfires, issues with large numbers of tourists and visitors during bushfire danger periods, the lack of signage regarding bushfire danger in the area, potential evacuation advice and actions, residents' leave-or-stay intentions in the event of a bushfire, vulnerable members of the community, and potential effects of bushfire on businesses, agriculture and stock.

KVCBC analysed existing bushfire plans for the local government area and were of the view that these were too general to address the specific geography and local infrastructure and assets of the valley. They developed a discussion paper relating to the development of a community bushfire plan that identified specific vulnerabilities of critical infrastructure and began discussions with local government and emergency management organisations, including the NSWRFS. Drawing on models developed in other bushfire-prone regions, the KVCBC advocated for a 4-level approach to community organisation in Kangaroo Valley, namely: 1) individual households, 2) neighbourhoods, 3) larger localities and 4) community-wide level.

These efforts created new networks of information sharing between the community, local government and emergency services. Although good progress was made, some interviewees reported that this was not without some challenges, especially in the early phases of KVCBC's advocacy for changes to local disaster plans on the basis of local knowledge and expertise. This aligns with the experience of other community-led resilience groups, as described by McLennan et al. (2021) in their case studies of 'outsider emergency volunteering' and the potential clash of cultures between that of emergency services organisations and community-led groups as analysed by Rawsthorne et al. (2023). Nevertheless, increasing trust and collaboration between community resilience groups and emergency management organisations was subsequently successfully developed, particularly during and since the Black Summer bushfires.

Bushfire-Ready Neighbourhood Groups Network

Following the establishment of the KVCBC and other discussions within the community, the first Bushfire-Ready Neighbourhood Groups were established in the Upper Kangaroo River area of the region. At a local community meeting, a 'grassroots up' participatory process was used to agree on the locations and boundaries of 9 neighbourhood groups, each with a neighbourhood coordinator and deputy. A significant number of documents, maps, knowledge and other resources were

developed by members of that community and shared with other groups that were subsequently established in the wider Kangaroo Valley area during 2019. Development of household bushfire survival plans was strongly encouraged and facilitated, for example, by sharing specific examples of plans already developed by knowledgeable residents. This was later described by one interviewee as having '… dramatically helped people get over the line of developing their own bushfire plan'. A WhatsApp group was formed to cover each of the 9 neighbourhoods and, given the lack of mobile phone reception in the area, all Upper Kangaroo River neighbourhood coordinators purchased their own UHF/CB radios to improve communications between groups in the event of power and/or telecommunications failures.

In the months and days before the Currowan fire, a number of other Bushfire-Ready Neighbourhood Groups were formed and very many, if not all, neighbourhood groups met face-to-face in the anxious lead up to the fire. Residents, together with representatives of KVVRFB and/or KVCBC, discussed the challenges facing them. This included listening to frank advice from local experts on the risks of staying to defend properties, finalising household bushfire survival plans and assembling contact details for all residents. One comment was:

> *That [neighbourhood] meeting, [my partner] and I said it, I don't know how many times, that meeting saved countless lives, in our opinion. [A local RFS member] went through what to expect for the fire, how horrifying the experience would be, how difficult it would be for someone to defend their property unless they were completely fully resourced and had everything in their favour, and even then they may not be able to. He went through the ferocity of the fire, that it could be 1,000 degrees Celsius, that it would be pitch black like night, that the roar of the fire and the wind would be so extreme you won't be able to hear each other communicate, hence why you need to have everything written down and rehearsed.*
> (Resident)

During the week immediately prior to the arrival of the fire, an intense effort was made by the Bushfire-Ready Neighbourhood Groups to assemble a database of the stay-or-leave intentions of all residents in localities covered by neighbourhood groups. This information, together with detailed maps of many of the neighbourhood group localities, was provided to the KVVRFB. This meant that fire crews, both locally and from other districts, and other emergency personnel, would be aware of the location of people who planned to stay and defend rather than evacuate early. Checks on such households were prioritised by fire crews and other emergency services in areas hit by the fire in the hours after it passed. Data from the interviews indicated that this process was seen to be extremely important and of great value to both the community and emergency services.

All 33 households that were interviewed in this case study had established some form of bushfire survival plan prior to the Currowan fire, although they varied widely from unwritten vague intentions through to well-documented plans addressing multiple scenarios. The 55% of households that originally intended to evacuate prior to the fire did so, typically some days in advance. A smaller proportion (39% of interviewees) planned to stay and defend, but about one third of these changed their plan in the weeks preceding the Currowan bushfire and eventually evacuated early because the perception of abnormally severe risks. Data collected by neighbourhood coordinators immediately before the fire aligned closely with that gleaned from the interviews. Figure 2 shows the reported original stay-or-leave intentions of interviewees (n=33) and their actual actions prior to the fire. The right column shows data provided by residents (n=401) to Group Coordinators prior to the Currowan fire.

An important finding was that the proportion of householders interviewed were uncertain whether to stay or leave before the arrival of the fire was lower than that reported for many other fires. For example, in a survey in the aftermath of the 2009 Black Saturday bushfires it was found that 26% of the 1,314 respondents were effectively undecided about what to do prior to the fires (Whittaker et al. 2013). It seems possible that the many efforts to get residents to develop a firm bushfire survival plan and the relatively long lead time before the arrival of the Currowan fire had positive consequences for the clarity of householder leave-early or stay-and-defend decision-making, though it is not possible to definitively validate this hypothesis.

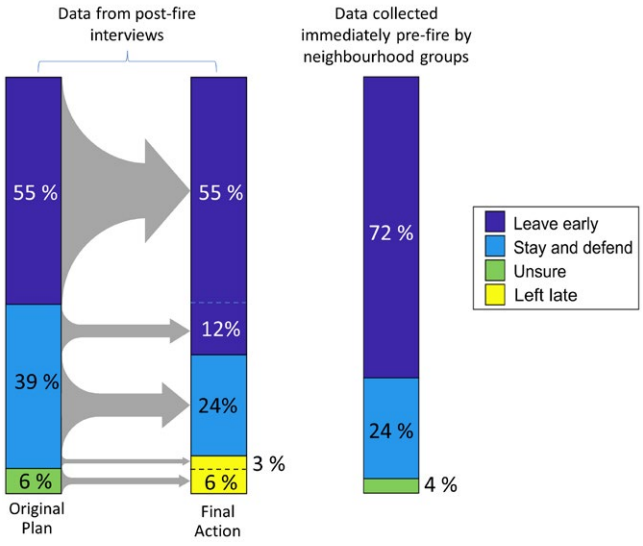

Figure 2: Householder leaving versus stay-and-defend intentions prior to arrival of the Currowan fire.

Many residents recognised the elevated level of danger early in the fire season as the Currowan fire grew in the south through November and December 2019. This forewarning allowed residents to make plans, clear vegetation and retrofit buildings. Many of the residents interviewed undertook substantial works on their properties in the weeks leading up to the arrival of the fire. Details of the types of preparations and retrofits undertaken are summarised in Figure 3. All of the assessed householders had prepared the area surrounding their houses (e.g. by clearing vegetation, watering and moving outdoor furniture), whereas a smaller group (35%) undertook more extensive retrofit works on their homes and other buildings.

Community-led response and recovery: the recovery drop-in centre

While there were no specific plans for a community-led recovery prior to the arrival of the fire, in the immediate aftermath, fire a new community-led bushfire emergency recovery group was quickly established, and within 3 days a recovery centre was set up in a shopfront in the village. From the interviews with residents and other stakeholders, it was clear that the recovery drop-in centre was critically important to the many significantly affected residents. Interviewees reported government and not-for-profit agencies were overwhelmed by the massive scale of the aftermath of the fires and were unable to provide substantial assistance at the local level for many weeks. The initial organic process of developing the drop-in centre was formalised through the establishment of the Kangaroo Valley Bushfire Recovery Association (KVBRA). An online GoFundMe fundraising campaign was established immediately after the fire and raised over $44,000 in a month. These funds were donated to the local volunteer rural fire brigades and to the KVBRA. A further $65,000 was raised for KVBRA via a fundraising dinner and auction shortly after.

Local volunteers at the KVBRA drop-in centre were quickly able to help people locate places to stay, contact their insurers and banks and apply for funds from charities and government sources, among many other important initiatives. The success of the recovery centre was, in part, due to the broad skillsets and commitment of the volunteers and good advice from members of the community and colleagues with prior bushfire recovery experience. It was also a place to share experiences with other residents and to receive emotional support through community connections. Complementing the drop-in centre was a community wildlife initiative to care for affected livestock, domestic animals and wildlife.

The drop-in centre was widely praised by the research participants and it offers a powerful example of how individuals with the necessary commitment and skills can provide practical and psychosocial support to their community and make a substantial post-disaster difference.

Ongoing evolution of disaster resilience initiatives

As recovery efforts continued following the Currowan fire, together with the challenges posed by the COVID-19 pandemic and a number of significant rain events, members of the Kangaroo Valley community sought to formalise and consolidate previous activities and initiatives.

It became clear that a single entity focused on disaster resilience would be beneficial, rather than multiple entities dealing separately with pre- and post-disaster phases,

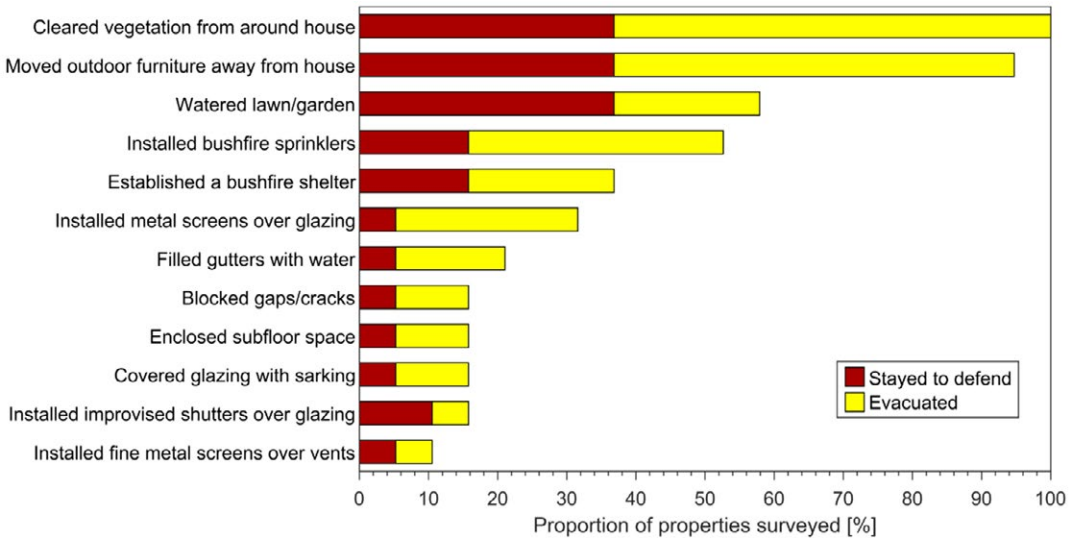

Figure 3: Summary of property preparation and home retrofits undertaken on the Kangaroo Valley properties assessed (n=19).

and with a broader focus than bushfire resilience alone. In addition, initiatives such as the KVBRA had always planned for a limited lifespan. So there was a desire to not lose the invaluable experience and lessons learnt from the initiative. Thus, a new incorporated body was formed and launched in November 2023 as the Kangaroo Valley Community Association for Disaster Resilience, known as 'Resilient KV'. The scope of this organisation was broadened to cover all types of natural hazards and all phases of the emergency management cycle, in contrast to the original focus on prevention and preparation for bushfires. Resilient KV continues to facilitate the Neighbourhood Groups Network and fills the gap left by the dissolution of the KVBRA. Advantages of formal incorporation/consolidation of the previous community-led organisations has also included the ability to obtain funding from government and elsewhere, and to purchase insurance cover.

Planning is underway to implement a Kangaroo Valley recovery drop-in centre should another major bushfire or other event occur. This includes addressing some of the challenges that were experienced after the Currowan fire, such as prearranged agreements for use of suitable premises, liaison with stakeholders (local municipal council), volunteer training (e.g. in administration, IT and data management) and training in trauma-informed support of people and the wellbeing of volunteers.

Resilient KV is continuing to develop a Kangaroo Valley Bushfire Preparedness Map. This was initially developed by a small group of KVCBC and community members using Google Maps as the primary source of geospatial information, with community members providing local information data layers such as hydrants, static water supplies, community assets and risks (Figure 4). This initiative has parallels with bushfire preparedness 'participatory mapping' activities documented by Haworth et al. (2016).

The network of Kangaroo Valley Neighbourhood Groups has continued to evolve and is now more closely linked with the KVVRFB. Senior KVVRFB officers are members of a Neighbourhood Coordinators WhatsApp group that facilitates closer 2-way sharing of information.

Summary

This case study of Kangaroo Valley provides examples of community-led resilience initiatives arising through the preparation, response and recovery phases of a significant bushfire event. It also covers the evolution of those activities as the recovery efforts blend into preparation for future events. The resounding sentiment among interviewees was that such initiatives were essential to the community's resilience during and after the Currowan fire and that they likely saved lives. While the Kangaroo Valley approach may not suit the contexts, resources or capabilities of all communities, its elements can be adopted and adapted for other communities.

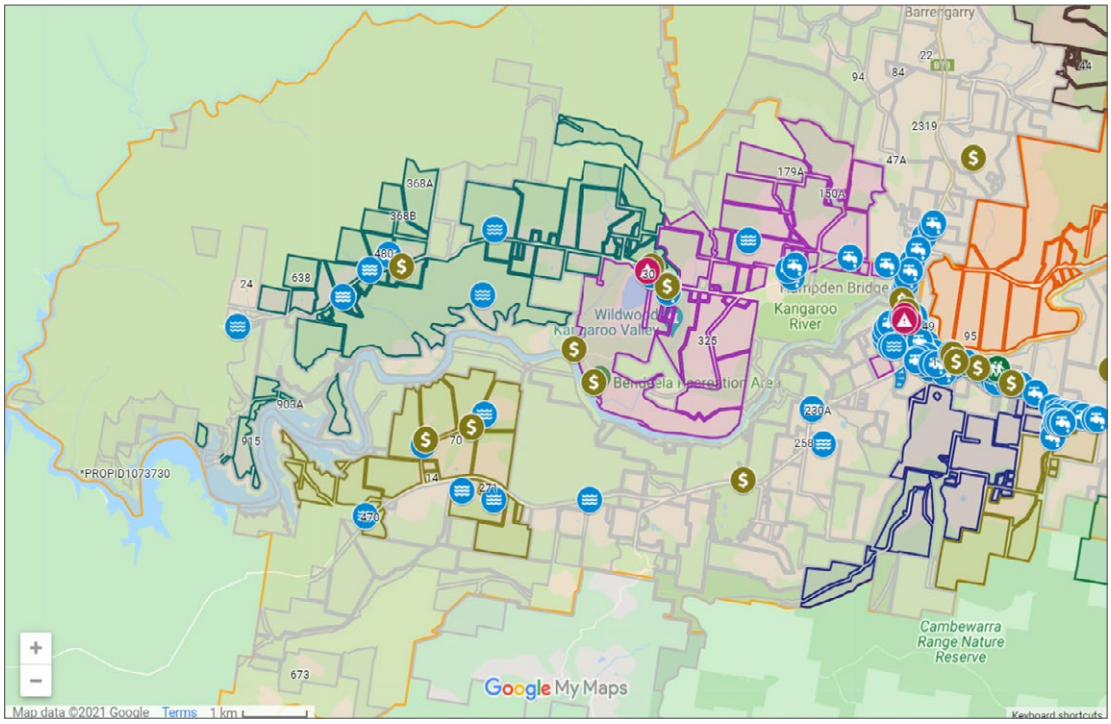

Figure 4: A pilot online Kangaroo Valley Bushfire Preparedness Map showing boundaries of properties, neighbourhoods and localities along with hydrants (tap icons), static water sources (ripple icons), infrastructure and assets ($) and hazards (Δ).

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Supporting disaster-affected communities in regional Australia with creative recovery initiatives

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Abstract

The incidence of environmental disasters in Australia are increasing. Moreover, they are expected to continue on an upward trajectory, leaving regional and rural communities in a highly vulnerable and precarious situation. Evaluating initiatives that support communities is essential to understand how best to help people process these events. This report is based on an evaluation of a Creative Recovery Network training programme supported by Arts Mid North Coast. The project was designed to support communities to build resilience in the aftermath of a disaster using creative processes. The evaluation used an action research frame that informed practice in real time by sharing data with stakeholders throughout. Qualitative and quantitative data were gathered and coded for thematic analysis. The evaluation included interviews, focus groups and surveys. The evaluation showed how the training provided the participants, all from disaster-affected communities, with a space to creatively express and process the many emotions that had arisen from their experiences. The training provided participants with tools that were successfully used in creative recovery workshops in their local communities. This paper reports on the Arts Mid North Coast and the Creative Recovery Network partnership project.

Disasters, mental health and the arts

The 2009 Black Saturday bushfires in Victoria, Australia were devastating. Sadly, 173 people lost their lives in bushfires that destroyed over 2,000 homes and seared more than 4,500 hectares of land, affecting 78 communities in total. As these numbers were unprecedented, recovery processes needed implementing as soon as was feasible. Arts Victoria recognised that creative recovery projects could help people to process, heal and rebuild and so funded and evaluated local initiatives. The evaluation found the projects had meaningful benefits for the participants on both an individual and community level. It also found that the rebuilding of community through the arts was valued on par with the necessary practical structural rebuilding (Fisher and Talvé 2011). The arts initiative helped create a 'caring community' that contributed to healing, self-confidence, creating structure, living memorials and, importantly, allowed people to give to each other (Fisher and Talvé 2011, p.50).

Recently, bushfires in Australia in 2019–20 burnt 17 million hectares and destroyed 3,094 homes, with 34 lives lost. In 2022, there were 46 disasters declared in Australia and these affected 316 local government areas (NEMA 2022). The Climate Council and Beyond Blue revealed that 51% of people in Australia who have experienced these events since 2019 described a range of mental health effects, 21% of whom reported major or moderate symptoms (Climate Council 2022). In 2023, the reports of bushfires around the world were again devastating. If such events continue, as is predicted, people will need a range of supports to rebuild their communities.

Effects on mental health

It is well-documented that stressful events cause both short and long-term physiological and psychological stress (Green et al. 2003). The effects on physical and mental health have become more concerning as the regularity and severity of disasters increase. The effects on individuals and communities can be long-term and complicated, involving loss of life and injury, damage to health and wellbeing, housing, financial and material losses, family separation, education and employment prospects as well as changes in community dynamics and the environment (Australian Red Cross 2023). Greater mental health support is an imperative for people in disaster-affected communities (Australian Red Cross 2023).

Palinkas and Wong (2020) showed the importance of developing mental health services specifically to deal with sub-acute climate-related events. The Australian Government recognises the need to support communities and emphasises the need for community, individual and social recovery (NEMA 2022). Suitable provisions for communities are crucial. Since the Black Saturday bushfires in 2009, there has been a better understanding of how creativity can help process the adverse effects of disaster on regional communities.

The arts as a recovery tool

Creative arts processes have been recognised by the World Health Organization to have benefits for mental health (Fancourt and Finn 2019). They have been shown to support individual, social and community connection, and build resilience in regional Australia (Gentle 2018; Gentle et al. 2020; Gentle and O'Brien 2021). Furthermore, the arts can be easily integrated into individual and community welfare to support people to process adverse events (Bennet et al. 2022). The creativity process is an essential component in creative recovery and requires readily accessible projects (Hancox et al. 2022).

Arts Mid North Coast (AMNC) is a well-established regional organisation and is the peak body for the arts and cultural development. It champions community engagement to build resilience and wellbeing (AMNC 2024). AMNC is situated in one of the areas harshly affected by the 2019–20 bushfires and 2021–22 floods. As such, it was well-placed to use local and state networks. Learning lessons from the Regional Arts Victoria evaluation by Fisher and Talvé (2011), AMNC applied for funding to deliver the Creative Recovery Network's training programme to disaster-affected communities. The training programme was an opportunity for:

- the arts to meaningfully support communities to recover and rebuild
- the arts to be integrated into and valued as part of broader community recovery efforts
- local artists and arts workers to gain increased knowledge, skills and confidence to respond to communities in recovery
- arts and cultural organisations to enhance their capacity to work with communities in recovery and respond in a coordinated way.

An arts-based partnership

AMNC partnered with the Creative Recovery Network[1] to provide a 3-day training programme to the Mid-North Coast of New South Wales. The Creative Recovery Network described the training workshops as:

> *…an introductory programme designed to establish best practices in trauma informed care to work with disaster impacted communities in safe and productive ways. Based on the recognition that disaster planning is a whole of community responsibility that requires specialised knowledge and experience, the programme supports the identification and development of creative facilitators to work in community-centred disaster planning.*
> (CRN 2023)

The training programme was devised, developed and facilitated by the Creative Recovery Network and funded and coordinated by AMNC.

> *Creative Recovery is a particular approach to supporting individuals and communities after a disaster. It involves introducing art and creativity as tools to work through feelings of grief, pain, foster connection and build stronger, resilient communities.*
> (AMNC 2024)

The collaboration gave the project flexible and responsive approaches to ensure communities had some agency in their recovery as recommended by the NSW Reconstruction Authority (Department of Planning and Environment 2022). The organisations provided a unique platform that placed regional communities front and centre of the project.

The training programme

The Creative Recovery Network is Australia's foremost leader in supporting and advocating for the intrinsic value of culture and the arts in community recovery. Creative recovery is a particular approach that involves introducing art and creativity as tools to work through feelings of grief and pain, foster connection and build stronger, resilient communities. The Creative Recovery Network developed a training programme informed by its experiences working with communities and the creative leaders fostering connected participatory programs with their communities. Their training program embeds arts

1. Creative Recovery Network, at https://creativerecovery.net.au.

and cultural development practices in disaster recovery and preparedness.

This research mined the data collected from focus groups, observations, interviews and surveys during the evaluation of that training.

Data collection processes

It was essential for the programme that data collection did not compromise the flow of the training sessions nor interrupt the participant's experience. A project's accessibility can be increased in regional areas by using evaluators who are emic to the data collection process (Harrison 2008). Hancox et al. (2022) used creative arts approaches to their study with communities in Australia to ensure the research itself was a supportive process. Similarly, this research used sensitive, naturalistic data collection methods. This ensured the research did not interrupt creative processes during the workshops and emphasised the study's authentic approach. The multiple methods and sources helped to provide robust and relevant data. Hancox et al. (2022) recommended that arts projects should be flexible enough to respond to community needs to remain relevant to the community needs. The action research frame the evaluation used guaranteed the data would be shared throughout, so it could be used in real time to enhance the programme. The evaluation was completed with participant's full written consent to publicly share the collected data.

Stakeholders and engagement

The training program was built from community need and was disseminated through the community by a range of organisations and individuals. AMNC saw connecting authentically with stakeholders through community and state connections as an imperative.

The stakeholders included:

- Biripi, Dunghutti and Gumbaynggirr Elders and communities
- AMNC council partners - City of Coffs Harbour, Bellingen Shire, Nambucca Valley, Kempsey Shire, Port Macquarie-Hastings and Mid Coast areas.
- communities affected by recent disasters
- service providers (emergency services and non-government organisations)
- local artists
- all state governments and the Australian Government
- Creative Recovery Network.

The Creative Recovery Network developed the training so it could be delivered to local councils, health services, emergency services organisations and artists. The training programme was rolled out by AMNC after some of the worst back-to-back disasters experienced in the region. Many of the possible associated risks were mitigated by the professional experience of the Creative Recovery Network training facilitator who could envisage where participants might struggle.

Methods

Methods and sources

Table 1 shows the data sources and methods of collection used for the evaluation. It includes the projects that stemmed from the training due to the action research frame that was used throughout.

Analysis

Evaluation data verification and coding

Data were analysed using Nvivo software. Table 2 shows the methods that indicated if objectives had been met.

Outcomes

Biripi, Dunghutti and Gumbaynggirr Elders and artists welcomed participants to Country for each of the workshops. The local cultural knowledge they provided confirmed how creative recovery is integral to Aboriginal and Torres Strait Islander culture and is rooted in creative practice.

The training was attended by 41 artists, arts workers, council and emergency service providers. The participants were

Table 1: Data collection methods and sources.

Groups	Method	Source
Kempsey	1. Survey	Training group participants
	2. Observation	Training groups
	3. Focus group	Participants and stakeholders
	4. Interview	Participants, organisers and facilitators
Taree	1. Survey	Training group participants
	2. Observation	Training groups
	3. Focus group	Participants and stakeholders
	4. Interview	Participants, organisers and facilitators
Bellingen	1. Survey	Training group participants
	2. Observation	Training groups
	3. Focus group	Participants and stakeholders
	4. Interview	Participants, organisers and facilitators
Creative recovery projects	1. Survey	Project participants and facilitators
	2. Interview and video	

given a post-workshop survey and a total of 39 completed surveys resulted in an overall rating of 4.8 out of 5 stars. It was a strong outcome for using the arts as a mental health and recovery tool in disaster-affected communities. Figure 1 shows general participant feedback.

Participant feedback from the training showed the workshops were used as a creative way to process some of

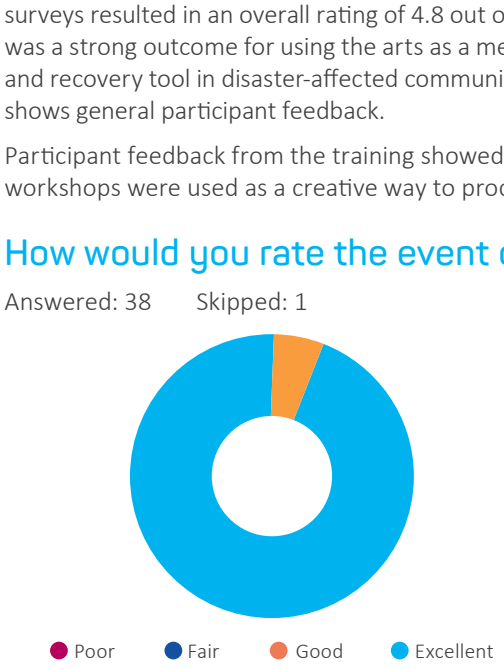

Figure 1: Survey outcomes.

the trauma associated with extreme events. Observations of the training showed how empathetic response, listening to community, connecting with people and using creativity as a tool were skills that could be learnt and applied. Additionally, the creative recovery projects that had stemmed from the action research procedures used a diverse range of techniques and art materials to engage geographically disparate communities. 16 participants of the training applied for and received small art grants to run 14 creative recovery projects. 745 people from local communities participated in those workshops, reaching far beyond the original aims of the training programme.

The evaluation demonstrated the original objectives set by AMNC and the Creative Recovery Network had been successfully met. These included:

- raised awareness of the role the arts can play in disaster recovery
- increased understanding of the disaster context and improved confidence
- increased awareness of the risks of future disasters, and built capacity in mitigating these risks
- increased skills, knowledge and networks
- supported community needs
- worked with stakeholders to show the benefits of arts-led recovery
- ability for communities to express changing disaster recovery needs
- increased awareness of the disaster recovery processes
- increased awareness of the risks and their response to future disasters.

Data showed that that the training provided participants with increased capacity to support resilience in disaster affected communities, increased connection to other people and services, and improved participants facilitation skills and confidence in offering targeted support.

The training outcomes extended beyond the original objectives to help connect communities in the Mid North Coast area who had felt separated. Figure 2 shows the ways communities benefited and that building collaborative, area-based projects can add to connectivity and, thus, resilience of communities. The programme was successful because there was an emic organisation coordinating the project that was using a ground-up approach that involved elders from communities as integral to planning and consultation.

Figure 2: How the training affects communities.

Recommendations and practice implications

The evaluation (Gentle 2023, pp.29–37) identified 9 recommendations and 5 practice implications that can be used to enhance future creative recovery work in regional areas:

- Evaluation: creative recovery projects needs to be emic to the workshops, either arts- based throughout the training, during reflection at culmination of training or as a focus group soon after. The focus group could be a way to initiate a community of practice.

Table 2: Evaluation data verification and coding.

Measures	Observation	Surveys	Focus group	Interview
Awareness of the role the arts can play in the disaster recovery process and supporting and sustaining community resilience. **Codes:** Resilience, arts in recovery, enhanced creativity, empowerment	Yes	Yes	Yes	Yes
Increase in the participant's understanding of the disaster context in the creative recovery. **Codes:** Arts in recovery, knowledge	Yes	No	Yes	Yes
Were participants more confident in working with communities impacted by disaster? **Codes:** Confidence, empowerment	Yes	No	Yes	Yes
Awareness of the risks of future disasters and feel confident in mitigating these risks. **Codes:** Disaster awareness, confidence, empowerment	Yes	Yes	Yes	No
Increased skills, knowledge and networks and capacity to respond to future disasters. **Codes:** Skills, knowledge, connections	Yes	Yes	Yes	Yes
How well the program supported the needs of community and whether there are areas for improvement. **Codes:** Barriers, connections	Yes	No	Yes	Yes
How well the program worked with key stakeholders (e.g. local councils, community organisations, emergency management, health services). **Codes:** External collaboration, connection	Yes	No	Yes	Yes
If the training led to an increased understanding and recognition for embedding arts-led recovery programs in disaster management plans. **Codes:** Disaster management planning	Yes	No	Yes	Yes

- Facilitation: creative recovery training programs is crucial to their success and having an experienced, knowledgeable and skilled facilitator is imperative.
- Project officer role: essential to support the project and organise a community of practice and should be integral to the program.
- Community of practice: with creative recovery facilitators would offer support and share knowledge. This will help to maintain momentum, collaboratively respond to local events and support future projects.
- Grants: identified and made available by the project officer and offered to trained facilitators post-training.
- Time allowed: the training could be residential or run over 3 days to help participants absorb, collaborate and be ready to begin a project by completion.
- Accreditation of training: essential will be essential for creative recovery responses to be embedded in emergency response management. The training is methodical and comprehensive so could be restructured to build a module of formal learning.
- Dissemination: optimal to be available throughout regional Australia. It would be beneficial for local council emergency preparedness and response teams, for creative recovery units at a state level and for emergency management agencies.
- Use of hubs: regionally based organisations used to spearhead the devolution of disaster recovery. Local, trusted organisations are best placed to act in recovery as they have the necessary connections and structures in place to respond to community needs.
- First Nations knowledge: local Aboriginal and Torres Strait Island communities should be prioritised when developing creative recovery training and projects to ensure knowledge and wisdom are at the heart of the programmes. This leads the whole community approach and encourages inclusiveness. By taking the time to acknowledge and reflect on the local knowledge of communities can enrich participant experience through connection with a deeper story of the land and its peoples. This provides a rich form of connection to the space. It grounds the project in something beyond time and place. Such consideration has the potential to allow for the grieving of what has past because of a disaster, using the perspective of the long history the area has already experienced. The wisdom of Dadirri (Ungunmerr-Baumann 2022) and other cultural approaches teaches ways of being that supports an appropriate recovery response and acknowledges cultural connection to the natural environment as a protective factor that can be harnessed during and after stressful events.

- Holding the space safely: facilitation of a group with experience of the trauma associated with disasters requires considerable skill.
- Upskilling artists: preparing local artists and arts workers using the Creative Recovery Network training will give participants a understanding of how to work with communities as well as build their local networks.
- Connections: focusing on the inter-relational aspect of the Creative Recovery Network framework will support a community and an individual's ability to 'bounce back' after experiencing a disaster.
- Creative recovery process: preparing communities to use creativity to process what they have encountered can help build strength and resilience.

Collaboration at every stage

The main outcomes were a direct result of the collaborative approach taken by AMNC and Creative Recovery Network that focused on what the communities needed. The ethos of both organisations allowed for a smooth partnership that was able to grow according to the community needs raised during the training. Figure 3 shows the flow of the process.

Discussion

The Creative Recovery Network provided interested communities with the skills necessary to facilitate local creative recovery projects. The training sessions were valued by participants not only for the learning they acquired but also because they were a means to process the many difficult emotions they had experienced during a host of climate-related events that seriously affected their communities. The participants were offered a range of information and tools that they could use to facilitate creative recovery groups in their local areas. The projects they designed and delivered used a variety of creative techniques that helped their groups form connection and process the effects of recent disasters, thus enhanced individual and community resilience. The creativity and accessibility of these projects responded to the recommendations of Hancox et al. (2022). The programme and its outcomes were aligned with the Australian Government's emphasis on community, individual and social recovery (NEMA 2022).

The evaluation examined the effectiveness of the network's 3-day training using surveys, observations, focus groups and interviews with participants and facilitators. The evaluation process enhanced the programme, as the action research method provided the data that instigated artist-led creative recovery projects that were also evaluated (Gentle 2023). A creative recovery model for supporting communities to process and recover was disseminated to stakeholders via the evaluation. Similar to the work of Bennet et al. (2022), the arts were shown to be a fitting way to support people and their communities to process the many emotions that surface from disasters.

Conclusion

For communities to build resilience and strengthen they need to feel supported and to connect with others. The arts have a unique capacity to support healing and are playing a pivotal role in disaster recovery in Australia. The research and associated literature show that the individuals, families and communities will continue to be exposed to high-risk hazards. Using creative recovery techniques to support people after such events offers opportunities to process emotions, build resilience and move beyond the event. This report illustrates how collaboration between organisations

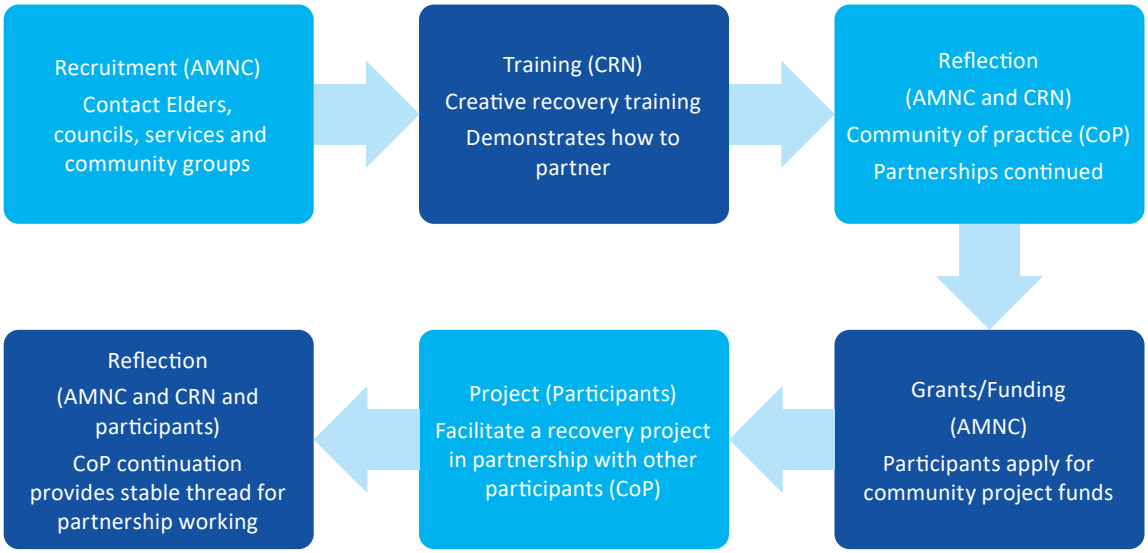

Figure 3: How organisational collaboration can work.

with a common goal can provide a range of stakeholders with the tools, services and supports they report as being necessary for their post-disaster recovery.

Acknowledgments

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About the authors

Emma Gentle is a researcher interested in the therapeutic nature of art-making. Her current work focuses on the capacity of art and creativity to improve mental health and promote wellbeing. Her work focuses on the effects of disasters on individuals and communities.

Science-informed risk reduction for earthquake-generated tsunamis in Western Australia

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Introduction

The Indian Ocean tsunami in 2004 resulted in 227,000 fatalities across 14 countries. It is a grim reminder that tsunamis are among the world's most deadly hazards. Most tsunamis are caused by large earthquakes, especially along the Ring of Fire that circles the Pacific Ocean. Tsunamis can be triggered by other atypical phenomena including volcanic eruptions and landslides. While Australia is located some distance from the Ring of Fire, tsunamis can and have reached the Australian coastline. Tsunamis can cross entire oceans and remain destructive when they reach the other side. For example, the 2004 Indian Ocean tsunami, generated by a 9.2 Mw magnitude earthquake near Sumatra in Indonesia, crossed 5,000 km of the Indian Ocean before it reached Somalia in east Africa, causing 300 fatalities (Fritz and Borrero 2006).

The 2018 Australian Probabilistic Tsunami Hazard Assessment (PTHA18), produced by Geoscience Australia, estimates the chance that tsunamis generated by large-plate boundary earthquakes will occur around the Australian coast (Davies and Griffin 2018). It identifies the coast of Western Australia as having the highest earthquake-generated tsunami hazard in the country (see Figure 1). This is largely due to the state's relative proximity and exposure to the Sunda Arc subduction zone in Indonesia, which has generated numerous historical tsunamis, including the 2004 Indian Ocean event. Of all natural hazards considered, Western Australia's Natural Hazards Risk Profile 2017 identified that tsunami posed some of the highest risks to the built environment (SEMC 2017).

An important limitation of the PTHA18 is that it only estimates the tsunami probability in deep water offshore due to plate boundary earthquakes. This is useful to identify broad areas of coastline where earthquake-generated tsunami (historically the most common type) may pose a threat to the community. However, developing tsunami risk reduction strategies requires an understanding of what tsunamis will actually do when they come onshore.

Tsunamis usually feature a long series of waves, not just a single wave. When these waves enter shallow water, they increase in height and travel more slowly. The area inundated depends on complex interactions between the sequence of waves and the elevation of the seafloor and land near the coast. Inundation areas cannot be estimated simply by looking for the onshore contour that corresponds with the maximum offshore wave height. Tsunamis may inundate some areas with elevations multiple times the offshore wave height while leaving other sites with similar elevation untouched.

The Department of Fire and Emergency Services (DFES) in Western Australia is the hazard management agency responsible for managing the adverse effects of a tsunami emergency across the prevention, preparedness, response and recovery spectrum (Government of Western Australia 2006). The department's roles and responsibilities include tsunami inundation modelling and participation in local and regional tsunami planning (SEMC 2022)

With these responsibilities in mind, DFES has a partnership with Geoscience Australia to understand what earthquake-generated

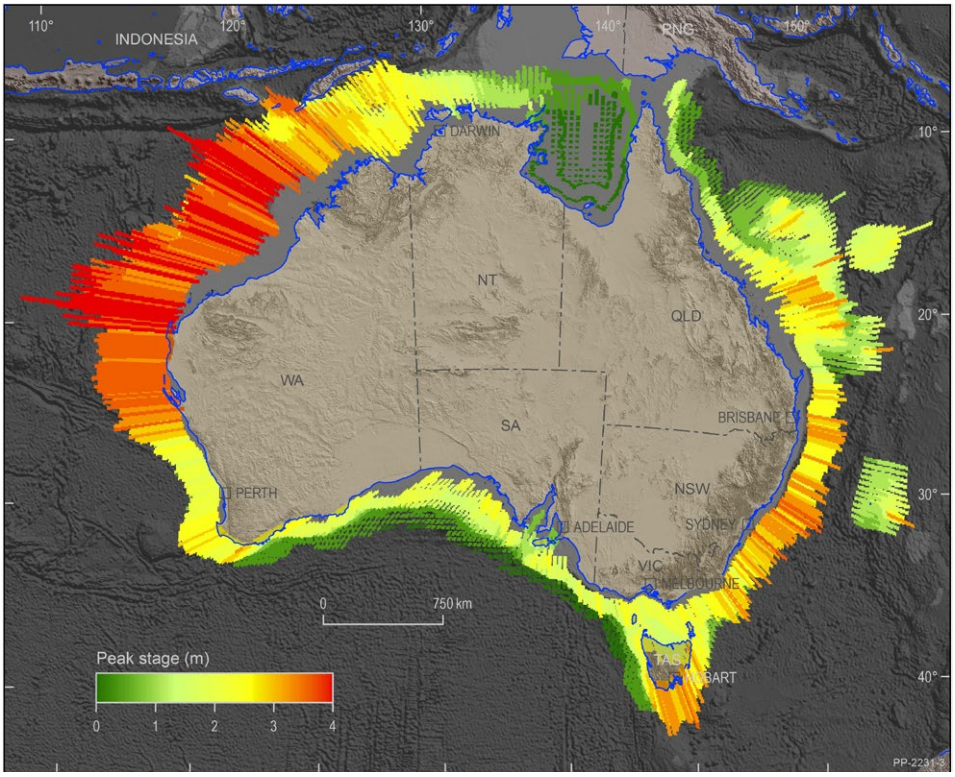

Figure 1: The 2018 Australian Probabilistic Tsunami Hazard Assessment of Australia's coastline.
Source: Davies and Griffin (2018)

Davies and Griffin (2018) estimate the average frequency of tsunamis with different sizes occurring in deep waters offshore of Australia. Only large-plate boundary earthquake sources are considered. This figure shows the 1-in-1,000 year tsunami amplitude (water height above the sea level). Reds and oranges indicate larger waves and greens indicate comparatively smaller waves.

tsunamis will do when they come onshore and to use this knowledge to design risk reduction strategies for specific areas along the coast. The work is a major update to previous modelling of inundation hazards in coastal townships (Stevens et al. 2008). Since 2008, advances in tsunami science and in elevation data coverage for Western Australia have enabled inundation models to be developed with greater accuracy and consistent spatial coverage. Importantly, the new modelling is being used to develop spatially extensive evacuation maps to guide emergency responses to earthquake-generated tsunamis.

The preliminary evacuation maps outlined in this study are an advance in undertaking preparedness for tsunami. The next steps involve extensive consultation with stakeholders to refine and finalise these maps. In this way, this study is an example of using science to inform operational risk reduction decision-making to increase community safety. The initial phases of the project focused on modelling earthquake-generated tsunami inundation and producing evacuation maps for a study area from Geraldton (430 km north of Perth) to Dunsborough (250 km south of Perth), including the Greater Perth area. Although the tsunami hazard in this zone is not the highest in the state, this area has the largest number of residents living on the coastline and, therefore, has a potentially increased exposure to tsunami.

What might happen when tsunamis come onshore?

The area inundated by an earthquake-generated tsunami depends on several variable factors, including details of the earthquake-induced seabed deformation and several fixed factors, especially elevation in near-coastal areas. While it is not possible to know earthquake properties ahead of time, the probability of different earthquakes can be estimated. For this reason, Geoscience Australia undertook a probabilistic approach to model tsunami inundation. Results include areas from Geraldton to Dunsborough, including the Greater Perth area.

High-resolution elevation data (offshore bathymetry and onshore topographic) are essential for tsunami inundation modelling (AIDR 2018). The Western Australian Government has overseen the collection of high-resolution

bathymetric and topographic LiDAR data, which has made detailed inundation modelling possible.

The inundation modelling involved combining PTHA18 with a high-resolution tsunami inundation model:

- PTHA18 was used to define possible earthquake-tsunami scenarios, their rate of occurrence and uncertainties in these rates. All considered scenarios originate on the Sunda Arc, which PTHA18 indicates is the most likely source of distant earthquake-generated tsunamis affecting the study area.
- Several hundred PTHA18 scenarios were selected for inundation modelling, with greater emphasis on scenarios featuring large waves offshore the study area. The scenarios represent a small fraction of those in PTHA18 but are sufficient for inundation hazard calculations (Davies 2022).
- A tsunami inundation model for the region from Geraldton to Dunsborough was developed using high-quality bathymetry and topography data. This model simulates the details of tsunami propagation and inundation. To check its accuracy, 2 historic tsunamis were simulated: the 2004 Mw 9.2 Indian Ocean tsunami and the 2005 Mw 8.6 Sumatra tsunami. These tsunamis were well measured at tide-gauges in the study area and the model showed good agreement with these observations.
- After modelling inundation for the selected PTHA18 scenarios, the results were combined to estimate the average frequency of tsunami inundation due to Sunda Arc earthquakes in the study area (Davies 2022). This frequency of inundation varies from site to site, depending on both the site elevation and the broader tsunami dynamics.

An example output covering a small portion of the modelled area is provided in Figure 2. It shows an estimate of the average long-term inundation frequency (events per year) resulting from tsunamis originating from Sunda Arc earthquakes, assuming a moderately conservative earthquake frequency model (84th percentile uncertainty). Variations on these outputs were developed to account for the uncertain frequency of large earthquakes (Davies 2022).

The methodology includes 2 conservative assumptions:

- All tsunami scenarios are modelled in an otherwise stationary ocean with water level matching the highest astronomical tide in Perth.
- The modelled land roughness is relatively low. It does not account for buildings or dense vegetation that can reduce inundation in some areas.

These assumptions tend to increase the size of the inundation zone. However, a potentially non-conservative limitation of the model is that coastal erosion is not treated. This could potentially change the topography

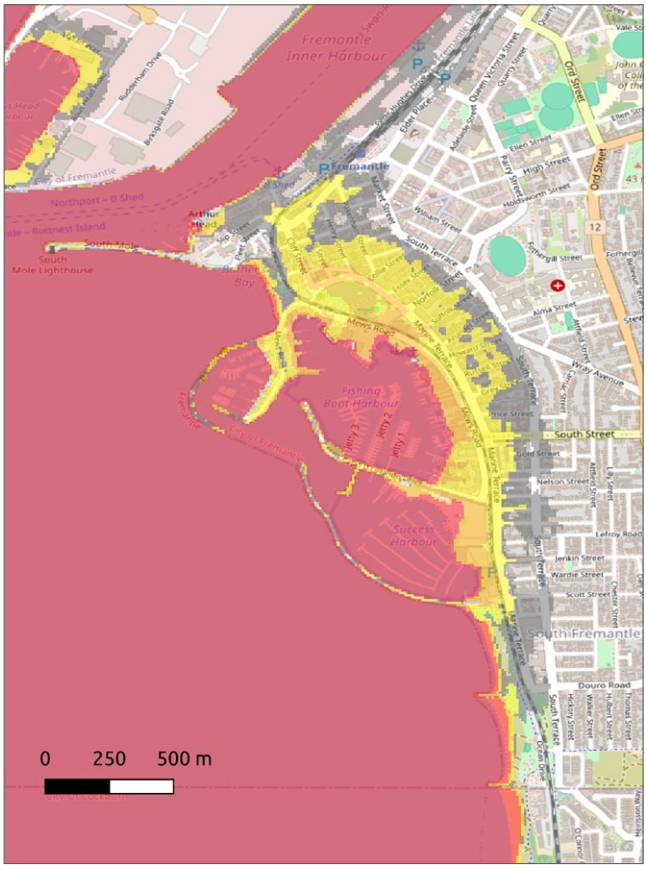

Figure 2: Example of a tsunami inundation map in the Fremantle (Perth) area.

The colours in Figure 2 show the modelled frequency of inundation according to a moderately conservative (84th percentile) model of earthquake frequencies: red (greater than 1-in-100 events per year), orange (1-in-100 to 1-in-500), yellow (1-in-500 to 1-in-2,500), grey (1-in-2,500 to 1-in-10,000).

and, thus, inundation patterns during an event. DFES has given qualitative consideration to this issue when using the results to inform evacuation mapping. With this approach, the final evacuation maps are more likely to be an overestimate than an underestimate, which is considered appropriate for public safety application.

Another limitation of the modelling is that atypical tsunami sources are not treated (e.g. submarine landslides, volcanic eruptions, local earthquakes, asteroid impacts). These are rarer events than tsunamis generated by plate boundary earthquakes and are difficult for the current generation of tsunami warning systems to detect and provide advanced warning. However, for atypical tsunamis generated far from the coast, advanced warnings may be possible using sea level observations. The scenarios treated represent the most likely case for which a coordinated evacuation is

possible, but further consideration of atypical tsunamis is recommended in the future.

Improved risk reduction using tsunami inundation scenarios

It is impossible to stop a tsunami once it has been generated so an important aspect of tsunami risk reduction is on pre-planning evacuation. Therefore, additional products were developed to support tsunami warnings.

If a large earthquake occurs, it will be detected within minutes by the Joint Australian Tsunami Warning Centre. They assess whether a tsunami has been generated and, if necessary, will issue tsunami warnings at least 90 minutes before expected arrival. Currently, 2 different warning levels may be issued (Allen and Greenslade 2010; Greenslade et al. 2020):

- Marine warning: The tsunami may cause dangerous waves, fast currents and minor inundation of beaches and shorelines.
- Land warning: The tsunami exceeds the 'marine warning' criteria. Some of these events may lead to significant inundation.

In the absence of detailed onshore modelling, the default advice is for people to evacuate 1 km from coastal and estuarine shorelines or at least 10 m above sea level (AIDR 2018).

Recently, it was recommended that the 'land warning' category be split into 2 levels ('minor' and 'major'). To date, this has not been operationalised (Greenslade et al. 2020). The warning levels are applied separately to each of the 67 Australian Marine Forecast Zones that collectively cover Australia's coast.

The Joint Australian Tsunami Warning Centre uses the location and magnitude of the earthquake (estimated minutes after it occurs) to identify similar modelled earthquake-tsunami scenarios in a precomputed scenario database. The modelled offshore wave heights in these selected scenarios are used as the basis for issuing warnings (Greenslade et al. 2020):

- Marine warnings: 95th percentile wave height between 20–55 cm.
- Land warnings: 95th percentile wave height exceeding 55 cm.

The 95th percentile wave height is computed within each of the Australian Marine Forecast Zones so the warning level may differ between zones. The warning level can also be adjusted based on observations of the actual tsunami wave height (e.g. from buoys) as it progresses across the ocean.

For this study, the inundation scenarios were used to map areas that could be inundated during marine or land warnings, which can help emergency services personnel to adapt their response to each kind of warning. To make these maps, each PTHA18 scenario was classified as either a marine warning or land warning for the study area, using the same offshore wave height criteria applied by the Joint Australian Tsunami Warning Centre. Preliminary 'marine warning' and 'land warning' evacuation zones were then defined by combining the modelled inundation extents of all PTHA18 scenarios classified as 'marine warning' or 'land warning'. The land warning zone was limited to include areas with a probability greater than 1-in-2,500 of occurring each year, while using a conservative '84th percentile' model of earthquake frequencies, following international best-practice (MCDEM 2016; Tonini et al. 2021). The limit represents a compromise between the risks of mass evacuation and the very low likelihood of even larger events, while avoiding an arbitrary choice of 'worst-case scenario' that is not well defined for tsunamis (MCDEM 2016).

These model-based zones were edited to produce actionable preliminary evacuation zones. For example, although the inundation modelling enabled the identification of individual house blocks, the boundaries of evacuation zones were adjusted to follow streets or other features that could be easily identified on the ground. The proposed marine evacuation zone was also extended to cover beaches and low-lying areas in the coastline and estuaries.

Tsunami safe locations are places for evacuees to meet and wait for further advice from DFES. These locations were defined using population data (to identify the number of residents who would need to be evacuated from each section of the land warning evacuation zone) and identifying features (such as ovals and parks) in proximity but outside the evacuation zones. These were selected to ensure that they were large enough to accommodate the required number of people and that they were accessible at any time of the day. Evacuation routes were modelled using geospatial least-cost path analysis (i.e. Fraser et al. 2014). This method helped to identify streets and define routes that were the shortest and most direct path between evacuation zones and tsunami safe locations for pedestrian evacuation.

Preliminary evacuation maps were produced showing the location of the evacuation zones for marine and land warnings, tsunami safe locations and evacuation routes (Figure 3). These maps were then reviewed by operational personnel and, where necessary, adjustments made based on their local knowledge.

The response to an impending tsunami is perhaps more time-critical than the response to any other natural hazard. Rather than wasting time working out how to respond once a tsunami warning has been issued, these maps offer a pre-planned 'recipe' of how to respond so an increased amount of time can be spent on implementing the response and less on planning the response.

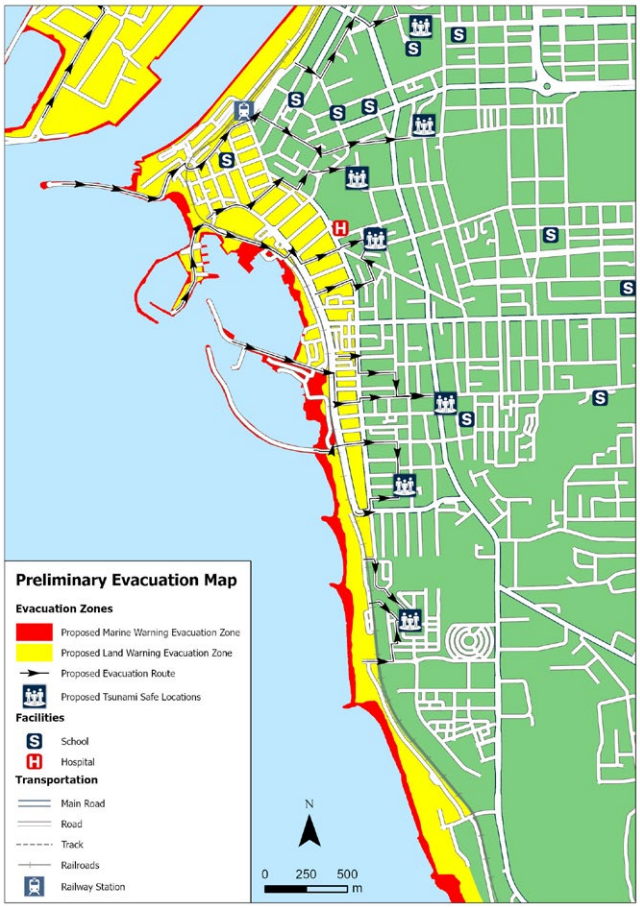

Figure 3: Sample preliminary tsunami evacuation map for Fremantle showing proposed locations of evacuation zones, safe locations and evacuation routes.

The proposed evacuation zones in Figure 3 are informed by inundation modelling for tsunamis generated by plate boundary earthquakes. Adjustments will be made to the strategies identified on these maps based on local knowledge.

Benefits of using inundation scenarios to design evacuation zones

For bushfire and flood, assets (property, infrastructure, landscape) are progressively exposed to the hazard as it moves across the landscape. This enables response resources to be moved between assets as different assets are exposed. In contrast, in a tsunami, all assets are exposed simultaneously. For this reason, identifying which assets to focus on is critical. The greatest advantage of inundation modelling is it improves knowledge of which assets to focus resources on.

In the absence of inundation modelling, the existing land warning advice is to move at least 1 km inland or 10 m above sea level (Allen and Greenslade 2016; AIDR 2018).

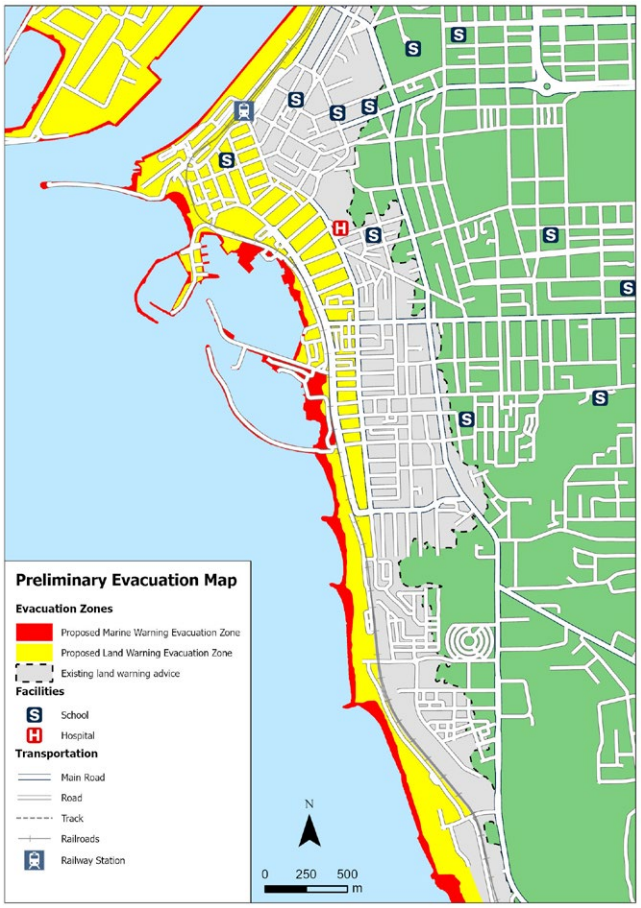

Figure 4: Comparison of default land warning tsunami evacuation zones and those informed by inundation modelling in the Fremantle area.

Figure 4 compares this default zone to the preliminary evacuation zones informed by inundation modelling in Fremantle. Table 1 compares the number of features within each zone for the Greater Perth area.

The inundation modelling enables education, pre-planning and response to be more focused than under the existing default land warning advice. Notably, the inundation modelling identified that a public hospital within the default land warning zone has a low probability of being affected and is no longer within an evacuation zone. This

Table 1: Comparison of the number of features in default land warning tsunami evacuation zones and those informed by inundation modelling in the Greater Perth area.

Features	Default existing land warning advice	Preliminary evacuation zones informed from inundation modelling
People	>100,000	<20,000
Schools	22	3
Aged care facilities	15	3
Hospitals	1	0

is significant because hospitals are difficult and resource intensive to evacuate. It is likely that, in the event of a land warning being issued, a decision would previously have been made to allocate significant resources to evacuate a hospital that likely would not to be affected.

The inundation modelling also enables tsunami education and pre-planning activities to be targeted. For example, the default land warning advice would indicate education and pre-planning activities should be implemented at 22 schools while inundation modelling identified just 3 schools require this.

In the Greater Perth area, the smaller size of the preliminary evacuation zones informed by inundation modelling has enabled safe zones to be located closer to where potential evacuees live than under the existing default land warning advice. This increases the likelihood that, in the event of a land warning, more people will evacuate on foot that will reduce traffic congestion and increase the number of people who are likely to successfully evacuate.

It is notable that inundation modelling suggested minor inundation could occur during 'marine warning' earthquake tsunamis. Previous studies identified marine warning scenarios that include some inundation (Greenslade et al. 2020). However, the inundation modelling assumed the highest astronomical tide that may not be the case when a tsunami actually occurs. It cannot be assumed that the marine evacuation zone will be inundated in all marine warning tsunami events. However, the results suggest that careful consideration should be given to the response to larger marine warning events, especially if they coincide with a high astronomical tide.

In the future, there is potential to tailor the evacuation zones by providing more than 2 warning categories (versus the current 'marine' and 'land' warnings) and tuning the warning thresholds for different coastal regions. For example, if the marine warning category were divided into 'minor' and 'moderate' or similar, it would be easier to determine whether any evacuations are warranted in the larger marine warning tsunamis. Alternatively, the boundary between 'marine warning' and 'land warning' could be revised using the model outputs to prevent marine warning inundation. Similarly, if the land warning category were divided into 'minor land warning' and 'major land warning' and tuned to different coastal regions, as suggested by Greenslade et al. (2020), it is likely that the land warning zones could be reduced for the majority of land warning tsunamis.

What is next

DFES will use the preliminary evacuation maps and undertake stakeholder engagement to help develop and finalise these maps. The stakeholder engagement will include guidance about how these maps may be used to improve public safety should a tsunami occur. This will assist DFES to meet its responsibilities as the hazard management agency for tsunami.

The current project was undertaken in the comparatively densely populated southwest Western Australia between Geraldton and Dunsborough including the Greater Perth area. Future phases of the project will focus on the north of the state which, while less densely populated, has higher exposure due to its closer proximity to the Sunda Arc. In the future, highly accurate near-coastal elevation data will be captured in this area that will facilitate tsunami inundation modelling.

DFES is planning to use the inundation modelling and evacuation maps to maximise the efficiency of the warning system, develop recommendations to update and amend tsunami plans and procedures, develop awareness products and a communications plan for tsunami awareness. Consideration will be given to the treatment of atypical tsunami sources, which are not modelled in this study. The aim is to reduce the time taken in planning the response when a warning is received and increasing the time to implement the response.

DFES plans to undertake education and pre-planning activities with the owners and users of those high-value community assets, such as schools, that were identified as being within the inundation modelling-informed tsunami evacuation zones.

This project highlighted the benefits of modifying the Joint Australian Tsunami Warning Centre warning thresholds based on modelling. This could make it easier to identify assets exposed to inundation and to target evacuations. Experiences from the Tonga volcanic tsunami in 2021, which nearly reached the land warning threshold in New South Wales and Queensland but did not produce substantial inundation, highlight the need for meaningful warning categories that focus evacuation efforts on sites most likely to be inundated.

Acknowledgments

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Supporting cyber-incident response with AIIMS

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Introduction

With cyber incidents becoming an increasingly visible part of the media landscape in recent years, many companies, government entities and not-for-profit groups find themselves coming to terms with the reality of cyber-incident response. As a relatively new phenomenon, organisations that have not yet experienced a complex cyber incident may underestimate the potential complexity and scale of the work needed to contain and remediate them. The demands of cyber-incident response can test a victim organisation's leadership and staff in unexpected ways that are not always obvious.

A cyber incident can be likened to emergency management response where protection of life and property and helping to mitigate and remediate unexpected events are activities that fall outside of an average person's or organisation's experience. In these cases, the skills and experience of trained personnel who work together using understood principles are needed to respond with certainty and prevent greater harm. Cyber incidents require a similar approach. Many organisations are ill-equipped to manage these events. In New South Wales, the link to emergency management is explicit through the Cyber Security Incident Emergency Sub Plan, which mandates how large-scale incidents affecting government are managed at a state level (SEMC 2018). However, many organisations are not aware of this link, instead relying on ad-hoc processes to manage a response.

The various information security standards such as ISO 27001 (ISO/IEC 2013), the NIST Cyber Security Framework (NIST 2024) and the Australian Signals Directorate advisory publications (ASD 2024) offer guidance on aspects of cyber-incident response. The most-commonly understood action resulting from these is to have a plan, which is an essential element in documenting and testing the elements of a response. However, such frameworks and standards can assume a 'perfect' organisation that has the necessary resources, awareness and control over its information and technology assets to achieve all the required activities quickly and efficiently. This is not always the case. For an unprepared organisation, cyber-incident response drains resources from business activities, asks executives to make tough decisions based on information they do not fully understand, imposes significant unexpected costs and lost productivity and can expect IT staff to make business decisions with uncertain downstream consequences.

Without a well thought out approach, everyone is in an uncomfortable position that can result in slow response times, poor public communication, unnecessary business disruption and, at worst, the inability to contain the incident and prevent further harm.

After leaving the New South Wales Government to join Northern Beaches Council in late 2023, I was prepared to implement a comprehensive range of governance and management structures necessary to triage, escalate and manage a future cyber incident. Instead, I discovered that the council already had 2 key processes in place. The first was the council's major incident response process based on the IT Infrastructure Library standard. The council was already experienced in handling incidents involving technology disruptions due to computer, network and software failures. The process was documented and the team was confident in its execution. The second and more surprising aspect was the council's incident management team that included senior leaders and experienced staff members. The team structure and process reflected the framework described in the Australasian Inter-service

Incident Management System™ (AIIMS) (AFAC 2017). Through a 2-day introductory workshop, I learnt how AIIMS supports emergency management for fires, floods and other emergency events but I could see parallels with my cyber-incident response experience.

I saw how real-world emergency responses differed from the cyber incidents I had experienced and how the AIIMS system could potentially be used in conjunction with the council's existing major incident response process to accommodate the unique properties of a cyber incident.

This paper introduces cyber incident concepts and practicalities and some of the challenges of responding to cyber incidents. The paper considers how AIIMS functions and principles could be used in conjunction with established IT practices to fill gaps in response that many organisations may benefit from.

The cyber threat

While the security of computer systems and networks has been a topic of concern, discussion and investment for decades, 2017 marked a turning point in public awareness of cyber-attacks (Poireault 2023). Two notable worldwide attacks labelled 'Wannacry' and 'NotPetya' became headline news as they spread over the Internet and disrupted private and public sector entities globally. Both examples of ransomware (software that encrypts and therefore denies access to digital information until a ransom is paid) Wannacry and NotPetya infected networks indiscriminately and caused billions of dollars of damage (Poireault 2023). Since then, an increasingly sophisticated range of cyber adversaries have honed their skills and adapted their operating models in response to industry trends. They have gained access to private and sensitive information held by governments, companies and small businesses. Excluding insider threats and online activists, there are 2 main classes of cyber adversaries: criminals and nation states.

Criminals

Like their real-world counterparts, cyber criminals are largely motivated by money. Their goal is to leverage what they can for financial gain such as coercing a victim to pay a ransom or pay money directly to them using false invoices or altered payroll details or simply stealing and selling sensitive information. The health care sector, governments and law firms have been popular targets for these reasons (Dudley-Nicholson 2023).

Criminals have evolved their tactics in response to potential victims protecting themselves better against ransomware attacks. Thus, these groups have moved to multiple extortion methods such as threatening the victim with the release of sensitive information, mounting more attacks against them and even contacting individuals whose information has been stolen to coerce them directly.

Nation states and their proxies

Countries spy on each other. However, internet connectivity allows an effortless way to cross international borders and nation states have adopted cyber intrusions alongside physical methods as standard tradecraft to progress their economic, social and ideological aims (Burgess 2024). The harvesting of information related to citizens, intellectual property, commercial opportunities and military secrets can be carried out remotely and often without detection. In some cases, affiliated criminal or ideologically motivated groups are used as proxies to gain access to entities of interest.

More recently, the threats of disruption of critical infrastructure (CISA 2024) and foreign interference (Burgess 2024) have been highlighted by Five Eyes intelligence agencies as potential goals for cyber adversaries.

Anatomy of a cyber attack

Various models for describing the elements of a typical cyber attack have diverse levels of complexity and information. Three commonly used models are the Diamond Model, Lockheed Martin Cyber Kill Chain and the Mitre Att&ck Framework. The models provide different views of a cyber attack that can be used depending on the organisation's goals. These models also illustrate a key aspect of the struggle victim organisations face in understanding and responding to cyber incidents, that of unfamiliarity and complexity.

Diamond Model

The Diamond Model of intrusion analysis helps to map the elements of a cyber attack based on 4 contributing factors (Tidmarsh 2023):

- Adversary – the identity and motivation of the attacker.
- Capabilities – the tools and techniques used by the adversary.
- Infrastructure – physical or logical resources used by the adversary.
- Victim – the individual, organisation or system attacked by the adversary.

The model is particularly effective when used for cyber-threat intelligence, allowing an analyst to discover relationships between events and learn more about an adversary.

Cyber Kill Chain®

The Lockheed Martin Cyber Kill Chain was developed to extend the military kill chain concept into the technology field. It describes the series of actions from finding a target through to assessing the effects of an attack (Korolov and Myres 2022). While not comprehensive in describing all possible cyber-attack scenarios it serves a useful purpose to understand the stages in which an attack may be

interrupted to minimise harm. The kill chain includes 7 activities performed by the adversary:

- Reconnaissance – researching the target organisation through publicly available information, including analysing its technology assets for weaknesses or misconfiguration.
- Weaponisation – crafting a malicious file or similar technical means to breach the organisation's computer network perimeter.
- Delivery – using email, messaging, USB storage devices, malicious websites or vulnerable infrastructure to get a payload into the organisation.
- Exploitation – using a vulnerability in the organisation's network environment to execute the payload on the victim's system.
- Installation – implanting malicious software on the victim's system to facilitate further attack stages.
- Command and control – creating a persistent communication channel for the adversary to control the malicious software.
- Actions on objectives – using the capability previously implemented to carry out the adversary's aims.

Mitre Att&ck Framework

The Mitre Att&ck Framework is a comprehensive, modern description of the tactics, techniques and sub-techniques commonly used by adversaries (The Mitre Corporation n.d.). Where Lockheed Martin's Kill Chain is simplistic, Mitre Att&ck is devilishly complex and detailed. It includes page after page of technical attack methods at all levels from reconnaissance down to individual technological attacks. It requires considerable technical knowledge and experience to understand the framework and how to defend against the methods it describes.

Why cyber victims struggle

The 3 frameworks described previously illustrate one of the many problems for business leaders when asked to handle a cyber incident – foreign concepts and language, along with immense technical detail and complexity. Despite incident response plans listing roles and responsibilities, standard operating procedures and playbooks, legal and jurisdictional arrangements and more, real-world experience uncovers many aspects that are not often documented. Some examples illustrating this include:

- senior leaders being bombarded with unnecessary tactical information by enthusiastic IT staff
- IT staff acting independently and not following instructions
- inability to prevent the attacker regaining access by treating the attack as a technical issue
- rigid business-as-usual processes that hinder time-critical activities, such as procuring specialist expertise
- senior leaders tasking technical staff with irrelevant tasks based on misinformed understanding
- staff working excessive hours because of key person dependencies
- tipping off the adversary that they have been discovered, allowing them to adapt their approach
- the adversary being in control of the organisation's network and communication tools
- technical staff having aims contrary to the business and neither being aligned to the response objectives
- uncertainty about who is in charge at any given time.

Complex cyber incidents are not simply a technical problem that can be solved by an IT department. In some cases, victims do not have the knowledge and experience to manage all aspects of an incident response. Effective responses are coordinated efforts, involving many internal functional areas with specific knowledge and scope that must work together seamlessly. Additionally, a range of external parties can be involved such as government cyber agencies, law enforcement, private incident response firms, suppliers, partners and customers.

Given the enormous reliance on technology to provide the backbone of many modern organisations, the potential scope of a cyber incident can affect all functions at all levels as well as anyone connected to the victim organisations either through technology or association. In this way, an incident response can become another line of business until the threat is mitigated, the incident is well understood and affected parties are notified.

Cyber – flood or pandemic?

Another key aspect of cyber incidents is that although some are obvious (such as being unable to access systems or information) many are quiet and often discovered after the adversary has left. Once an incident is suspected based on an observed event, an organisations needs to confirm that something did indeed occur and needs to identify the scope and implications of what happened. This can take some time. It can take weeks for a forensic examination of a large computer network using specialised software tools. Discovery and analysis of information involved in a large data breach can take months. During this time, leaders are relying on technical incident responders to provide reports that may only show progress instead of results. As such, the organisation's leadership can feel exposed due to a perceived lack of progress and the inability to appear open and transparent.

Cyber incidents are less like fires or floods, and more like a pandemic. Leaders must trust the opinions of subject-matter experts in the absence of an observable physical threat while speaking confidently and authoritatively to their audiences. The damage may already be done but cannot yet be described.

A potential solution

With all this complexity, a diverse range of internal and external stakeholders, the motivations and capability of the adversary and the constraints of the victim organisation, a method is needed to bring structure and certainty to what is a very uncertain situation. By uniting subject-matter experts and technical incident response activities with business people, activities, priorities and support structures through a single framework, an organisation can position itself to act swiftly, decisively and effectively. Incident response objectives must be clear, well-informed, communicated and managed. This level of organisation cannot rely on a single team. The victim organisation must respond to the incident in a united way, considering all relevant information, opinions and experience and authority. This is where the AIIMS incident response system could provide an answer.

How AIIMS could fill the gaps

The 2017 AIIMS manual describes how the system supports a common incident management system for responding agencies and personnel in emergency response (AFAC 2017). While cyber-incident response could escalate to an emergency in some circumstances, any such incident that requires a high level of coordination, resourcing and collaboration across multiple business and technical areas could benefit from AIIMS. This is because the system is based on principles of scalability and flexibility to meet the needs of a particular incident.

Applying the system

There is not just one way in which AIIMS could be integrated into cyber-incident response. Depending on the scenario, AIIMS principles of Unity of Command and Functional Management could be used as part of a united or linked structure to provide a cohesive response.

Information overload

IT staff who view their employer through a technology lens can often enthusiastically describe the intricacies of the attack and the technical work being carried out at the expense of understanding business impacts. Their role is to understand the incident in depth and carry out often complex and highly technical activities to investigate, contain and remediate the attack.

From the AIIMS perspective the role of IT in conjunction with any external incident responders form the bulk of the Operations and Investigation functions. In the early stages after discovery, it may not be obvious what has happened, or if anything happened. Confirming this may require the forensic investigation of thousands of devices to determine the path an adversary took, and the action they performed.

By employing the AIIMS concepts of Unity of Terminology and Common Operating Picture, the Incident Controller and all response functions could understand the scope, impact, risks and progress to help steer the response at a business level, while being free of the minutia of the technical response.

Failing to understand the adversary

Cyber incidents are not caused by computers and their ultimate goals are not computer systems and networks. They are the work of individuals and groups who are working to achieve an objective that ultimately affects people. Incidents that are treated simply as an IT issue fail to address the human ingenuity and motivation that adversaries possess. An increased level of understanding helps to successfully resolve the incident permanently.

Gathering and using information to add context to what is observed is the role of the Intelligence and Planning functions. There is a growing number of cyber intelligence sources from both the public and private sectors that can provide useful threat context during an incident. By assuming the actions are the result of a human and learning from similar incidents, response actions can be taken with greater confidence and potential effectiveness.

Another aspect is to gain insight from the business's perspective. Correlating what is observed at both a technical and business level can provide additional intelligence value, allowing the Planning Function and Incident Controller to consider alternative strategies, business continuity arrangements and communication plans. These could be incorporated into a single Incident Action Plan that demonstrates how theoretical policies and procedures will be applied in practise.

Rigid business processes

In any governed or regulated organisation, especially in government, the acquisition and management of resources required to support a response can be hampered by procurement rules, delegations and availability of key staff for approvals. Depending on the scale of the response, contract retainers with specialist incident response companies can be used up very quickly. For example, a 40-hour retainer may only last a few days when multiple response resources are required. In the case where a victim organisation does not have such arrangements in place, going to market for competitive quotes could cause a dangerous delay in the response.

The Planning, Logistics and Finance functions in the AIIMS system could work together to provide the necessary resources and expertise as quickly as possible while the response continues. Overseen by the Incident Controller, this could enable an effective way to provide consistent and flexible support while maintaining focus on the response objectives.

Distracting tasks

The independent role of the Incident Controller, combined with the Planning Function could provide an alternative escalation path that can be used to manage business requirements without interrupting planned tasking aligned to the response. It is reasonable that in a large incident, especially when the details are not clear or cannot be communicated widely, that leaders from any area of the victim organisation could approach IT staff directly for information or workarounds. From an outsider's perspective, there may be no obvious progress to resolve business issues. This can lead to escalation of business impacts through various paths to find a short-term solution. Ordinarily this situation can be dealt with expertly by its service desk and other support staff devoting time and effort to the problem. Within an incident, their focus can be elsewhere and this could lead to conflict.

Staff welfare

In the initial phases of a response IT staff can be in a constant state of alertness as they try to piece together what has happened and how to respond. Over time, more resources may be brought in to add additional skills and expertise, but often not to relieve existing staff.

Some IT organisations rely on staff with exclusive knowledge who, under normal circumstances, are not used to handing over their role. In many cases there may be no other skilled person to hand it to. This situation can be considered part of initial planning prior to any incident. It could be rectified by requiring a source of extra resources, cross-training and thorough documentation. During a response, the Planning and Logistics functions potentially have the challenge of tracking hours worked, supporting key resources to keep working towards an agreed objective and enforcing breaks so that staff can recover. This requires an independent view and authority from the Incident Controller to ensure that people can disconnect and recover.

Tipping off the adversary

There are situations where communicating a cyber incident can harm the response. Adversaries can monitor information published on the Internet and can adapt their approach based on the organisation's actions. In some cases, it could be necessary to conceal the incident from staff and stakeholders until more is known to avoid an uncontrolled communication through social media or email.

The Public Communications and Intelligence functions must work closely with the Incident Controller to assess what information can be disseminated to which audience, balancing necessary and justifiable communications with the potential influence on the response. This could be difficult for communication to staff, where open communication may be desirable to prevent rumours and distrust.

The adversary in control

In a larger and well executed incident, a situation may occur where the adversary has gained control of significant network resources and access. This control could potentially be used to perform reconnaissance on the incident response itself, allowing the adversary to remain a step ahead of responders for a longer period of time.

In an extreme case, the Planning, Logistics and Finance functions could be tasked with procuring alternative communications and information management infrastructure to be used exclusively for the response. Similar to tipping off the adversary, extreme care must be taken with this approach as it requires a level of focus that would distract from the operational and investigative functions.

Conclusion

Every organisation will have different requirements based on its size, structure, technology environment, risk tolerance and the nature of the incident itself. This paper considered how AIIMS could support cyber-incident response without addressing the many ways that the framework could be implemented, nor every aspect. For organisations that have an emergency management function based on AIIMS, aligning their cyber-incident response processes with that function may be relatively quick. For those whose focus is cyber-incident response, the AIIMS methodology offers an understandable and flexible approach to organising existing or future resources.

I have not attempted to illustrate the relationships or functions because of the wide variety of possibilities and the understanding that any untested plan is likely inadequate. A key element to integrating AIIMS with other response approaches would be to exercise it in context to understand where responsibilities should best sit and how functions could work together.

The Northern Beaches Council is in the early stages of drawing these links. It will continue to develop and refine its approach, cognisant that a united approach provides the best path to protect the council and its many stakeholders in the community. It is my hope that some readers may see a similar opportunity to consider how AIIMS could be used to unite their own response processes as it may also initiate the cross-sharing of knowledge that would allow IT teams who are inexperienced in incident response to leverage the organisational experience of emergency responders. We are all in this together.

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Epidemiology of mass stabbings in Australia and worldwide: the need for enhanced counter-violence medicine

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Introduction

Mass stabbing attacks, while rare in Australia, are not unheard of. Enhanced counter-violence medicine coupled with creating a culture that values active bystanders as immediate responders, can help mitigate the effects and also deter such attacks from occurring in the first place.

The violent stabbing attack that occurred at a Sydney shopping centre on 13 April 2024 (Visontay et al. 2024), is one of the deadliest and most extensive mass stabbing (or any planned mass violence) recorded in Australia in decades. When it comes to understanding violent public attacks, the phenomenon of mass shootings in Australia is well-documented (Chapman et al. 2016). Historical data reveals a total of 14 mass shootings in Australia (McPhedran 2020). A significant number of these incidents, specifically 9, occurred in New South Wales. Notably, the vast majority of these shootings took place before major gun law reforms in 1996. From 1979 to 1996, Australia experienced 13 fatal mass shootings.

Paramedics at the Westfield shopping centre waiting to treat injured people.

Image: Helitak430, CC0, via Wikimedia Commons

In stark contrast, in the period post-1996 reform, there has been only one incident (ABC News 2015).

The profiles of the perpetrators indicate that many experienced significant acute life stressors or ongoing difficulties prior to attacks, though a formal diagnosis of mental illness was not commonly recorded (McPhedran 2020). In comparison, less is known about mass stabbing incidents. These events are not as thoroughly chronicled as their shooting counterparts, particularly those not categorised as terrorist acts.

Using the Global Terrorism Database (GTD)[1], there has been 6 documented terrorist attacks in Australia that involved knives as the primary weapon and occurrences spanned between 1981 and 2020 (see Table 1). These attacks targeted private citizens and property, with some attacks directed at business entities and police forces. All implicated perpetrators were motivated by Jihadi-inspired extremism. The attacks have led to 6 fatalities.

However, this data does not encompass non-terror-related stabbing incidents, such as that at the Westfield Shopping Centre in Sydney. This suggests a gap in the tracking and understanding of this type of violence. By examining previous studies, only one non-terror-related mass stabbing attack was identifiable in Australia prior to the Westfield attack (Amman et al. 2022).

Historically, knives and sharp objects have not been the most common weapon used in terror attacks in Australia. The terror attack that took place on 16 April 2024 at a church in Sydney against a bishop and a priest is the latest case (Turnbull and Atkinson 2024). Overall, the data on terrorist attacks in Australia indicates a predominant use of incendiary devices. These were used in approximately 70% of the recorded terror incidents. Firearms have been used in 13% of the attacks, while knives and other bladed weapons have been involved in 10%. Explosives, including bombs and dynamite, have been used in about 5% of the cases (Tin et al. 2021).

Public mass stabbings, much like shootings, require the perpetrator to be in close proximity to their victims. This proximity significantly reduces the likelihood that the attacker can escape arrest or avoid being fatally wounded during the intervention. Despite these operational similarities between stabbings and shootings, the strategies for countering them differ significantly due to the accessibility of the weapons involved. While firearms are generally regulated and harder to obtain, knives and other sharp objects are everyday tools, readily accessible and commonly found in households. This accessibility makes preventive policies challenging.

Internationally, the trends in violent acts against the public, particularly mass stabbings, reveal distinct patterns and motivations that vary significantly by region. Data show that the majority of mass stabbing attacks are carried out by lone, male offenders using knives. Notably, half of all documented mass stabbings have taken place in China (Amman et al. 2022).

In terms of motivations, approximately a third of these attacks were reportedly linked to the perpetrator's mental illness. Interestingly, there is a marked correlation between the location of the attack and the attacker's motive. Incidents driven by mental health issues have been

1. Global Terrorism Datawbase, at www.start.umd.edu/gtd/

Table 1: Evaluation data verification and coding.

Date	City	Perpetrator group	Fatalities	Injured	Target type
16/12/2020	Brisbane	Jihadi-inspired extremists	2	0	Citizens and property[a]
9/11/2018	Melbourne	Jihadi-inspired extremists	2	2	Police, citizens and property [b]
9/02/2018	Melbourne	Jihadi-inspired extremists	0	1	Citizens and property[c]
7/04/2017	Queanbeyan	Jihadi-inspired extremists	1	0	Business[d]
10/09/2016	Minto	Jihadi-inspired extremists	0	1	Citizens and property[e]
23/09/2014	Melbourne	Jihadi-inspired extremists	1	2	Police[f]

a. www.couriermail.com.au/subscribe/news/1/?sourceCode=CMWEB_WRE170_a_GGLanddest=https%3A%2F%2Fwww.couriermail.com.au%2Fnews%2Fqueensland%2Fpolice-probe-whether-knife-used-by-rahge-abdi-linked-to-couple%2Fnews-story%2F8369ac8022ddb962f5edfad3fa2052b5andmemtype=anonymousandmode=premiumandv21=GROUPA-Segment-2-NOSCORE

b. www.reuters.com/article/idUSKCN1NE2M3/

c. www.theguardian.com/world/2018/feb/15/sister-of-bangladeshi-student-accused-of-melbourne-stabbing-arrested-in-dhaka#:~:text=Sister%20of%20Bangladeshi%20student%20accused%20of%20Melbourne%20stabbing%20arrested%20in%20Dhaka,-This%20article%20isandtext=The%20sister%20of%20a%20Bangladeshi,attacked%20officers%20with%20a%20knife

d. www.smh.com.au/national/nsw/service-station-worker-fatally-stabbed-in-queanbeyan-police-hunt-for-two-teenagers-20170407-gvfkat.html

e. www.abc.net.au/news/2016-11-24/terrorism-inspired-attacker-ihsas-khan-made-admissions/8054708

f. www.nytimes.com/2014/09/27/world/asia/isis-australia-mohammad-ali-baryalei.html

disproportionately more likely to occur at educational institutions. Interestingly, the majority of attackers (90%) were not repeat offenders (Amman et al. 2022).

When examining the geographic patterns of mass violence, stark differences emerge between mass stabbings and mass shootings. Mass shootings are more prevalent in the United States, Russia, Yemen, the Philippines and Uganda. In contrast, mass stabbings occur predominantly in China Japan, Canada, India and Israel, with China accounting for more than half (and by some estimates, over 60%) of global cases (Silva 2023).

Other epidemiological characteristics that can be compared across the 2 forms of mass violence include:

- location of attacks – open areas are the most frequent sites of mass stabbings, contrasting with commercial locations for shootings
- survival of perpetrators – the survival rate of offenders diverges; 77% of stabbers survive the incidents compared to 42% of shooters who survive
- casualty figures – despite differences in modality and context, the number of casualties inflicted by mass stabbings and shootings are surprisingly similar, indicating that both forms of violence are effective at harming groups of people (Silva 2023).

While it may seem intuitive that China and the United States, 2 of the most populous countries in the world, report higher numbers of mass stabbings and shootings the disproportionality of these incidents relative to their populations is striking. Despite comprising less than 18% of the global population, China accounts for over 50% of the world's mass stabbing incidents. In China, where gun control laws are among the strictest in the world, the rarity of firearms may shift the means of mass attacks to weapons that are readily available.

While mass stabbing attacks are a rarity in Australia, the evolving nature of global and domestic threats necessitates ongoing vigilance. In August 2024, the Australian Security Intelligence Organisation raised the terror threat level from ‘possible’ to ‘probable,’ marking the first such escalation in nearly a decade (Haghani and Spaaij 2024). The Global Peace Index (GPI)[2] and the Global Terrorism Index (GTI)[3] can also be used as barometers for assessing Australia's shifting security concerns and atmosphere over time.

Australia's 2023 GPI score was 1.52, positioning it 22nd globally (higher rankings indicate more favourable positions and safer conditions). This Index is composed of 23 indicators, ranging from perceived criminality in society, homicides, violent crime, jailed population, military expenditure to relations with neighbouring countries and levels of political instability. A tracing of this index over time reflects a slight shift to relatively unfavourable positions compared to a decade ago (Figure 1).

On the terrorism front, Australia currently ranks 57th based on its GTI 2023 score. The GTI assesses the effects of terrorism based on incidents, fatalities, injuries and the number of hostages taken. Similar to GPI, the GTI shows a slight worsening of Australia’s position from 65th a decade ago to 57th place (lower rankings indicate better conditions).

Figure 1 shows Australia’s trends on both these indices. Australia's slightly deteriorating scores in both the GPI and GTI over the past decade could potentially highlight the need for continued and fortified planning and policy adaptation to pre-empt and mitigate emerging and evolving public security threats.

The need for enhanced counter-violence medicine

Counter-Terrorism Medicine (Tin et al. 2021) is rapidly emerging as a critical sub-specialty, reflecting the need to enhance frontline responses to terrorist acts. This includes mass stabbings. The distinct and often more severe nature of injuries inflicted in terrorist stabbings compared to civilian incidents requires the development of specific medical protocols and training for trauma units (Merin et al. 2017).

There are significant differences in terms of trauma preparedness. Terrorist stabbings typically aim to inflict maximum harm, resulting in multiple victims with complex, severe injuries that can overwhelm standard emergency protocols. These incidents often result in simultaneous admissions of multiple patients with penetrating wounds, primarily to the upper body, which are life-threatening and require immediate and specialised care. In contrast, civilian stabbings usually involve fewer victims and less severe injuries, with a different pattern of wound locations, often in the abdominal area.

2. Global Peace Index, Vision of Humanity website www.visionofhumanity.org/maps/#/
3. Overall Terrorism Index Score, Vision of Humanity website www.visionofhumanity.org/maps/global-terrorism-index/#/

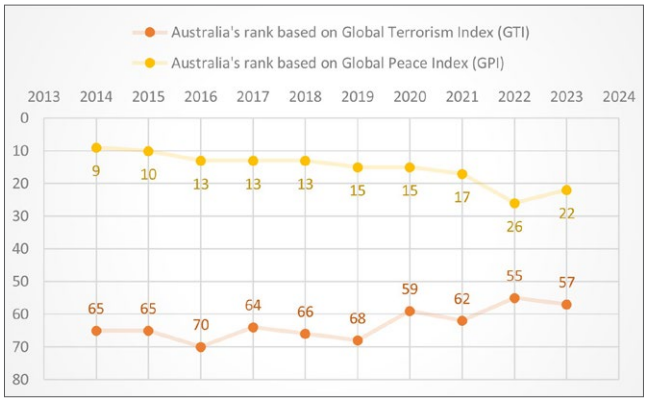

Figure 1: Australia’s changing GPI and GTI rankings in the world between 2014 and 2023.

The adaptation of trauma care protocols to better handle the unique challenges posed by terrorist stabbings is essential. This includes advanced surgical and medical treatment approaches as well as logistical considerations to efficiently manage the high influx of patients during mass casualty incidents.

The potential role of 'active bystanders'

Bystanders also play a role in the immediate aftermath of public violent incidents. These individuals can be considered part of the emergency response team, as 'zero responders' (Haghani 2024; Haghani et al. 2023) or 'immediate responders' (Haghani et al. 2023). These proactive individuals can be pivotal in bridging the gaps before emergency services arrive on the scene. Their quick actions, whether by reporting the incident, confronting the attacker, providing first aid or managing crowd movement, can significantly mitigate the negative effects of the attack.

In cases like the Sydney attack, active bystander interventions proved to be lifesaving. By using impromptu barriers to slow the attacker, providing immediate medical assistance or guiding others to safety, these individuals did more than witness; they actively shaped the outcome of the crisis.

Integrating 'zero responders' into emergency preparedness and response can dramatically enhance societal security. Societies benefit immensely when they acknowledge and prepare their citizens to act in crisis situations. Training and supporting zero responders can be considered a key enabler in national security policies.

Different cultures and countries exhibit varying approaches towards zero responders. For example, Israel's Good Samaritan Law (Ashkenazi and Hunt 2019) protects active bystanders from civil liability, compelling them to assist in emergencies and potentially offering compensation for any resultant costs or injuries. Similar provisions exist in Australian law to protect people who assist others who are injured, ill or in danger, although there are differences in legislation across the states and territories.[4]

Statistically, the presence of more zero responders during an emergency correlates with higher survival rates. While not everyone can be trained for such roles due to willingness or capability issues, research suggests that not all community members need comprehensive training to significantly enhance emergency response outcomes (Haghani and Sarvi 2019; Haghani and Yazdani 2024).

While the role of zero responders is crucial to mitigate the effects of mass violence, it is essential to carefully consider the potential physical and psychological risks they face. The integration of civilians into emergency response should be promoted with these considerations in mind (Australian Red Cross 2024). Active involvement in emergencies can lead to injury or trauma and, without proper training, people's actions might inadvertently exacerbate the situation. Therefore, it is important to provide structured guidance at a societal level, along with support and recognition, to ensure that zero responders are adequately prepared and protected. Being a zero responder does not mean confronting a hostile attacker or risking lives. An immediate bystander response can take many forms, including identifying a threat at an early stage and alerting fellow citizens or authorities, guiding people to safety, facilitating an evacuation or delivering first aid.

An example is the incident in New York City in 2010 where street vendors in Times Square (ABC News 2010) noticed a suspicious vehicle emitting smoke. Their quick report to authorities led to the discovery and defusing of a car bomb, potentially saving many lives. Preventing terrorist attacks is not solely the responsibility of the public. Businesses and private security providers also play a critical role. High-traffic venues like sports arenas, concert halls and shopping malls can be prime targets for terrorism (Haghani 2024). The vigilance of security personnel, adjusted to the level of existing threats, adds an important layer of protection. A notable example is Richard Jewell (Ishak 2023), a security guard at the 1996 Summer Olympics in Atlanta. Jewell's keen observation of an unattended backpack, which turned out to contain a bomb, and his prompt action in notifying authorities and assisting in evacuations, ultimately saved many lives.

Unlike other disaster events, the threat of terrorism is dynamic and heavily influenced by our level of preparedness. The likelihood of an attack, particularly on public venues is intricately linked to the perceived robustness of security measures and the overall readiness of society (Australian Government 2018). An aggressor's decision to target a specific venue is shaped by the security posture of the location, which informs their assessment of the likelihood of success or failure of the attack. Being better prepared by strengthening counterterrorism medicine and fostering a culture of vigilant active bystanders and zero responders can significantly enhance collective resilience against such threats and potentially deter them.

4. Good Samaritan Legislation summary, at https://australianemergencylaw.com/2017/02/22/good-samaritan-legislation-a-comparison.

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From community consultation to critical infrastructure resilience: a case study of 3 'invitations to responsibility'

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Introduction

In disaster recovery, how do we undertake genuine community consultation, but also create the contexts in which this leads to action and to future systems resilience? In February 2023, New Zealand experienced Cyclone Gabrielle. For Tai Tokerau Northland, this was the largest disaster in a generation and led to the largest recovery the region had coordinated (Northland Civil Defence Emergency Management 2023). A part of preparing the *Regional Recovery Plan* for Northland was community consultation (Trüdinger 2023, 2024). This paper explores how community feedback about lifeline utilities and critical infrastructure led to infrastructure providers responding to the communities with written commitments to rebuild what was destroyed by Cyclone Gabrielle. They also committed to take practical steps towards future resilience. This innovative step was shared with critical infrastructure providers around the country. This paper draws on the idea of 'invitations to responsibility', a concept borrowed from the social work and family therapy fields to invite those in positions of power to take accountable actions.

First invitation to responsibility: from community consultation to infrastructure action

More than 300 people participated in the community consultation in Northland, New Zealand, following Cyclone Gabrielle. There was significant damage to roads (450 local roads damaged), power (64,000 customers affected) and telecommunications (30,000 customers) and it was these significant infrastructure assets that were common concerns raised throughout the consultation. These affected individuals, households, families, marae[1], businesses, farmers, community services and more. However, rather than just expecting restoration of service, many respondents asked what the lifeline utilities and critical infrastructure providers were going to do about future resilience in severe weather events.

Cyclone Gabrielle occurred in early February 2023. The local community response moved from response to recovery in late February. On 24 March, only 6 weeks after the event, the Northland Lifelines Group convened. This group comprised critical infrastructure entities that provide essential lifelines services and are named in New Zealand's legislation as having a legal requirement to ensure continuity of service, even in emergencies. The meeting was about the cyclone, the effects to infrastructure, response plans and actions and lessons identified. While all of these are important to review soon after an emergency,

1. marae – a traditional Māori site containing buildings where significant gatherings occur, often used as civil defence community-led centres during emergencies in Aotearoa New Zealand

that day saw the release of the Initial Recovery Action Plan for Northland. Under the *National Civil Defence Emergency Management Plan Order 2015*[2], the regional statutory role of Group Recovery Manager across New Zealand holds the legal responsibility to coordinate recovery activities of lifeline utilities during recovery periods. This meant asking the Lifelines Group for their input to the upcoming Regional Recovery Plan, as well as their views on the challenges and requirements for communities to build future resilience.

This discussion took the form of an 'invitation to responsibility' where we asked:

> *If we were to listen to these community voices, to take on this feedback and respond to the challenge about action for future readiness seriously, what would this look like? Would it be possible to meet this challenge from communities with a list of 'Critical infrastructure commitments' that we could include in the Recovery Plan?*

We borrowed the notion of invitations to responsibility from the field of community work and therapeutic practice, especially working with men around issues of violence (Jenkins 1990).

As a result of the invitation, 6 lifeline utilities committed to at least one specific, achievable action that led to resilience in the short term (3 months), medium term (15 months) and long-term (27 months). These actions were documented as a combined list of 'critical infrastructure commitments' in the Regional Recovery Plan (see Northland Civil Defence Emergency Management 2023).

As far as we are aware, this is the first time that a region's lifeline utilities have worked together in this way and provided a unified approach to critical infrastructure resilience as part of post-disaster recovery in New Zealand. By including the steps taken and still needed for service restoration, as well as the 'joined up' list of resilience commitments, the lifeline providers showed they had heard the messages of concern from the customers and communities and that they intended to take action.

Second invitation to responsibility: bringing community voices to an infrastructure conference

In mid-2023, the National Lifelines Council announced the National Lifeline Utilities Forum. This is the pre-eminent gathering of critical infrastructure providers, emergency management practitioners, scientists and governments in New Zealand. This conference was wide-ranging in its content. However, the draft conference programme did not contain 2 major topics: disaster recovery and the voice of communities. A second invitation to responsibility was made where we asked the organisers: 'If community are at the heart of emergency management, especially post-disaster recovery, what would it mean if community voices are not present? Is this something you might be interested in doing? If so, how might you go about this?'

To their credit, and testimony to the long-standing relationship of mutual respect between the Lifelines Council and Northland Civil Defence Emergency Management, the conference organisers listened to this feedback and immediately set about finding speakers for each topic.

Unfortunately, the speaker who had been approached to represent communities had to cancel at short notice before the conference. We agreed to present on their behalf with the condition that we could read out the words from community members – in this way, if community members were not present, then at least their voices could be.[4] While not as ideal as community members being present themselves, we could at least do something towards having community members 'speak through us, not just to us' (Denborough 2008, 2012). Here are the community responses we shared.

The following is a selection of deidentified Northland community responses to 3 questions on recovery and resilience.

Q: How were you and your community affected by Cyclone Gabrielle?

> *Our road and local access routes were closed a number of times (due to trees, slips, silt, flooding). Power went out 3 times – the longest stretch was 32 hours. Our landline was out for 2 weeks, and there were periods where cell phone connectivity was even more patchy than usual … As a mum of young kids, I felt isolated. Especially as my partner is an essential worker and was away from home, and we had limited ability to communicate.*
>
> *We had no power for a week and no internet or cell cover for almost 2 weeks. Although we prepared as best we could with water supplies and had a gas cook-top, it was difficult personally as I have a dependant 82-year-old husband. The loss of contact with no internet, cell cover or landline meant we were quite isolated as we live in a rural community. It meant that if I had an emergency with my husband, there was no way for me to make contact with services. The nearest coverage for cell phone contact was close to the hospital!*
>
> *My mother is medically dependent. Not knowing when or if the power would come on meant a trip to town to organise oxygen and try to get a generator with no luck.*
>
> *We were cut off from all forms of communication, with cell towers down and no power for 7 days. Not to*

2. *National Civil Defence Emergency Management Plan Order 2015*, at www.legislation.govt.nz/regulation/public/2015/0140/latest/DLM6485804.html.

mention our petrol stations not able to take Eftpos, so if you didn't have cash, you couldn't get petrol to go places, or buy food. Our Four Square was put in a position of whether to allow us to 'tick up' our supplies.

The most common issue I have seen is the amount of people who have lost their freezers full of food due to no power (some are still without power).

We lost income at our shop and holiday park. Roading access impacts delivery of goods to local business centres, business trading and access by customers. Businesses are losing custom; that has a flow-on economic effect to the community.

Q: During the cyclone, and in the days that followed, what did you find most helpful? What were you thankful for? What examples did you see of people helping each other? What is helping your community get through this?

Power companies being clear about their issues and timeframes around resolution.

Thankful for power to keep our fridge on and to continue having hot water.

It was extremely helpful to have internet connectivity to keep up to date with the progress of the storm.

Copper wire [phone line] saved us but considered old tech and we can't upgrade (turned out copper wire helped keep us remain connected).

Grateful for the fantastic work done by power companies and road workers to restore order.

Power companies made amazing effort to get power back on (and therefore cell towers).

This is contrasted by:

Being rural and completely self-sufficient with off-grid power, water and, wastewater made the experience almost painless. We were able to provide refrigeration to our neighbours to preserve their cold and frozen foods as well as charging their devices to keep them in touch with the outside world.

Q: What are your hopes and dreams for your community in the coming months after Cyclone Gabrielle? What does 'recovery' from Cyclone Gabrielle look like to you?

My hope is that infrastructure, roading and communication systems will improve in Northland to ensure the community can endure future catastrophes.

More resilient infrastructure – e.g. power lines underground, prioritising roads on routes that are not at risk of flood or coastal inundation, and improving resilience of infrastructure that has to be in flood plains and coastal areas i.e. avoiding spend on repairs that will only last until the next cyclone.

Need to lobby those organisations who provide services and ask them what they are going to do better next time. People lost food in freezers, couldn't contact doctors, or communicate with support services.

I want to see long-term investment in infrastructure – especially by companies who make profits in NZ; they should be investing into resilient infrastructure. I hope and dream that our roads will be built back better – and I hope that there are better systems put in place for emergency situations – particularly around communication so that we can find out if people are okay.

Redundancy in lifeline services that are essential. Communication and transportation are the highest in my opinion as they are the enablers for Police and FENZ and the other lifelines.

We need better cell phone coverage, which we didn't have for 10 days. How could those that needed help dial 111 if there was no coverage?

Third invitation to responsibility: the 'ethos of obligation'

Providing this input for participants provided a way to share community member experiences of the cyclone and its effects on infrastructure. It reminded the engineers, scientists, emergency managers and council workers 'who was at the heart' of what they do. It also gave a platform for a third invitation to the approximately 300 conference attendees. After sharing the accounts above, we asked, 'Having heard these voices, these stories and these challenges, what steps could you take to improve infrastructure resilience in your regions? And how might you be able to re-orient your organisations to be more available to hearing the voices of those you serve?'

How did these words, and this final invitation to responsibility resonate with the audience? Many attendees approached us afterwards, telling us that bringing the voices of community members into a formal conference reminded them about the context of their work and why their work gave them personal and professional meaning; that their work is linked to their own histories and what they give value to. Some spoke of having a sense of invigoration for their work. Some were visibly moved from reflecting on these links between the communities they work with and their own lives. These were unexpected discussions to be having with water systems designers, road managers and GIS spatial analysts at a formal sectoral conference.

These sentiments were expressed in a comment on the platform that the conference used for posing questions to presenters. This post was the most 'up-voted' (questions or comments that conference participants said they wanted spoken from the stage / raised with presenters) across the 2 days of the conference:

Bringing the voice of communities to the conference was a step towards what Eva Ziarek (2001) calls the 'ethos of alterity' or the 'ethos of responsibility' – drawing on questions such as, 'what obligations might we whose voices are heard, or who have access to various platforms, or walk with privilege, have? And what are we doing about it?' We find these questions to be profoundly invigorating in our work.

Final invitations to the field

The final invitations we'd like to extend are to recovery managers. Given that much of recovery work is advocacy, how might you 'skill up' in being able to invite decision-makers and those that hold power to take steps to be accountable to the communities they serve? What 'invitations to responsibility' have you made to recovery stakeholders, government and programme partners and what was the outcome? And how might you capture these stories and circulate them so that other recovery managers can learn from the actions you've taken? We welcome recovery practitioners contacting us who are interested in these explorations and extending on this practice together.

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Results for predicting blow-up fire events using the Hierarchical Predictive Framework

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In October 2023, a paper on the new Hierarchical Predictive Framework[1] detailed ways to predict blow-up fire events and the risks of extreme bushfires in southeast Australia. The framework was based on over 20 years of archival data on extreme bushfires and their context. This paper presents the results of the framework's operational trial carried out over the summer bushfire season of 2023–24 based in Canberra.

At the end of September 2023, there were no alerts issued for the forested areas of south-east Australia, but the potential for alerts was flagged and this required close monitoring. Some drying events in local rivers had occurred indicating increasing flammability of large dead-and-down fuels that could raise the risks of bushfire. At that time, the Canberra Dipole was climbing towards zero at a rapid rate, indicating a real potential for blow-up fire events (BUFEs) early in the fire season.

At the end of October, Level 1 and Level 2 alerts were issued. More river drying events had been logged, causing a Level 2 Alert. As the Dipole passed zero, a pyroCb occurred near Nymboida in New South Wales.[2] In early December, the situation was unchanged. Two more pyroCbs had occurred (2023d, Pilliga, NSW, 9 December and 2023e, Pilliga, NSW, 18 December). The Dipole then stopped rising.

This was due to 2 interlinked factors:

- A persistent warm sea surface temperature anomaly had formed offshore (see Figure 1). This was of such a magnitude that the US National Oceanic and Atmospheric Administration issued a coral reef bleaching alert for that area. The anomaly acted to both moisten the air above it and alter the isobaric patterns on the coast, making rain troughs highly likely.
- Prolonged onshore flows of that moist air interacted with inland troughs, creating heavy rains and reducing land temperature anomalies.

On 24 December, the alerts were downgraded as the entire eastern section of the Australian continent stayed under moist air with frequent rainfalls. Past instances had shown that the BUFE potential could persist until the new hydrological regime settled in, so the Level 1 and Level 2 alerts were classed as 'ending'. On 8 January, the alerts were cleared. Most river flows had risen to new base levels. This suggested at least one month, if not longer, before new alerts might be required.

On 18 February, no alerts were issued but an advice that monitoring was required was issued due to a series of decreasing river flows. As that series grew, a Level 2 Alert and associated Level 1 Alert were issued on 27 February. This stayed in place until widespread rains associated with an East Coast Low[3] arrived in early April. Without anticipated summer heat, this caused all alerts to be cancelled.

A BUFE event occurred northwest of Ballarat in Victoria on 22 February. This led to the addition of a new river flow site from that area

1. McRae R (2023) Operational prediction of extreme bushfires, *Australian Journal of Emergency Management,* 38(4):67–76. https://doi.org/10.47389/38.4.67
2. pyroCb event in NSW (event 2023b, 25 October) at, www.highfirerisk.com.au/pyrocb/register.htm.
3. East Coast Lows are intense low-pressure systems that occur off the eastern coast of Australia and sometimes Tasmania. Although they can happen at any time of the year, they are more common during late autumn and winter, with a maximum frequency in June.

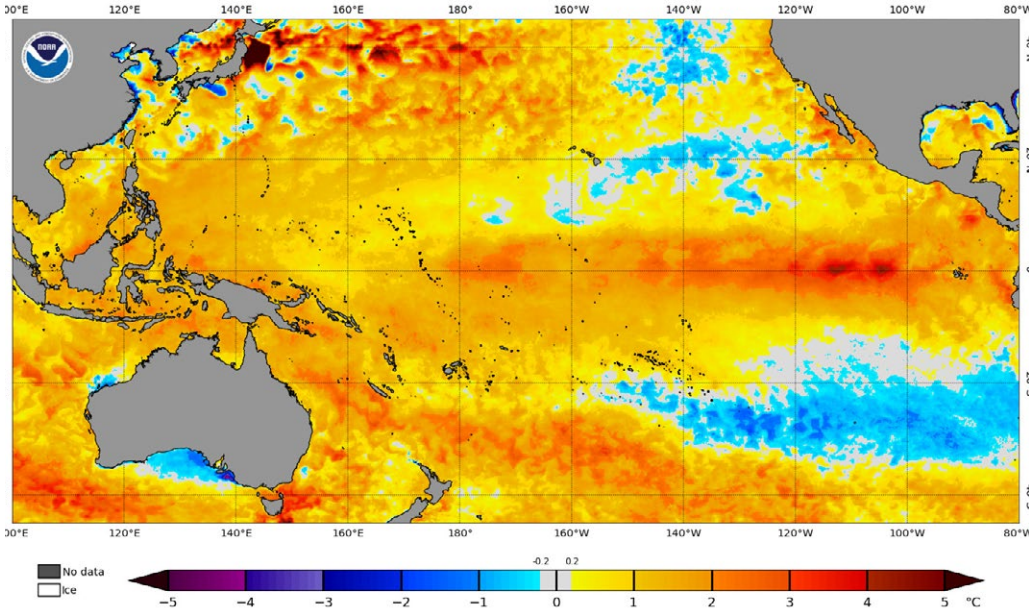


Figure 1: Sea surface temperature anomalies from 8 January 2024, which was the peak of the persistent event.
Source: NOAA Satellite and Information Service, at https://coralreefwatch.noaa.gov/satellite/index.php.

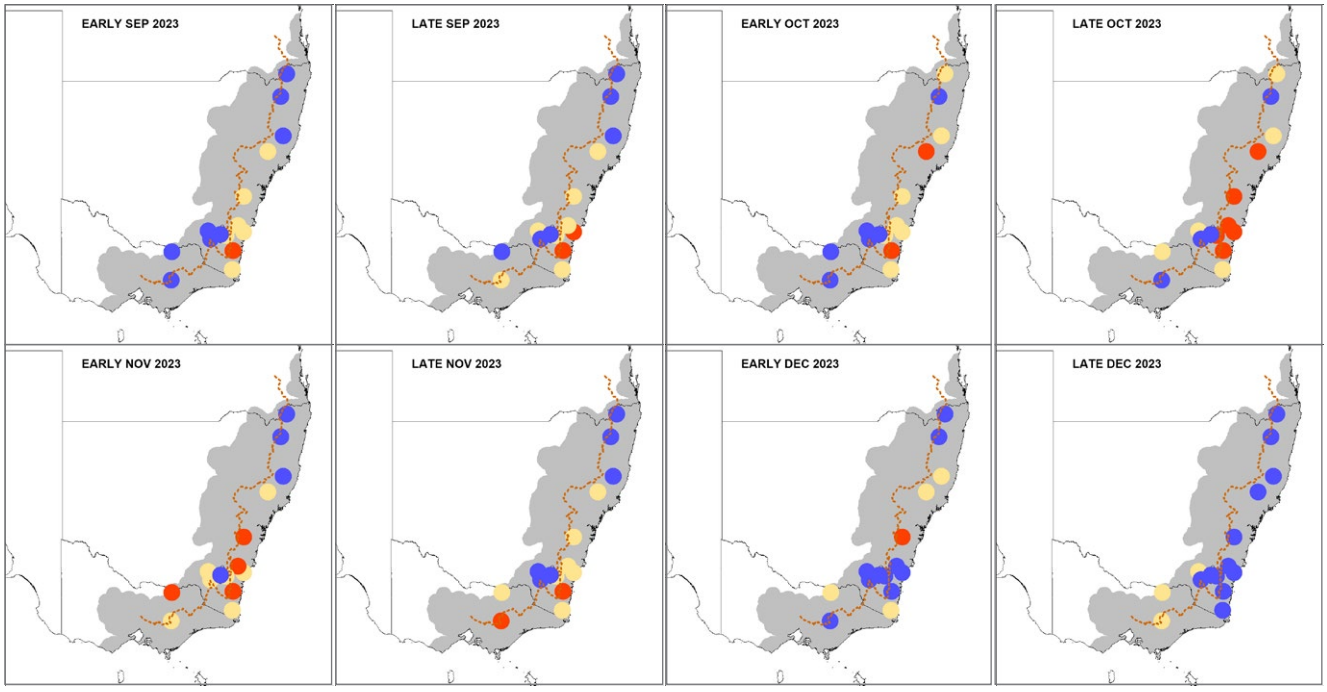
to the framework. This initially had a drying event in place, which eased in early April.

Figure 2 shows the evolution of river drying events throughout the season.

Figure 3 compares the standard Hierarchical Predictive Framework indices since 17 December 2017 and includes the extreme bushfires of summer 2019–20 and the following wet years.

It is instructive to compare time series of the predictions and observations (see Figure 4), which are counts of dry river flows and satellite hotpots. For the latter, this comparison uses VIIRS hotspots with a Fire Radiative Power over 100MW – a hot fire (from NASA Fire Information and Resource Management Service[4]).

4. NASA Fire Information and Resource Management Service, at https://firms.modaps.eosdis.nasa.gov/.



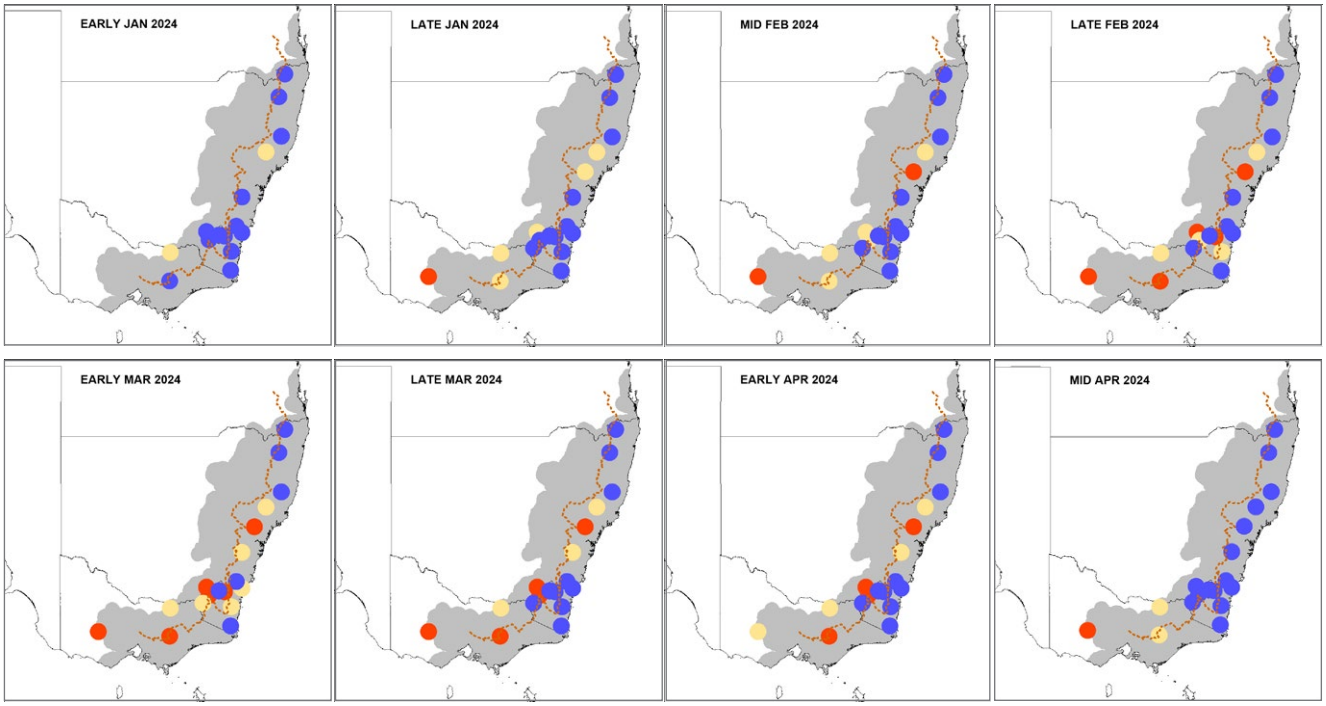


Figure 2: Timeseries of river flow assessments.

Blue shows elevated flows with no risk of drying, orange shows possible drying within a month, and red shows dry. The brown line shows the Great Divide. The pulse of river drying events is clear. Note that the events are not intended to be relevant to their local catchments, rather to the entire study area. Before December, fire activity typically stays north on the Hunter River, during January it spans the whole area, and after that the focus south of Sydney. Note that a new hydrology site west of Melbourne was added In January and played no role in the framework prior to that.

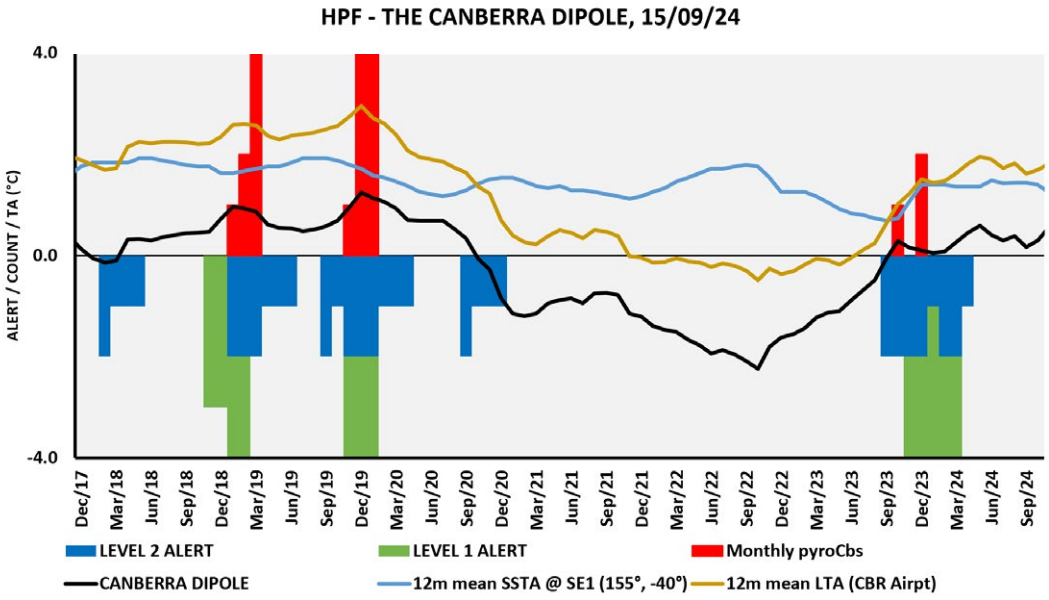


Figure 3: Time series of Hierarchical Predictive Framework products between 2017 and 2014.

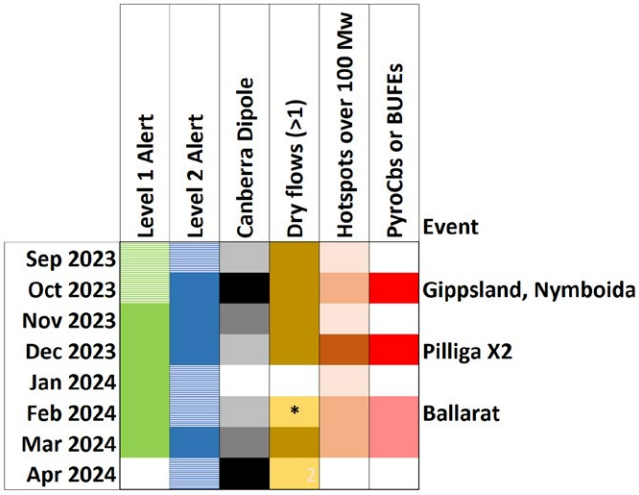


Figure 4: Summary of Hierarchical Predictive Framework prediction and observations.

* marks the addition of a new hydrology site near Ballarat, central Victoria.

Also tallied are major fire events. The October 2023 spike in hotspot observations is from a large foehn-wind driven BUFE in the East Gippsland district of Victoria and major fires in the Nymboida area of north eastern New South Wales. The spike in December 2023 is from the protracted fire in the Pilliga Forest in north-central New South Wales, which generated 2 pyroCbs. Even though the Dipole was falling, the river dryings, and thus a Level 2 alert, were still in place. The data showed that, on a daily timescale, hotspot spikes tended to occur while the river dry flow count was increasing.

The Hierarchical Predictive Framework is not a fire danger rating. It does not apply to quasi-steady-state fires that are covered by the Australian Fire Danger Rating System.[5] However, the Summer 2023 Seasonal Bushfire Outlook[6] (AFAC 2023, p.8), released in October, provided climate outlooks indicating:

> *…the chance of above average and extreme temperatures; reduced average rainfall over the southern half of the continent; increased heavy rainfall when meteorological conditions are favourable; and a longer fire season, with more extreme fire danger days.*

Increased heavy rainfall ended up dominating the summer season from early December onwards for both normal fires and those covered by the Hierarchical Predictive Framework.

At the time of writing, most sites west of Canberra are dry or nearly so. This may be a vital clue to what the next fire season may bring. As always, careful monitoring is required.

Conclusion

This review showed that the Hierarchical Predictive Framework worked as intended in the lead-up to the 2023–24 bushfire season. Following summer, the onset of wet weather placed the entire region into a less flammable state until late February 2024. Had the oceans not reconfigured, through rising sea surface temperature anomalies in early summer, then the framework clearly shows that this summer could have produced many BUFEs. The framework met its objectives for Levels 1 and 2 to provide a clear, long-lead-time outlook for BUFEs in the forests and woodlands of south-east Australia. This successful result successfully concluded the framework's trail period. In the future, it is recommended that fire behaviour analysts develop skills in using Level 3 of the Hierarchical Predictive Framework that provides fire ground predictions in near-real-time, or for the span of reliable weather forecasts. This is not available through other systems. Adoption of this predictive framework will need collaborative assessment of its performance.

5. Australian Fire Danger Rating System, at www.afdrs.com.au.
6. AFAC (2023) Seasonal Bushfire Outlook Summer 2023. AFAC website www.afac.com.au/auxiliary/publications/seasonal-outlook/seasonal-outlook-article/seasonal-bushfire-outlook-summer-2023.

The Hierarchical Predictive Framework is at, www.highfirerisk.com.au/hpf.

More operationally useful material on extreme bushfires is at www.highfirerisk.com.au.

About the author

Adjunct Professor Rick McRae retired from a career in bushfires and emergency management spanning 3 decades. He is a visiting fellow at the University of New South Wales in Canberra. He specialised in fire behaviour and served on major fires in the ACT, Tasmania and Canada. He has served on national committees on bushfire matters and has run national emergency management workshops. He has specialised in the use of satellites, and on extreme wildfires.

Human rights tools are a key lever to address climate change-accelerated disasters

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'If I was asked to leave this island, I can't. I can't leave my community, because this is my home.' Stanley Marama, communication to the United Nations Human Rights Committee (Billy et al. 2019, p.6, para. 32)

Stanley Marama is one of the trailblazing 'Torres Strait 8' (Torres Strait 8, n.d.), a group of Torres Strait Islander people who made a complaint against the Australian Government claiming that their islands are being negatively impacted by climate change and that their human rights are being breached due to inadequate climate policy and action (Billy et al. 2019). The Torres Strait 8 submitted to the United Nations Human Rights Committee that their low-lying island communities and homes across the Torres Strait are being damaged by sea level rise and increased flooding from storms. They were deeply concerned at the prospect of having to leave their homes as this would mean cultural and material loss for themselves, their families and their communities. They described these climate change effects as a 'slow-onset catastrophe' (Billy et al. 2019, p.5, para. 30).

The Torres Strait 8, with the support of the Gur A Baradharaw Kod Torres Strait Sea and Land Council and ClientEarth (a UK-based environmental law charity) effectively won their case. The majority of the United Nations Human Rights Committee held the view that the Australian Government was violating its human rights obligations as the Torres Strait 8 and their communities had not been sufficiently assisted to adapt to climate change effects across their region (United Nations Human Rights Committee 2022). This was the first time that the United Nations Human Rights Committee found that a nation state had violated its international human rights law obligations through inadequate climate policy and action (ClientEarth 2023). The Australian Government provided a response to this finding, noting that Australia is committed to the design and implementation of the Torres Strait Climate Centre of Excellence and the creation of the National First Peoples Platform on Climate Change (Attorney-General's Department 2023, p.3). The Australian Government response further noted that funding was being provided through the Disaster Ready Fund, which could be used for projects such as building sea walls (Attorney-General's Department 2023, p.9).

This complaint was able to proceed because Australia has ratified the First Optional Protocol to the International Covenant on Civil and Political Rights, which allows direct communications with the United Nations Human Rights Committee (Optional Protocol ICCPR 1966). Australia has not yet ratified the equivalent Optional Protocol to the International Covenant on Economic, Cultural and Social Rights (ICESCR 1966). However, the Commonwealth Parliamentary Joint Committee on Human Rights recently released a report calling for a federal Human Rights Act (Parliamentary Joint Committee on Human Rights 2024) supporting the position of the Australian Human Rights Commission (AHRC 2022). A federal Human Rights Act would make the protection and promotion of human rights in Australia directly justiciable (Parliamentary Joint Committee on Human Rights 2024, chp.7).

Considering that the United Nations Human Rights Committee found that the Australian Government has positive obligations due to climate change to prevent arbitrary interference with privacy, family and home

(ICCPR 1966, Art.17), the possible ramifications of this finding are profound and widespread (United Nations Human Rights Committee 2022, p.14, para.8.10). Such findings, and other rights-oriented legal actions, could be extended to Australian mainland areas that are prone to floods and bushfires. The Australian Government is undoubtedly on notice to take action to prevent the destruction of lives, homes and cultures due to climate change and is now under the watch of the international community (Schuijers 2023).

As a newcomer to the disaster sector, I have noticed that, in some quarters, there is disdain for human rights-based law and approaches as they are seen as far removed from the people who experience these events. We know that climate change is occurring and that it is having destructive and disparate effects on communities (Howard et al. 2023; IPCC 2023), including First Nations peoples already experiencing the ongoing effects of colonisation (Billy et al. 2019, p.15, para.85). The international and domestic legal systems, despite their limitations, can hold governments accountable and human-rights based jurisprudence can gradually shape momentum to generate and enforce real policy and practice change. Rather than being seen as a removed instrument, human rights law is a powerful and tangible lever that, for those working in the disaster sector, such as researchers, practitioners and advocates, they should embrace in ways relevant to their work as a tool to make progressive rights-based change.

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Disaster, social contracts and self-reflection: community resilience in Tamborine Mountain

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Queensland University of Technology

On Christmas Day 2023, a tornado tore through the Queensland hinterland town of Tamborine Mountain leaving the community without power and without a quick emergency response to the event. How the community responded and recovered was studied to determine the baseline community resilience and recommend improvements.

Tucked up behind the Gold Coast, Tamborine Mountain was a magnet for tree-changers during the COVID-19 pandemic. The town is known for its subtropical rainforest, country-town feel and artistic pedigree. It has the added allure of being a 50-minute drive from the Gold Coast or Brisbane. It has a small-town vibe while being near urban economic centres. As a result, the resident population grew between the 2016 and 2021 censuses.[1] When a tornado tore through the town on Christmas Day in 2023 at roughly 9 pm, it caught many people unprepared and ill-equipped to be without power for 14 days.

This was not the first time this sort of event has struck the area. A decade before, ex-Cyclone Oswald hit the mountain. Some residents recall it being worse and some did not. What is clear is that roughly every 10 years, some major event happens, mostly storms but sometimes fire, that disrupts the community. While the pre-pandemic population grew at a modest rate (1,227 new residents between 2001 and 2016), the had community coped. But as the

A tornado caused significant damage to houses, roads and power infrastructure in the Tamborine Mountains, Queensland in 2023.

Image: Claire Elise Photography

influx of new residents who were unfamiliar with the area and its exposure to these hazards, resilience waned.

To establish the levels of knowledge and preparedness of people in the area, a study was conducted to identify how the community responded and recovered and to determine the baseline community resilience to recommend improvements. The study found that many households were not prepared in the physical sense. Without town water or sewerage, residences were reliant on power to operate household systems such as water pumps and biocycle systems. Compounding this was the community's unpreparedness for the on-the-ground chaos and a perceived lack of official response. Initial days were spent relatively idle expecting a response before the community realised that the local council was not coming to their aid in the way people thought it would. Only then did community members spring into action.

This delay raises questions. Is the community's collective action evidence of its resilience? Is it unrealistic that residents in semi-urban environments should expect continuity of power from power providers? Should everyone across Australia, regardless of their location and situation, invest in a portable generator? Was the community's expectation of a response overinflated? As a Tamborine Mountain resident, I found myself asking these questions to understand community expectations of preparedness and recovery.

Researching resilience

In part catharsis and part education, I dedicated my final MBA studies to researching my community's resilience using the Torrens Resilience Initiative Community Scorecard.[2] It was selected as the preferred tool as it allowed for multiple potential hazards and was designed for a community to enact, the latter being an attribute that became more relevant as my research progressed.

The results from the Scorecard (see Figure 1) were relatively unsurprising. The community was moderately resilient. While many of the physical contributors to resilience posed little risk by themselves, it was the interaction of multiple indicators that contributed to a weakened resilience. Three of the 5 access roads for the town were cut and this slowed the response times from external providers to reinstate power. Without power, there was no running water or fans, which made the subsequent heatwave unbearable and the clean-up response even slower. On New Year's Day, a tropical low dumped 750mm of rain in the area. Many properties had damaged roofs or were not yet covered. Many also had debris that had not been removed and the excessive rainfall added water damage to already compromised structures. All of this was exacerbated by newer residents who were naïve to the local risks and were unprepared and without community connections. People didn't know what to do, who to turn to and, arguably, had some very unrealistic expectations.[3]

Changing disaster social contracts

This study opened a bigger question about the social contract around emergencies and disasters. In post-event reviews of Hurricane Katrina, the 2011 Tokyo earthquake and tsunami, the 2011 Brisbane floods and other events, commentary returns the theme that command-and-control bureaucracies were limited in their response and fall short of the expectations of affected populations.[4,5] This is a theme that crosses cultural boundaries.

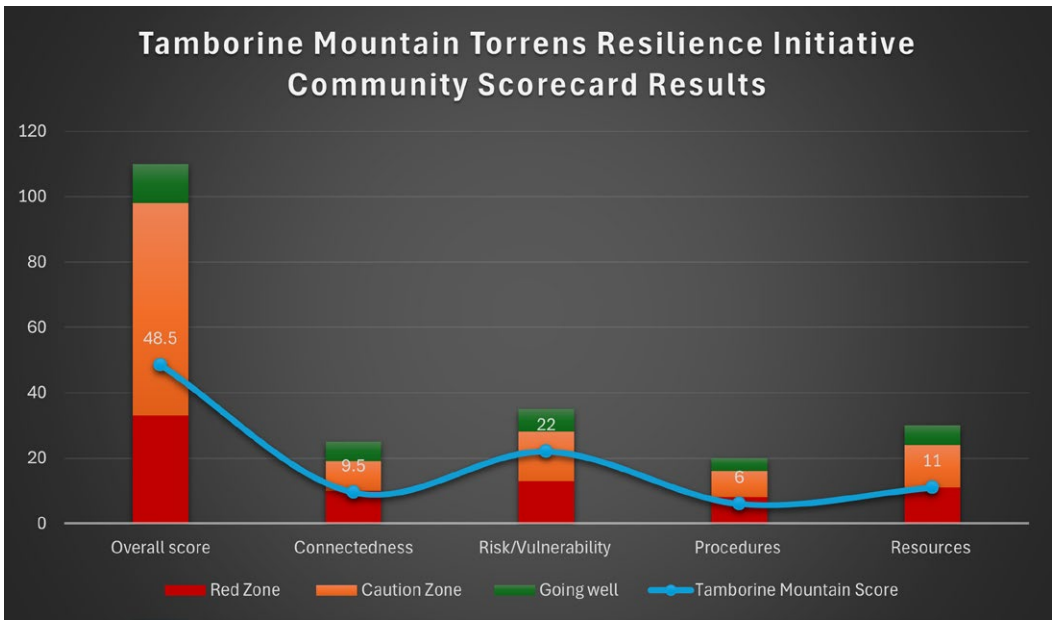

Figure 1: The Scorecard graphed the resilience levels results from the study.

People expect that as they are contributing members of society, governing bodies will recognise their discomfort and distress in times of need and provide aid regardless of individual preparation. Conversely, governing bodies expect people to prepare for their risks and self-manage during recovery by using insurance companies as safety nets and, in so doing, free government resources.[6] It is the distance between these stances that causes discontent in both sides. Research has shown that the more authorities attempt to raise hazard awareness through public campaigns, the more dependent populations became on emergency services organisations.[7] By raising awareness, it is also raising expectations of an official response that could, in part, explain current declining volunteer participation rates.[8]

From research to action

With the research complete, my question becomes 'Where to from here?'. There are some unavoidable truths facing Tamborine Mountain. Firstly, it is likely that memories of the most recent event will fade and the allure of its natural beauty will continue to attract new residents. Secondly, the community is highly vulnerable to high-risk hazards so more can be expected in the future and insurance companies are unlikely to provide a comprehensive safety net.[9] Finally, there needs be a shared responsibility and resources for preparedness, management and response and so structures should be established that support preparedness, through a new empowering social contract.[10,11] Government, top-down information alone does not create actionable knowledge. That required reflection, local assessments and co-creation[12] and will only come from within a community that must be motivated to initiate and continue the work.

In hindsight, I selected the Torrens Resilience Initiative Community Scorecard because, as a resident rather than a researcher, it provided a meaningful sense of community empowerment to identify actions we can do to improve our collective resilience. For Tamborine Mountain, those actions are to reinstate monthly peer-to peer information sessions for new residents supported with community-developed material on preparation, biannual inter- and intra-community scenario planning sessions to develop a preparedness mindset and embedding disaster preparedness in the local schools to develop the resilience in the next generation. I would strongly encourage communities to use the scorecard to get a greater appreciation of resilience and to devise interventions to improve resilience in a community.

Access the full report on this study from the Queensland University of Technology website, https://eprints.qut.edu.au/248393.

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Key concepts for experimenting with AI to address the challenges of disasters and climate change

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In November 2023, the Melbourne School of Population and Global Health hosted a workshop with disaster and climate change practitioners and researchers to explore the possible uses, risks, ethics and opportunities of AI to mitigate mental health and wellbeing effects of disasters and climate change. This paper provides the main findings from the workshop.

There are rapidly increasing climate disasters happening in a time of surging Artificial Intelligence (AI) technologies. Simultaneously, there is a growing recognition of the health risks of climate change and discussion of ways to potentially address these risks through use of AI.[1,2] For example, there is growing discourse on the risks and benefits of AI use within health care systems.[3,4] However, specific uses of AI to manage the health and wellbeing effects of disasters (which are projected to increase in frequency and severity due to climate change[1]) remain understudied.

At the November 2023 workshop, key concepts were identified from practitioner experimentation with a Large Language Model (LLM) to address gaps in knowledge found in a rapid literature review. This review found that speculation predominates on the use of AI for climate change and there is limited literature on immediate AI applications for practitioners. Our experiment was to use GPT4 and the AskYourPDF Plugin to prepare a grant application to support recovery and climate adaptation in a disaster-affected community that experienced great material loss and the death of children and a teacher. The grant opportunities were real,[5,6] evidence-based resources were uploaded as guidance[7,8] and the disaster-affected community was a fictional compilation of real cases.

The experiment highlighted concerns and opportunities about the LLMs. Participants indicated that GPT4 was 'good for summarising, brainstorming and getting

things started'. Risks noted included concerns that use of LLMs to construct grant ideas would 'lead people to bypass asking the community what their primary concerns are [in disaster recovery]'. For some participants, it made them 'feel dead inside' in the sense of losing aspects of creativity and human-to-human interactions. Logistically, participants noted that LLMs are only as good as the questions asked and they indicted a need for prompt-writing resources. Other concerns were raised, including how to adjust grant processes if using GPT4 becomes a widespread practice, leading to grant applications looking the same. Ethical concerns included the profit-driven setup of OpenAI, perpetuation of racism and sexism by GPT4[9] and a potential 'narrowing effect' if certain ideas are given more precedence than others. For example, GPT4 suggested solar panels to address climate change but did not recommend supporting a community's grieving during anniversaries of the disaster.

It is critical to confront the practical and ethical complexities of AI use. The concepts described are important areas for continued critique and experimentation within emergency and disaster management, research and planetary health.

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Strengthening the role of urban farmland in Japan's disaster preparations

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Japan is a country that experiences many earthquakes. How the country is dealing with loss of urban farmlands remains a challenge.

According to the Japan Meteorological Agency (2024)[1], approximately 200 major earthquakes have occurred in Japan since 1996. In recent years, major earthquakes in Japan include the 2011 earthquake off the Pacific coast of Tohoku, the 2016 Kumamoto earthquake and the 2024 Noto Peninsula earthquake. According to NHK (2024)[2], the 2024 Noto Peninsula earthquake caused extensive damage including collapsed buildings, fires, tsunamis, landslides and liquefaction.

The Ministry of the Environment (2017)[3] states that 'Japan has many typhoons and earthquakes, and landslides are more likely to occur due to topographical and meteorological conditions'. It is important to note that Japan is an area prone to earthquakes.

It is feared that, at any time, an earthquake with an estimated magnitude of 7 may directly affect the Tokyo metropolitan area. Due to the concentrated population, if an earthquake was to hit Tokyo, the Government of Japan estimates that there would be many casualties and millions of people would be left stranded. There is concern that an earthquake hitting the Tokyo metropolitan area will be in areas with large numbers of wooden houses and major damage is expected due to buildings collapsing or burning. As a result, there is an urgent need to improve preparedness for major earthquakes. This is particularly important in areas with a high concentration of wooden houses.

Characteristics of Tokyo and disaster predictions

The Tokyo metropolitan area is the political and economic centre of Japan and comprises Tokyo23city and 39Municipality. The region includes mountains, hills and plateaus. It is characterised by topography ranging from lowlands below 4 metres above sea level to mountains 2,000 metres above sea level. It is also home to the volcanic Izu Islands and Ogasawara Islands in the Pacific Ocean. From the post-war reconstruction period to that of high economic growth, urbanisation progressed rapidly without the construction of adequate urban infrastructure, resulting in densely wooded-buildings areas. There is also a lack of urban infrastructure such as roads and parks and areas are at a high risk from earthquakes and fires due to many ageing wooden buildings.

Prediction and prevention measures

The large-scale fire that occurred in Itoigawa City, Niigata Prefecture in 2016 reminded us of the importance of fire-proofing urban areas. There needs to be effective measures to make these urbanised areas resistant to fire and earthquake and there is an urgent need to increase preparedness for major earthquakes.

The Tokyo Metropolitan Government (2021)[4] is building a disaster-resilient city based on significant criteria:

- Formation of fire-spread barrier zones to prevent large-scale urban fires.

In 2024, the earthquake on the Noto Peninsula caused extensive damage and collapsed buildings.
Image: Sae Nishi

- Securing functionality of emergency transportation roads to create an urban disaster prevention network that allows for smooth rescue operations and evacuations.
- Creating safe and high-quality urban areas to improve disaster prevention according to local conditions by improving infrastructure such as disaster prevention roads, making buildings fire-proof and earthquake resistant and creating safe, high-quality urban areas.
- Securing evacuation sites to properly secure evacuation sites to protect residents from large-scale urban fires.

According to the Ministry of Agriculture, Forestry and Fisheries (2024)[5]:

> *Urban agriculture plays a variety of roles, such as supplying fresh agricultural products by taking advantage of its proximity to consumption areas, providing a place to experience farming, securing open space in case of disasters and providing green spaces that provide peace and moisture.*

One of the roles of urban agriculture is to secure disaster prevention spaces in the event of a disaster. However, according to the Tokyo Metropolitan Government (2020):

> *As of 2021, the agricultural land area of Tokyo is 6,410 ha, which is equivalent to 2.9% of the total area of Tokyo. Of this, 73.8% is fields, 22.6% is orchard land and 3.5% is rice paddies. In the 10 years since 2011, 1,190 ha (decrease rate of 15.6%) has been lost.*

This shows that the amount of urban farmland contributing to 'evacuation areas and fire prevention zones' is decreasing. Also, according to the Tokyo Metropolitan Government (2020)[6]:

> *Looking at trends in the composition ratio of agricultural workers by age, the proportion of people aged 60 and over has reached 68.8% in 2020, compared to 50.3% in 1990. The percentage of young people working in agriculture is extremely low at 1.4%. The average age of farmers as a whole is 65.6 years old, which is an increase of 1.5 years over the past 10 years. The population is ageing.*

If no action is taken, it is expected that the conversion of urban farmland into residential land will progress in the future. This is because urban farmland is owned by residents, not the public. According to the Ministry of Agriculture, Forestry and Fisheries (2012)[7], 'preparing to pay inheritance tax' is the most common reason given for the conversion of farmland often for the purposes of housing, apartments and parking lots. As farmers age, it may be assumed that their farmland might convert to residential land through inheritance.

Sae Nishi volunteering in the cleanup after the Noto Peninsular earthquake.

Image: Nobuo Nishi

Other possibilities for urban farmland

Urban farmland is not only used for agriculture, fire prevention zones and evacuation sites. It is also an effective place for children's education and growth. The Kumamoto earthquake should be used as an opportunity to reconsider reforming traditional educational methods. According to PRTIMES (2022)[8], 'We surveyed 500 kindergarten parents, and about 70% wanted their children to have "experiences in nature"'. There is a clear conflict among parents who feel there are not enough opportunities for their children. Therefore, urban farmland in modern environments such as Tokyo where overcrowding in residential areas is a problem, it is important to consider ways to improve the value of urban farmland.

These efforts contribute to changing the consciousness of residents. The dilution of neighbourhood relationships in urban areas is seen as a problem (Ministry of Internal Affairs and Communications 2014)[9] and, in this context, disaster prevention training in urban farmland area can promote 'neighbourhood ties and ties between older men and women'.

Ways ahead

I propose a new perspective to strengthen the role of urban farmland in Japan's disaster prevention measures. Firstly, in an ageing society, preventing the conversion of urban farmland to residential land is crucial. The Tokyo Residents' Mutual Assistance Tax is a newly established tax stipulated in the Local Tax Law. The Tokyo Metropolitan Government will use the tax revenue to purchase urban farmland and prevent it from being converted to residential land to retain disaster prevention and educational support measures. Urban farmland is a limited natural area that exists in small cities and is an important site for children's education. To increase the value of urban farmland, the Tokyo Metropolitan Government will establish urban farmland disaster prevention training as a subject in elementary schools.

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The 7th International Fire Behaviour and Fuels Conference

Joanna Wood

Natural Hazards Research Australia

The global fire science community gathered to discuss the latest research, practices and future themes at the 7th International Fire Behaviour and Fuels Conference held concurrently in Canberra Australia, Boise Idaho and Tralee Ireland in April 2024.

There were 11 keynote addresses and 363 presentations that took place concurrently around the theme 'Fuel, Fire and Smoke: Evolving to Meet Our Climate Challenge'. Delegates were treated to more than 100 research presentations from colleagues, peers, research students and industry leaders. Hosted by the International Association of Wildland Fire (IAWF), themes tackled risk modelling, fuel management, emerging tech and approaches, cultural perspectives, human dimensions and weather and climate.

Opening keynote speaker in Canberra and Boise and speaking from her home in Indiana, US Fire Administrator Dr Lori Moore-Merrell, provided global context to the ongoing and increasing challenges facing fire response and management agencies. She drew on recommendations from the Wildland Fire Mitigation and Management Commission's report to the US Congress to improve federal policies related to the mitigation, suppression and management of wildland fires and the rehabilitation of land devastated by wildland fires.

Dr Moore-Merrell emphasised the fire science community's role in meeting climate challenges through developing fire-adaptive communities and preparedness. She stressed the need for 'intelligence, not just information' through leveraging information across all fire and emergency management agencies.

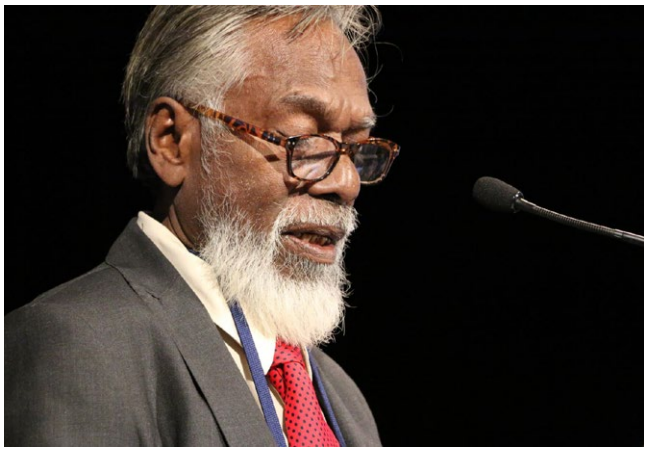
Dr Lachlan McCaw drew on his extensive experience as a fire scientist in Western Australia and elsewhere to celebrate fire management achievements over the past 40 years, and where to from here. Professor Nerilie Abram from the Australian National University spoke about the future of fires and fire ecology and highlighted the effects of climate variability on dangerous fire weather in southeast Australia.

Dr Lori Moore-Merrell, US Fire Administrator was the keynote speaker at the conference.

Image: NHRA

IAWF Vice President, Trevor Howard.

Image: NHRA



Dr Dean Yibarbuk, Chairman Warddeken Land Management Ltd.
Image: NHRA

Alen Slijepcevic with Joe Buffone, NEMA, and IAWF Board Member, Dr Sarah Harris.
Image: NHRA

Dr Dean Yibarbuk, Chairman Warddeken Land Management Ltd, presented on the disconnection of First Nations peoples in Western Arnhem Land from their cultural fire practices and their subsequent re-establishment in the last 20 years. Streamed to delegates in Boise, Dr Yibarbuk shared his and the Warddeken Rangers mission to 'share the gift of understanding of fire without fear' with fire managers around the world.

The panel discussion was hosted by anthropologist and disaster psychologist, Dr Steve Sutton. The panel comprised Dr Yibarbuk, Aidan Galpin (SA Country Fire Service), Dean Freeman (Riverina Local Land Services), Dr Rowena Morris (Natural Hazards Research Australia), Kirsty Babington (ACT Parks and Conservation Service) and former IAWF President, Dr Mike DeGrosky, visiting from the US. The panel discussion unpacked culture, human nature and fire management. Dr Sutton posed the questions:

> *Do the varied communities and organisations we are part of understand how these relationships work and how they need to adapt to meet climate change?*

Professor of Wildlife Conservation, Professor Sarah Legge from Charles Darwin University highlighted the value of small patch burning on species biodiversity through the Pirra Jungku project alongside the Karajarri Rangers in the Great Sandy Desert in the Western Kimberley region of Western Australia.

The concept of 'right fire' carried out in the correct cultural way by the correct people and the way these people interact with the fire is key. This ensures diversity of the short, mid and mature growth vegetation that is crucial to biodiversity in the Great Sandy Desert as well as reducing the effects of feral animals.

The final keynote speaker, Dr Dan Pronk, brought a change of pace by looking at building resilience for people working in high-stress, high-consequence roles. A former Australian Army SAS doctor with more than 100 active missions in Afghanistan, Dr Pronk developed the Resilience Shield approach to building resilience in response to the high levels of stress he experienced once discharged from active service. His unique personal insight into the sustained and ongoing stress and trauma associated with first responder roles, as well as the overwhelming evidence that members of the emergency management sector experience higher rates of mental and physical illness, were a timely reminder that everyone, from frontline staff to planning and researchers, can be at risk of high stress and burnout.

The IAWF acknowledged Alen Slijepcevic AFSM, Country Fire Authority, with the Distinguished Service Award, recognising his commitment and outstanding contribution to furthering the goals of the Association. Alen is well known in the Australian and international fire science and management sectors.

Pre-conference workshops included 'Exploring the state of the science if ember transport and impacts', presented by the University of New South Wales and 'The future of fire-weather intelligence', presented by the Bureau of Meteorology. Field trips were to the CSIRO National Bushfire Behaviour Research Laboratory in Canberra.

Keynote presentations and other select recordings are available at https://canberra.firebehaviorandfuelsconference.com.

Human factors of incident management teams

Glenn A. Jones ESM CEM

In a world where emergencies and disasters are escalating and climatic events are growing more volatile, the necessity for a high-performance incident management team (IMT) is not just important, it's critical.

IMTs are the frontline in controlling, coordinating and commanding to mitigate the effects of these incidents. The team's high-quality intelligence and analysis transform them into a predictive and proactive force, playing a pivotal role in incident management. These teams can be and are often composed of highly skilled individuals who possess a diverse range of expertise and are trained to handle a wide array of incidents. They are also drawn from disparate parts of organisations or agencies (local, state and interstate) such as the case for the summer bushfires in New South Wales in 2019–20. Establishing a high-performance IMT is about efficient systems, organisational doctrine and training. It is also about creating environments where leaders and individuals can positively interact. This is achieved when the leadership and organisational systems and processes foster an culture that values and embraces human factors, principles and practices in an ethical way.

Introduction

IMTs are often formed from disparate groups of people who may or may not have worked together before. Developing a cohesive and efficient team is more than training and organisational systems; it requires embracing human factors to understand how people interact with devices, products and systems. When applied to the interaction of people, it meets their psychological needs so that an organisation's leadership, inter-relationships and systems interrelate to create a productive, innovative and stable work environment.

An ethical culture in which people thrive

Culture within an organisation comes from leadership, systems and inter-relationships based on 3 psychological needs: autonomy, relatedness and competence. These needs create an environment for beneficence.[1] The term 'beneficence' covers ethical and moral behaviours and includes humanity and promoting the good of others. In plain language, the goal is to benefit or promote the good of others.[2]

The 3 needs as described by Ryan and Deci (2000)[3]:

- Relatedness: IMT members need to feel a sense of belonging and attachment to other people. To achieve this, they need to be included and connected. Within an ethical culture, people are more likely to embrace shared values and beliefs and display behaviours that align with the ideals and expectations of the team.
- Competence: IMT members usually have mastery of their assigned functional area and should be considered competent or, if new, mentored to grow their confidence. By providing positive feedback and an opportunity to learn, members will feel they have the knowledge and skills needed for success and are more likely to be proactive and mission-focused.
- Autonomy: IMT members need to feel in control of their roles and enabled to undertake them. This sense of being able to take action that will result in real change

plays a significant part in helping people feel self-determined and empowered within constraints such as policy, procedures and training.

Individuals contribute to establishing mutual trust within the team. According to Tracy (2016),[4] there are 3 fundamental components necessary for trust in ethical and reliable relationships:

- Honesty - demonstrated through transparency and openness. An honest leader is willing to consult, collaborate and communicate (speak and listen) to ideas and feelings. An honest leader follows through on commitments.
- Integrity - is a leader's moral principles and willingness to speak up about actions that are not morally, ethically or organisationally suitable. Integrity is also demonstrated by work ethic and conduct that would be deemed professional.
- Loyalty - is demonstrated through trust and standing by supervisors and subordinates. Loyal leaders give and expect loyalty in return. Loyalty is the most fragile of elements for an ethical leader; it is complex to gain and easy to lose.

These elements are central to establishing an ethical culture. It is important to note that honesty, integrity and loyalty garner trust. Trust is lost when a leader is dishonest, lacks integrity or is disloyal. To lose one of the foundation elements is to lose all of them.

Human factors principles and practices

In 2003, Transport Canada produced an excellent guide on human factors for aircraft maintenance personnel.[5] Aspects have been adapted to the emergency management environment:

- Reduce error: Adopt a process where errors and failures are regarded as reflective learning opportunities. This builds honesty and relies on integrity and loyalty. This approach encourages identifying and reporting to prevent unforeseen or negative consequences from developing. It helps to minimise risk and enhances systems and practice development.
- Increase efficiency: Have a culture and practices that foster inclusiveness, recognition and competency development to enable personnel to optimise performance and their efficiency.
- Maintain inclusive and open communication: Communicate clearly and transparently as shared information builds shared situational awareness and understanding. Clear, concise and unequivocal language and direction maintains consistency and priority of effort. Communication provides new information, positive or negative and is added to the environment as soon as possible so consequence management can occur. This increases responsiveness and allows for proactive rather than reactive conduct.
- Manage fatigue: Promote organisational and personal responsibility to monitor and manage personnel fatigue. Tiredness affects decision-making and performance and, even the most efficient roster, individuals will have different needs.
- Situational awareness: Leaders and team members should be vigilant to the effects of the operations and demands on team members and balance work wherever possible. Situational awareness includes knowledge about the event, the personnel and their physical and mental needs.
- Manage stress: Balance work across personnel and do not assuming immutable structures help reduce stress (mainly when one functional area is overstretched and another is not). High stress levels impair cognitive function. Another critical driver of stress is reactive operations. Gaining tactical and operational advantage allows time for personnel to complete tasks and reduces the pressure of failure.
- Manage complacency: Monitor personnel and develop an effective work tempo to mitigate overconfidence and allow time to check tasks and mentor. Overconfidence can lead to oversight and errors. Leaders using critical thinking and making evidence-based decisions can avoid many of the biases that can emerge through overconfidence.
- Lack of knowledge: Use fact-checking, local knowledge and other means to validate data into actionable information. This reduces incorrect, old or bias-driven information as teams often operate with incomplete or insufficient knowledge, which can result in errors.
- Minimise distraction: Ensure only necessary personnel are in the IMT and establish rules for discussions, control noise volume in the IMT centre and focus on relevant details to allow personnel to remain attentive and situationally aware.
- Promote teamwork: Promote inclusion and competency that enable and empower personnel. Champion trust and ethical conduct to create high-performance teams as effective teamwork is crucial for safety.
- Buffer external pressures: External pressures affect critical thinking and decision-making effectiveness. This may require using evidence based argument or contingency planning to manage. 'Delay is better than disaster'.[6]
- Manage resources: Inadequate resources hinder performance. Incident control centres may sometimes be affected by a lack of internal resources or system failures and external resources needed to achieve a mission. Solid and resilient teams adapt and can

overcome such shortfalls. Highly fatigued and stressed teams with ineffective leadership will struggle to remain competent, capable and effective. Planning and execution early to ensure incident control centres are well resourced before events limit the ability to garnish resources within limited timeframes.

- Promote positive norms and culture: Establish a positive culture through trust, effective leadership, promoting supportive behaviours and reduce negative behaviours to maintain buy-in from personnel. The organisational culture influences team behaviour.
- Promote positive assertiveness: Monitor and provide positive feedback and guidance to create effective assertiveness so that decision-makers feel supported and empowered. This encourages positive assertiveness and decision-making. Failing to speak up or being unnecessarily authoritative can lead to personal and operational problems. Micro-managing and excessive control over personnel can create doubt and slow information flows and the conduct of the operations. This will have a detrimental effect on tempo or operations and synchronicity of effort.

Conclusion

By considering human factors, organisations can create safer and efficient environments for everyone involved. How people interact, as well as the systems and culture that create a positive environment, are at the heart of a high-performance IMT.

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Maintaining momentum at the 2024 Australian Disaster Resilience Conference

Lisa Jaunalksnis

Angela Draper

Australian Institute for Disaster Resilience

Since the inception of the Australian Disaster Resilience Conference in 2018, communities have experienced an increased number of disaster events, often overlapping and cascading. These events highlight many areas of vulnerability for communities, landscapes, businesses and governments.

The effects of the COVID-19 pandemic, bushfires, floods, cyclones and storms has been coupled with the pressures of increases in the cost of living. The Australian Disaster Resilience Conference confronted these issues and explored how to navigate this 'new normal' and prepare for the future.

The Australian Institute of Disaster Resilience hosted the 2024 Australian Disaster Resilience Conference in September in Sydney. This year, 600 delegates attended and attended presentations about 'Maintaining momentum: driving systemic change to create a more resilient future'.

This year is the seventh anniversary of the Australian Disaster Resilience Conference. It was a milestone event and the biggest conference yet, with both the conference and professional development field trip sold out. The 2-day conference program featured 2 streams of presentations offering a comprehensive conference experience that delegates could tailor according to their interests as well as keynote speakers who presented topical and pressing issues relevant to the sector.

Dr Lori Moore-Merrell, Fire Administrator from FEMA, presented a keynote address on

The AIDR stand brought delegates together to talk about disaster risk reduction and resilience during ADRC24.

Image: AIDR

transformational leadership and innovation in a world of change. Douglas D'Antoine, Recovery Executive Officer from the Shire of Derby in West Kimberley, drew on best practice and his own experience in his discussion on Aboriginality and the Fitzroy Valley Flood Recovery Working Group.

Other keynote presentations included Dr Catriona Wallace, Adjunct Professor and Founder of Responsible Metaverse Alliancem, who discussed the how and why of responsible AI. Brendan Moon, Coordinator General of the National Emergency Management Agency, explored disruption as innovation and designing for risk in Australia.

This year's inspiring keynote speakers set the tone for each day's events and prompted delegates to consider the ways we can create change for a disaster resilient future. As the program continued, the exceptional work taking place across the country became evident through the passion and dedication of the presentations.

The panel discussion on masculinities, culture and disaster resilience was moderated by Dr Emma McNicol, Monash University, and featured John Richardson, AIDR Manager Knowledge Development and Bhiamie Williamson, Monash University, Steve O'Malley, Gender and Disaster Australia, Collin Sivalingum, Australian Red Cross, and Antony Ruru, Fire and Emergency New Zealand. The group discussed how culture influences perceptions of masculinity and how it then influences perceptions and responses to disaster.

On day 2, Anne Crestani, Resilient Villages Project, and Karen Cody and Cathrine MacNamara, ABCD Inc, discussed how resilience is built for the community by the community. This session provided insight into the Resilient Villages field trip to the Blue Mountains that took place the following day. Both their presentation and the field trip gave a unique insight and place-based example of the value and effectiveness of communities working together to strengthen readiness.

In the AFAC24 Exhibition on the Solutions Theatre stage, Dr Isabel Cornes, AIDR Senior Project Officer, introduced the Planning for Animals Handbook (part of the Australian Disaster Resilience Handbook Collection) and the importance of considering animals during emergencies and disasters.

AIDR had a strong presence throughout the AFAC24 Exhibition with the return of Resilience Lane, sponsored by NRMA Insurance, the AIDR stand and the AIDR Knowledge Centre, which featured the popular poster. It was a highly active space with conference delegates discussing and sharing experiences, reading the posters and networking.

The 2024 Poster Award winners were announced in the closing ceremony. Congratulations to Shari Bent from Disaster Relief Australia for her winning poster 'Building community partnerships and connections with a big map'. Congratulations to the 2 highly commended posters, 'Safety in the game: sport as an effective channel of communication within all communities' by Elijah Chan, Fire and Rescue NSW, and 'Youth in Emergencies Development Program' by Ness Wiebford, Australian Red Cross.

The conference brought together a diverse and passionate crowd from a range of sectors and offered a unique experience to learn, share knowledge and collaborate through thought-provoking presentations, panel discussions, networking functions and AIDR's exhibition space.

The delegates and speakers shared their energy, ideas, commitment and support throughout the conference and this will maintain momentum for this important work. Thanks is extended to sponsors and partners for their significant contributions to the conference: NRMA Insurance, IAG Insurance, Fire to Flourish, NSW Reconstruction Authority, NEMA, Weatherzone and AFAC.

Proceedings of the 2024 Australian Disaster Resilience Conference are available at: https://knowledge.aidr.org.au/resources/australian-disaster-resilience-conference-2024-proceedings.

The panel discussion explored 'Masculinities, culture and disaster resilience'.

Image: AIDR

Conference delegates gathered around the poster display in the AIDR Knowledge Centre.

Image: AIDR

Australian Institute for Disaster Resilience

AUSTRALIAN DISASTER RESILIENCE KNOWLEDGE HUB

Disability inclusion and disasters

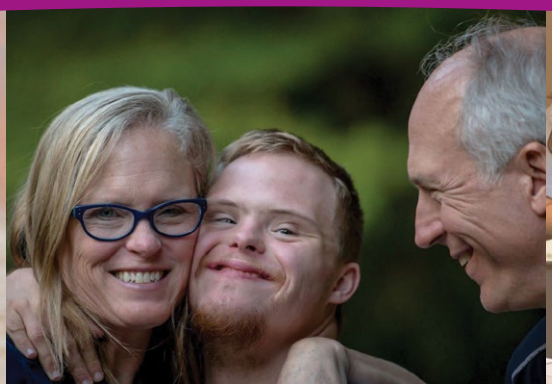
In Australia there are approximately 4.4 million people living with disability.

The AIDR disability inclusion and disasters collection brings together research, guidance, resources and tools to support disability-inclusive disaster risk reduction (DIDRR) in policy and practice.

View the collection online

knowledge.aidr.org.au/collections/disability-inclusion-and-disasters

Legal and policy frameworks



Planning for disability-inclusive disaster risk reduction

Emergency management DIDRR

Leave Nobody Behind webinar series

Collaborating 4 Inclusion

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Disability inclusion and disasters in AJEM

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Australian Disaster Resilience Knowledge Hub

A national open-source platform that supports and informs policy, planning, decision making and contemporary good practice in disaster resilience.

The Knowledge Hub:

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- links national guidelines with research
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Disaster Mapper

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