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SUPPORTING A DISASTER RESILIENT AUSTRALIA

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Image: courtesy David Whitehouse and the Cyclone Testing Station

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Contents

News and views

Reports

Research

Foreword

Alistair Dawson APM
Inspector-General
Emergency Management
Queensland

It is an honour to contribute to this edition of the *Australian Journal of Emergency Management* and I take this opportunity to acknowledge the incredible efforts of the many staff and volunteers in the disaster management, health, police and emergency service and other frontline sectors during these unparalleled times.

To say we are in challenging and complex times would indeed be an understatement. COVID-19 has tested us all with new variants, new restrictions and new challenges. It has also tested our thinking, our work practice, and our ways of life. We now find ourselves gearing up for the bushfire, storm and cyclone seasons in Australia with the concurrent threat of COVID-19.

In the disaster management sector, our personnel have been working alongside health and frontline workers to respond to the pandemic for over 18 months. Fatigue management must form a major part of disaster management plans. At the top of our to-do lists must be ensuring the health and wellbeing of people, having contingency arrangements in place and looking to upskill and diversify the sector while delivering for the community.

COVID-19 has taught us that we must not only expect the unexpected, but we must plan and prepare for the unexpected. This underscores the importance of working together, sharing knowledge and ensuring we have robust continuous improvement mechanisms.

It has never been more important to identify and embed learnings in our daily practice and to truly commit to learning from lessons. Post-event debriefings and reviews are an important part of the learning process. But we must go further than identifying lessons. Embedding the learnings and testing the lessons is a vital part of closing the loop. It ensures we don't suffer from learning amnesia and continue to track our lessons and learnings.

Another contributing practice is tracking progress. Robust monitoring and evaluation programs are a good way to keep on top of the progress made on previous report recommendations so that we don't need to re-learn old lessons.

In this edition of the *Australian Journal of Emergency Management*, I would like to draw attention to an article on the K'gari Bushfire Review recently undertaken by the Office of the Inspector-General of Emergency Management (IGEM) in Queensland. Our team recently returned to the island to debrief with locals and fire management agencies on the outcomes of the review.

It has been pleasing to see the great progress made towards greater inclusivity of the community in bushfire planning and hazard-reduction activities through the Locality Specific Fire Management Group for K'gari.

IGEM looks forward to working with its stakeholders to track the progress and effects of the review's recommendations to deliver ongoing improvements in Queensland's disaster management arrangements.

Heat Smart: building resilience to heatwaves in Western Sydney

Kelly Gee
Western Sydney Regional Organisation of Councils

Andrew Gissing
Risk Frontiers

Heat resilience is a significant and growing challenge for NSW and is of particular concern in Greater Western Sydney. The region's historical temperature patterns and rapid rate of urbanisation, combined with its socio-economic and demographic make-up combine to deliver a significant risk profile. Rising global temperatures, continued urban development and an ageing population will see risk increase in the coming decades.

The Western Sydney Regional Organisation of Councils (WSROC) has instituted the Heat Smart Western Sydney program to address this challenge. The program is part of the Turn Down the Heat Strategy[1] that provides a coordinated approach to building a heat-resilient Western Sydney. This paper describes the development of a regional program to improve heat resilience for at-risk groups in the area.

Heatwaves and the community

At a community level, heatwaves are acknowledged as a major source of stress and anxiety. The experiences of residents in Western Sydney show heatwave is percieved as a threat equal to, or greater than, bushfire. A survey (n=317) conducted in May 2020, found 62% of respondents thought heatwaves posed 'extreme' or 'high risks' to their health and safety, 30% had felt unwell or sought medical treatment and 34% had felt distressed/ mentally stressed during previous heatwaves. Further, communities had experienced disruption to critical infrastructure during previous heatwaves, with 32% losing power and 24% reporting transport disruption.

Respondents' key concerns about heatwaves were the possibility of bushfires (80%, n=227), personal discomfort (71%, n=201) and loss of sleep (70%, n=198). There were also consequences for at-risk people (68%, n=193), pets and animals (65%, n=184) and people's physical health (61%, n=173). Over half (58%, n=163) of respondents were concerned about additional costs of electricity. Only 2% (n=5) of respondents indicated they had no concerns about heatwaves.

How prepared are communities?

Most respondents considered themselves to be either 'well prepared' or 'somewhat prepared' for heatwaves. More males than females thought they were prepared. The percentage of respondents who considered themselves well prepared generally increased with age and a much greater percentage of those with a chronic illness or disability reported being well-prepared. Actions respondents reported undertaking are listed in Table 1.

Respondents nominated several barriers to becoming prepared for future heatwaves. The most significant related to socio-economic factors including the cost of home upgrades or inability to carry out such upgrades due to tenancy.

Table 2 shows that cohorts with heat-related vulnerabilities, including chronic illness, disability or age, were over-represented in reporting these barriers.

These results indicate improved information on low-cost adaptations, including options for renters, as well as assistance schemes for older and low-income groups could reduce barriers to adaptation.

Heatwave-risk management and governance

Despite posing a significant and growing risk, heatwaves have not historically received similar attention as other natural hazards when it comes to risk assessment, mapping, land-use provisions, construction standards or emergency management planning. In contrast to the comprehensive planning for flood, bushfire and coastal erosion hazards, the NSW State Heatwave Sub Plan deals exclusively with

`Table 1: Preparedness actions

Preparatory actions taken for future heatwaves	Percentage responses	Number of responses
Installed air conditioner	61	170
Purchased fans	59	163
Installed blinds and shutters	44	122
Planted trees for shade	25	70
Purchased cool packs	21	57
Discussed preparedness with vulnerable family members, friends or neighbours	18	51
Developed an emergency plan	12	32
Installed swimming pool	9	26
Developed an emergency kit	8	23
Relocated to cooler suburb	4	11
Redesigned home	4	11
Visited doctor prior to summer regarding treatment of illnesses during severe heat	2	5
Nothing	8	23
Unsure	3	8
Other (please specify)	10	29
TOTAL	**100**	**277**

Table 2. Barriers to heatwave adaptation

People surveyed (%)	Barrier	Groups affected
46	I can't afford it	31–40 and 71–80 age groups people living with chronic illness or disability
22	I rent my home/ unit	18–30 and 31–40 age groups people living with chronic illness or disability
14	I don't know what to do	18–30 age group
9	I am not physically able	People over 70 years people living with chronic illness or disability
5	I live alone and have no assistance	people over 70 years

information-sharing between agencies and the public. It does not fully address the reduction of risk before the event nor practical response in an emergency. This sits in contrast with sub plans for other natural hazards.

A review of the literature and interviews with Western Sydney orgnaisations, including emergency management personnel, found some limitations in the current approach to heatwave management and governance:

- There is no specific organisation in NSW accountable for prevention and preparedness for heatwaves as is the case for flood, bushfire and storms.
- There is a lack of clarity in the roles of local government with respect to heatwave and emergency management generally. There is also a lack of heatwave emergency planning at the local level.
- The broad scale of current heatwave warning systems does not reflect the significant variation in exposure across greater Sydney.
- Governments and community organisations in Western Sydney expressed concerns that at-risk individuals are not well-identified, nor communicated with well, and building capabilities of community organisations and service providers is critical to connect with these individuals.
- Regional approaches to heatwave are preferred given the spatial distribution of exposure and vulnerability, urban nature of the community, and the benefits of collaboration with stakeholders who work across local government boundaries.

What action is occurring?

Heatwave resilience is a priority regional issue for WSROC, local governments, the health sector, community service providers and infrastructure operators. Many local governments are already addressing heatwave resilience by:

- quantifying urban heat island affects[2]
- developing cooler public places[3]
- implementing urban forest strategies and tree-planting programs
- updating land-use planning and development controls[4]
- improving infrastructure resilience[5]
- enhancing community awareness and engagement[6]
- encouraging household cooling activities
- establishing extreme weather protocols for rough sleepers
- trialing cool refuges.

What still needs to occur? A framework for action

To build heat resilience in Western Sydney, an integrated, whole-of-community approach based on prevention, preparedness, response and recovery (PPRR) principles is needed. An integrated heatwave management strategy encourages partnerships, shared responsibility, better understanding of the risk environment and an adaptive community that acts on

Figure 1: Integrated heatwave risk management approach.

this understanding. Such a strategy includes components as illustrated in Figure 1.

Specific themes identified to improve heatwave resilience:

Prevention

- Revise state and local planning instruments to mitigate urban heat islands and support adaptation to a warmer climate.
- Revise housing design standards so that dwellings can maintain survivable temperatures in extreme events without air-conditioning.

Preparedness

- Enhance governance and coordination through clearly defined extreme heat management arrangements including localised triggers for action.
- Improve understanding of extreme heat risk considering current and future conditions, as well as community exposure and vulnerability.
- Provide information on better practice risk management planning to define a state-wide extreme heat management framework.
- Improve identification and connection with individuals exposed to extreme heat.
- Expand community engagement and capacity building around heat risk and preparedness.
- Enhance the capacity of local government, community organisations and institutions to mitigate and manage local heat risks.
- Integrate community organisations and frontline services (e.g. primary health care) in local emergency management planning.
- Enhance the capacity of businesses, community organisations and institutions to withstand extreme heat effects.
- Improve infrastructure resilience to heat so it functions when people need it most (e.g. energy, transport and telecommunications networks).

Response

- Enhance warning services so they are locally tailored and targeted (suburb level).
- Develop outreach programs to support at-risk individuals during extreme events.
- Improve the availability of cooling shelters, cooled water facilities, and air-conditioned venues with a focus on areas of highest risk.
- Support energy affordability for at-risk groups.

Recovery

- Undertake research to understand the effectiveness of extreme heat management measures.
- Improve measurement of extreme heat effects on people and cities.

Next steps

Given current and future patterns of heatwave and community exposure, expansion of current heatwave management approaches is required for a heat-resilient Western Sydney. In partnership with regional stakeholders, a Heatwave Resilience Framework has been produced that outlines key actions for addressing gaps and inspiring co-ordinated action.

Acknowledgements

The Heat Smart program received funding under the NSW Natural Disaster Resilience Program. The program is being undertaken in collaboration with local councils and NSW Health. The views expressed herein do not necessarily reflect the views of the New South Wales Government.

End notes

1. Turn Down the Heat Strategy, at: https://wsroc.com.au/projects/project-turn-down-the-heat.

2. Benchmarking heat studies, at: https://apo.org.au/person/198421.

3. UV Smart Cool Playground project, at: www.cumberland.nsw.gov.au/uv-smart-cool-playground-project.

4. Urban heat planning toolkit, at: https://wsroc.com.au/media-a-resources/reports/summary/3-reports/306-wsroc-urban-heat-planning-toolkit.

5. Western Sydney Cool Roads trial, at: www.cityofparramatta.nsw.gov.au/western-sydney-cool-roads-trial.

6. Cool Streets, Blacktown, NSW – Pilot Project, at: www.coolstreets.com.au/blacktown-pilot-project.

Designing fire danger outlook products for climate timescales

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The climate fire weather outlooks for the new Australian Fire Danger Rating System (AFDRS) are the first of their kind in Australia. We engaged with critical stakeholders to guide the product development process for the graphical communication of fire danger risk for climate timescales (monthly and seasonal).

The many challenges

The main goal of the AFDRS climate service is to present complex datasets as actionable information. This is not without its challenges, which the AFDRS product development team encountered when producing accessible, graphical depictions of statistical data for a non-specialised audience.

While surveys showed that there is a strong cross-industry demand for fire-weather outlook products, not all sectors have the capacity or expertise to effectively adopt such products into decision-making processes. This posed the first challenge: obtaining 'use cases'. Knowing what type of information would be used, how and when it would be used (use cases), is foundational to the product-design process so that the products would be suitable for end users. Obtaining use cases was not straightforward given how novel the products are. Many sectors did not have the specialist expertise available to discuss interpretation and operational use.

The second challenge was managing expectations around climate data for groups who regularly use weather data. Most stakeholders with an interest in fire-weather outlook products regularly make decisions based on short-timescale weather information. While weather and climate products describe similar phenomena, they are based on different types of data due to the nature of the modelling used to produce them. This subtle but significant difference often clouded and confused discussions about how products could be incorporated into operational decision-making processes.

The third challenge was producing graphical, non-dynamic products that meet information needs. The necessary trade-off between information content and simplicity was complicated by the limitations inherent in the AFDRS dataset, which restricted what information could be drawn from the data in a scientifically sound manner.

A baseline for user needs

Stakeholder guidance was essential to the design and development process. The aim was to tailor output products to best meet user needs and encourage successful adoption of the fire-danger outlook service. Stakeholder engagement occurred through regular meetings, surveys and targeted workshops. We commenced the design process with a set of desirable attributes of potential fire-weather outlook products:

- Relevant and actionable: the information should be relevant to decision makers and be provided in ways that allow it to influence decisions and improve outcomes.
- Scientifically sound: the forecasting methods should be peer reviewed, scientifically documented and supported by sound science.
- Verifiable: the performance of outlooks should be assessed against subsequently observed outcomes.
- Probabilistic: forecasts should faithfully represent future uncertainty.
- Clearly defined: the meaning of forecasts should be clear and understandable.

Some prototypes (e.g. Figure 1) were developed through a previous project that focused on the forest fire danger rating (ERP-14). The lessons from

that project were adopted by the AFDRS product development team. The spatial, map-based products based on existing Bureau of Meteorology products were generally received well. Products that depict temporal information (such as trends over time), however, were not particularly well received, despite being explicitly requested by participating stakeholders. These products required significant refinement.

Lessons learnt

Feedback from the survey was used to improve the design of temporal outlook prototypes. The new prototypes have been readily welcomed in initial stages of introduction and are being assessed by a larger stakeholder group through a survey.
The 3 main lessons from the initial stakeholder survey:

1. 'Familiar and simple' is better understood and more likely to be adopted by users.
2. What customers request and what they can adopt and use operationally may be quite different.
3. Many potential users are focused on tactical and near-term operations (next few days), using weather forecasts to support decision-making process; interpreting and using climate information is very different to interpreting and using weather information as the temporal scale (how the information is portrayed) and the use cases are different.

Applying lessons to guide design

Each of the lessons were crafted into guidelines to aid the development process. The 3 resulting guidelines were:

Development guideline 1: Build incrementally on a familiar knowledge base to create new products. These new products require some statistical interpretation skills. If the same kind of analysis could be applied to each product, the necessary learning required by end users to effectively use the full product suite will be reduced. Simple, correctly interpreted plots will be more effective than complex plots.

Development guideline 2: Understand what users want to know and why users want to know it. The specialised statistical understanding required to develop and interpret products cannot be justly assumed of the user. To ensure the products have the desired characteristics, those with statistical expertise need to apply it to the context of the dataset and the operational needs of the target groups to develop products that are scientifically sound and accessible without extensive end user training, while striking the balance between information content and usability.

By understanding the 'what' and 'why' that users need, we can draw on the data to present it in a way that supports decision-making on these timescales. This means that the family of products are relevant, fit-for-purpose and adopted into operational processes. It is envisaged that the successful take up of these products will rely on support to interpret them during the initial stages of the service.

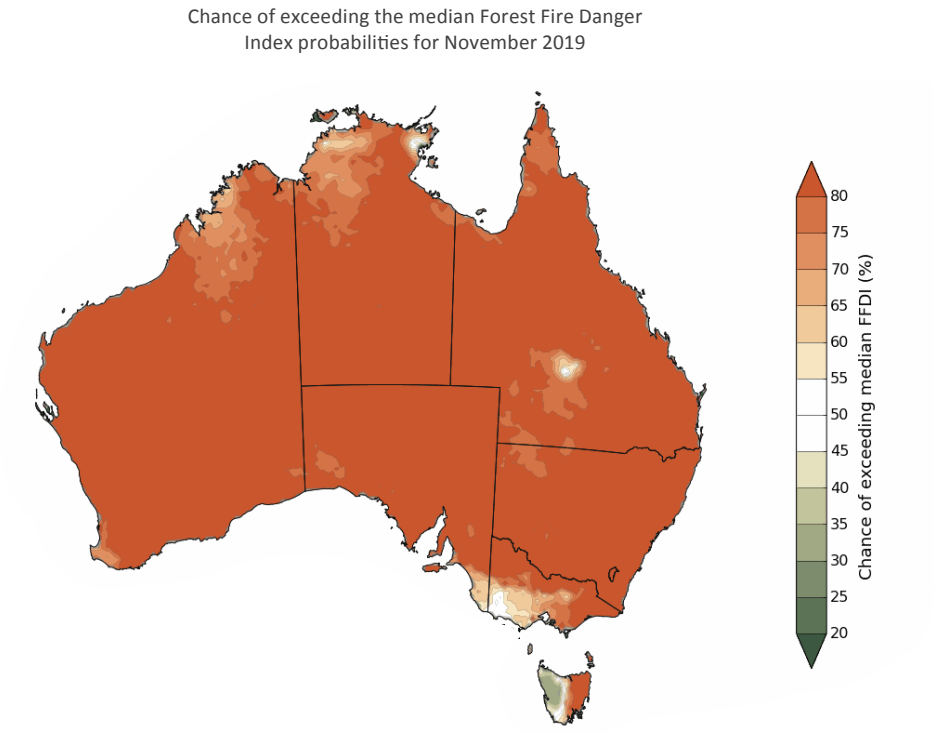

Figure 1: Chance above median forest fire danger rating, similar to Bureau of Meteorology operational rainfall and temperature products, data from 1 Nov 2019.

Image: Bureau of Meteorology

Development guideline 3: Create a specific focus group with those involved in planning and decision-making given the monthly to 3-monthly lead times of the climate products. In most cases, these products are completely new to this audience, so it is difficult for many users to imagine how they might be applied operationally. It is particularly difficult when potential users are used to making decisions based on weather information (from 1–7 days in advance). Given this, the expectations of these users need to be managed around what kind of scientifically supported information could be drawn from the new AFDRS climate dataset. While it is important that the new products are broadly useful, the needs of the most relevant 'product user groups' must be prioritised in the engagement process.

Prototype development

We applied these guidelines to create the product suite. The direct application of each guideline resulted in a specific, but interlinked, set of product characteristics.

Prototype result 1: Based on user requirements, we created tercile temporal plots (Figure 2). Although tercile data is quite technical in its creation, it has a relatively simple interpretation of 3 categories of fire behaviour index: below, about and above average (normal). This 'product pull' by the users was built on the reception to and acceptance of the need for tercile spatial plots in the initial survey. They were not as popular (nor as easily interpreted) as the 'chance above median' products, but the general stakeholder group was regarded as having a basic ability to interpret and use this sort of information in the plots. Tercile information is more appropriate than chance above median for displaying temporal information and variations over time.

Prototype result 2: We developed a broad understanding of what information users need and why. In general, this cohort needed to answer the following question: 'should our operations and planning activities deviate from the usual?' Given this, we developed readily interpretable plots that could aid in broad operational interpretation of the following:

Above average fire behaviour index →	Escalate operations
About average fire behaviour index →	Maintain operations
Below average fire behaviour index →	De-escalate operations

A more nuanced approach is necessary for each specific agency decision, but this broadly applicable idea links the outlooks into an operational decision-making and planning process.

Prototype result 3: A focused target group was nominated for initial feedback consisting of at least one longer-term strategic planner from each jurisdiction. Two workshops provided first-impression feedback and then considered feedback on the products. Both sets of feedback offered unique and valuable insights into how the temporal product could be improved for operations.

Results

It is necessary to adopt scientific advances for best practice in delivering outcomes to support the safety of communities and efficient emergency services planning. Stakeholder engagement allowed us to design products that align with user requirements and skills.

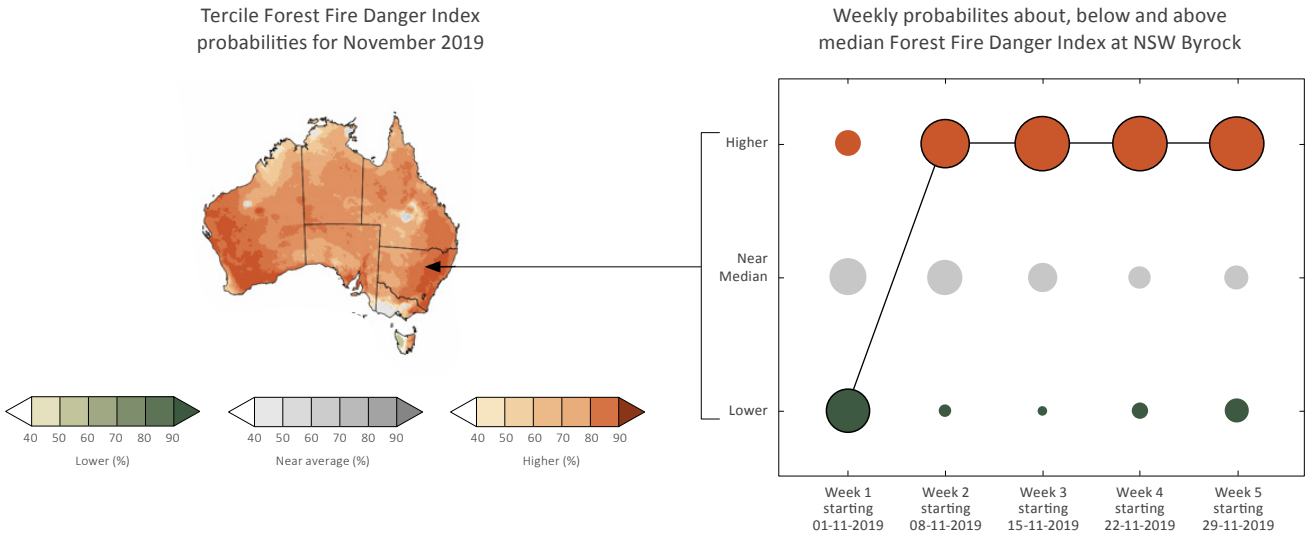

Figure 2: Tercile plot and timeseries for a NSW location, illustrated using Forest Fire Danger Index data from 1 Nov 2019.

Image: Bureau of Meteorology

Evacuation centres are lifeboats, not cruise ships: managing expectations and prioritising improvements

Samantha Colwell
Resilience NSW

Resilience NSW has accountability for coordinating evacuation centres during disasters. Evacuation centres provide basic needs for those with nowhere else to go. However, meeting these needs and managing expectations during the catastrophic 2019–20 bushfire season proved challenging.

What we did

The 2019–20 bushfire season in NSW was the state's worst natural hazard event, causing the destruction of over 2,400 homes and resulting in a significant disaster relief workload. The Welfare Services Functional Area (WSFA) hosted by Resilience NSW and supported by multiple agencies, operated 100 evacuation centres where 30,000 evacuees were registered and over 8,000 people were placed in emergency commercial accommodation.

Historically, there has only been one or two evacuation centres at a time, which are managed locally. In this event, due to the size, scale and duration of the continued operations, state-level coordination became more important.

The challenges

An evacuation centre is a lifeboat, not a cruise ship. It exists in times of emergencies to provide basic needs of individuals, families and their animals. Accommodating the needs of over 30,000 evacuees was challenging, especially if people required greater needs that cannot be accessed in an evacuation centre or had inflated expectations about the levels of comfort that would be provided.

With multiple evacuation centres open 24 hours, in some cases for many weeks, resourcing of staff became a challenge. In some circumstances, staff with little or no training were deployed to work in complex roles and experienced very stressful conditions. Evacuation Centres are staffed by Department of Communities and Justice and supported by Salvation Army, Disaster Recovery Chaplains, Red Cross and Anglicare. The situation was constantly evolving as evacuation centres opened and closed based on the escalation of the bushfires. Resourcing and rostering for these centres were significant tasks that was hampered by a lack of access to some areas.

Several evacuation centres on the NSW South Coast were over capacity due to a swell in population during the holiday season. Road closures inhibited evacuees moving to other areas or transiting through the area. Preferably, evacuees should seek accommodation with friends or family and consider staying overnight at an evacuation centre their last resort. In the best circumstances, the WSFA provides commercial accommodation for people with the greatest need such as the elderly, people with disabilities and families with young children. This was a challenge due to low vacancy rates during peak holiday season and resulted in many people requiring the facilities of evacuation centres.

Another challenge was the presentation of residents from aged care residences at evacuation centres. In some circumstances, there was no option but for residents to sleep on the floor. Aged care residences are required to have pre-approved arrangements with other facilities or commercial providers to house their residents in such events. Evacuation centre staff were confronted by the arrival of aged care residents as they are not nurses or carers, yet they were expected to

provide care to individuals who required significant support. It was also confronting for elderly individuals who were distressed by the emergency and were taken to a facility where they could not access suitable care. There were complaints made against aged care residences that did not have adequate emergency procedures in place. This resulted in a recommendation from the NSW Bushfire Inquiry to review the Evacuation Decision Guidelines for Private Health and Residential Care Facilities.

Evacuation centre staff also encountered people with significant medical needs who were dropped off by their carer. In one circumstance a lady in a wheelchair who was non-verbal was left unattended with no information provided about her medical requirements while her carer left to attend to their home. As an evacuation centre can only provide basic first aid, this individual was relocated to a hospital.

The support of vulnerable people is a challenging issue that has no easy solution. There are areas that can be improved within an evacuation centre however, the key is early preparedness and ensuring that people with special needs have an emergency plan in place. It is unrealistic to expect that an evacuation centre will have all the same comforts of someone's home and evacuation centre staff are not medical professionals nor carers.

Major disasters attract media attention and often pull on the heartstrings of people wanting to help. With 2,400 homes destroyed by bushfires, communities rallied and provided support through donations, with millions of dollars going to charities to support affected residents. The issue for many evacuation centres was unsolicited donations ranging from clothes, toys, appliances, food and even furniture that was dropped off at the centres. NSW Government policy mandates that physical donations must not be accepted, and people are encouraged to make monetary donations to charities. Despite this, large volumes of donations were left at centres. This created a space problem and, in many circumstances, disposal of second-hand items resulted in a cost to government.

NSW Bushfire Inquiry

The ability to learn lessons following a disaster is critical and NSW was subject to both the NSW Bushfire Inquiry[1] as well as the Royal Commission into National Natural Disaster Arrangements. The NSW Bushfire Inquiry produced recommendations for the sector, several of which Resilience NSW is implementing in evacuation centres. One recommendation includes increased training for evacuation centre staff and Resilience NSW has rolled out evacuation centre training for over 1,100 staff from the Department of Communities and Justice to better prepare for future events. Resilience NSW will also work with the community partner agencies to support them in a targeted recruitment campaign and to induct additional volunteers.

Further work is underway to address recommendations in relation to auditing identified evacuation centres to ensure they are fit-for-purpose with a risk assessment and consideration of alternative power sources. Resilience NSW, along with State Emergency Management Committee (SEMC) stakeholders, are auditing facilities as well as capturing data at a centralised point. Currently, the selection and audit of evacuation centre locations occurs at the Local Emergency Management Committees to ensure local risks are considered. One emerging challenge is that they have different systems and there is no state-level list of either the approved locations or whether an audit has been conducted. Resilience NSW is working with SEMC members to update critical state-level guidelines, including the NSW Evacuation Management Guidelines[2]. This will include better approaches to support people's animals and their registration during evacuations as well as updated criteria around the suitability of centre locations.

Further changes have been required in the management of evacuations and evacuation centres since February 2020 due to the pandemic. It is a complex scenario to evacuate large groups in one location together while minimising the risk of spreading COVID-19. Resilience NSW worked with NSW Health and other SEMC representatives to create COVID-safe evacuation plans. A supplement was added to the NSW Evacuation Management Guidelines stipulating ways to reduce the spread of COVID-19 during evacuation. These include evacuation as the last resort and encouraging people to stay with friends and family. In the event evacuation is necessary, anyone who has COVID-19 or their close contacts who are self-isolating will be accommodated separately by NSW Health and will not be permitted to attend an evacuation centre. Physical evacuation centres will have, physical distancing, sanitisation, additional cleaning, staggered meals times and a focus on putting evacuees in commercial accommodation quickly rather than staying in the evacuation centre.

A new COVID-safe concept is a drive-through evacuation centre where evacuees remain in their vehicle while they are triaged and a needs assessment is completed before they are sent to suitable accommodation.

The experience of managing such a large evacuation significantly increased Resilience NSW's experience and capability. During the floods in March 2021, where 33 evacuation centres were established, lessons learned from the 2019–20 bushfire season had already been implemented. There were more trained and prepared staff and processes were fresh in mind. Resilience NSW is committed to implementing improvements and building capability.

Endnotes

1. Final Report of the NSW Bushfire Inquiry July 2020, at www.nsw.gov.au/nsw-government/projects-and-initiatives/nsw-bushfire-inquiry.

2. NSW Evacuation Management Guidelines March 2014, at: www.opengov.nsw.gov.au/publications/19473.

Bushfire resilience in the Great Southern, Western Australia

Melanie Haymont
Shire of Denmark, Shire of Plantagenet and City of Albany

Kath Kinnear
Bio Diverse Solutions

Daniel Panickar
Eco Logical Australia

Activities to manage bushfire risk in the rural–urban interface are often guided by local knowledge, policy and best practice. While these activities are well-intentioned, there is a need to prioritise work and measure effectiveness before resources are expended. Using scientific methodologies and new technologies, this project provides a scientific basis for mitigation activities to reduce bushfire risk.

Under the State Hazard Plan for Fire[1], an integrated Bushfire Risk Management Plan must be developed for local government areas that have significant bushfire risk. This plan identifies and assesses risks from bushfire across multiple tenures and asset classes.[2] The Great Southern region, particularly the local governments of the City of Albany, Shire of Denmark and Shire of Plantagenet, has a varied demographic with nodes of high seasonal population fluctuations. This, in combination with topographical constraints and unique vegetation types, requires additional analysis of evacuation routes and assessment of risk to create confidence in the community in managing bushfire risk. Local emergency management committees report to district committees and make recommendations about evacuation locations. However, these committees are often under-resourced and under-informed to make these recommendations.

Eight precincts across the 3 local governments were chosen for this project. The process involved science-based methodology to guide decision-making around the management of risk. Each precinct was assessed to ascertain current road networks and possible vulnerabilities in a bushfire event. The data included reviews of local roads standards, road widths and road hierarchy information. The assessment looked at access and egress for future public roads, cul-de-sacs and turn-around capability, emergency access routes and access ways. The output identified mitigation activities, funding and future town planning requirements.

The precincts were assessed to ascertain current water storage, servicing and possible vulnerabilities during a bushfire. The review included government supplied water hydrants, infrastructure and water current capacity through water corporation procedures for servicing, filling and sustaining. It also included bushfire brigade sheds in the precinct and other infrastructure. Gaps identified were GIS-mapped for spatial representation. The method of assessment and recommendations followed the PACE procedure: Primary, Alternative, Contingency and Emergency, for each precinct.

Bushfire risk assessment

The project used the CSIRO[3] bushfire modelling toolkit, SPARK. The software is fully configurable, which allowed for ignition scenarios and configurable inputs such as rate-of-spread models, weather and fuel parameters. In addition to informing the risk assessment, the outputs could be incorporated into other deliverables such as the evaluation of access, water supplies and emergency shelter options.

The likelihood and consequence of bushfire attack on life and property is typically influenced by landscape, locality and site-specific factors. The bushfire risk assessment undertaken for the precincts was based on analysis of:

- landscape risk
- locality risk
- building risk.

Landscape risk

Two forms of analysis were used to determine landscape bushfire risk: burn-perimeter analysis and bushfire rate-of-spread analysis. The burn-perimeter analysis was used to assess the degree of potential bushfire exposure from bushfire attack scenarios arising from different wind directions. The burn-perimeter analysis modelled the fire spread from a set of ignition points using different wind directions and tallied the quantity of the resulting fire spread models at each point across the landscape. The bushfire rate-of-spread analysis was used to assess the potential bushfire spread and speed in different bushfire attack scenarios. This provided insights into the potential time to impact within the precinct as well as the road network giving access to or from the precinct. The analysis was made by computing fire spread scenarios from a set of distant ignition points for differing wind directions. The fire spread models were collated, indicating estimated bushfire rates of spread for each point across the landscape.

Inputs used were:

- weather: FDI of 80
- wind directions: ESE, SW and NNW
- fuel: vegetation mapped by Kinnear & Panickar (2020)[4] and manually converted into AS3959:2018 classes
- fuel parameters associated with each vegetation class as per AS3959:2018
- mapped buildings for the precinct
- ignition points:
    - burn-perimeter analysis: a grid of ignition points was applied regularly (250 m spacing) within a 5 km buffer line from the buildings within the precinct and ignited sequentially
    - bushfire rate of spread analysis: a ring of ignition points was applied regularly (100 m spacing) along a 5 km buffer line from the buildings within the precinct and ignited in parallel.

Ignition points were moved closer to the precinct in areas where the 500m buffer would place an ignition point in the water, a non-vegetated area or an area of vegetation separated by a significant body of water.

Locality risk

The analysis of locality risk assessed the quantity and degree of bushfire hazard in the immediate locality of buildings in the precinct as a measure of the increased potential for severe bushfire attack. For locality risk, bushfire intensity models were generated for different attack directions.

Inputs used were:

- mapped buildings of the precinct
- a ring of ignition points, spaced 100 m apart and buffered by 500 m from the buildings within the precinct and ignited sequentially
- weather and other inputs from the landscape risk
- ignition points moved where required as detailed in landscape risk.

Risk ranking

A risk analysis process was undertaken to assess the comparative level of risk exposure for each precinct. The intent was to establish a risk-based ranking so that risk treatments across the 8 precincts could be prioritised. This risk analysis was achieved by assigning each risk assessment (landscape, locality, building and evacuation) for each precinct a score, standardising the scores and then classifying these into a 5-class grouping (ranking) using the Natural Breaks (Jenks) data classification approach.

Community engagement

Community engagement was important to the success of the project and involved community groups, interested parties and precinct residents during site assessments. A total of 235 people attended 8 community information sessions. Information and feedback from these sessions guided the final precinct reports and overarching report. Information sessions were held with representatives from fire services, land management agencies, non-government organisations and related associations.

Results

The study confirmed that the 8 precincts are at extreme risk of bushfire and the capacity of people in these precincts to evacuate is compromised under differing bushfire scenarios. The communities at risk were involved during the project and requested more collaborative community, stakeholder and government agency interaction.

Successful implementation of the project recommendations is subject to funding either at local, state or Australian Government levels. Current funding is limited to state agency funding on public lands through a mitigation activities fund. Focus areas are presented as a road map forward with an emphasis on shared responsibility.

The project outlined a scientific methodology for asset-based bushfire risk assessment. The methodology is tenure blind and identified the need to enhance and refine bushfire protection measures at the point of the asset ahead of extreme bushfire events. Additionally, it provides a road map for targeted, measurable and quantifiable outcomes to reduce

End notes

1. Government of Western Australia 2020, *State Hazard Plan for Fire. At: https://semc.wa.gov.au/emergency-management/plans/state-hazard-plans/Documents/StateHazardPlanFire.pdf.*

2. Government of Western Australia 2020, *Guidelines for Preparing a Bushfire Risk Management Plan 2020. At: https://www.dfes.wa.gov.au/waemergencyandriskmanagement/obrm/Documents/Guidelines-for-Preparing-a-Bushfire-Risk-Management-Plan-2020.pdf.*

3. The Commonwealth Scientific and Industrial Research Organisation is an Australian Government agency responsible for scientific research.

4. Kinnear & Panickar 2020, *Client projects. At: www.biodiversesolutions.com.au/projects.*

Innovation hiding in plain sight: volunteer-driven case studies

Gordon Hall ESM
Dr Faye Bendrups
National SES Volunteers Association

Volunteers make up 87% of emergency responders in Australia. They arrive at their volunteering role with education, training, professional qualifications and life experience. This is an asset of enormous potential value, hiding in plain sight.

This asset can be exploited to engage volunteers, and to improve education, development and retention. It can also enable the sector to find new solutions to problems through innovation and collaboration.

Youth Development and Retention Project

The National SES Volunteers Association (NSESVA) views the development and retention of younger members as a critical issue for future capability. To boost youth engagement, the NSESVA Board sponsored a contingent of young State Emergency Service (SES) volunteers to participate in the AFAC National Memorial Service in Canberra. Comprised of representatives from each state and territory SES agency, the youth contingent was invited to tour Canberra, including Parliament House, Geoscience Australia (receiving a briefing on its role in emergency services) as well as the ACT Emergency Services Training Centre and ACT Emergency Services Operations Centre. The final night included a special dinner and presentation where each member of the youth contingent presented a 4-minute speech as part of their development.

The first contingent attended the 2019 AFAC National Memorial Service. The attendance of the youth contingent was cancelled in 2020 and 2021 due to uncertainty of travel and border restrictions. It is intended that the youth contingent will recommence participation of the National Memorial Service and Canberra tour in 2022 and is expected to increase to 2 representatives per jurisdiction.

The 2019 youth contingent attending the AFAC national memorial service.

Image: Faye Bendrups

The Refuge Project

Emergency services agencies have an increasing focus on connecting with communities and assisting them to develop a shared responsibility for their own safety. However, communities may never be involved with the emergency management sector and emergency services agencies may not have a full understanding of diverse communities. One project that took a different approach is the Refuge Project[1] in Melbourne that was led by creative artists and involved migrants and refugees, local schools and Aboriginal and Torres Strait Islander peoples.

The Refuge Project has run for 6 years at the North Melbourne Arts House. The venue operates as an arts centre but is also a designated relief centre in the City of Melbourne's emergency preparedness plan. Refuge has conducted artist residencies, online panel discussions, emergency simulations and a major annual public event based on a different theme each year. Partners in the project include the Australian Red Cross, St John Ambulance and the local VICSES Footscray Unit, whose response territory includes the City of Melbourne.

The project's website explains:

> *Refuge drops us in the hot zone of different climate-related disasters. Flood, heat, pandemic and displacement: this five-year project offers us new ways to rally as a community and prepare for climatic events. Refuge brings together people who might not normally collaborate in a crisis, including local residents, artists, scientists, Elders and experts from the world of emergency services. Their task is to identify what matters when the unthinkable becomes real: what being prepared means in the face of disaster, how the survival of the individual is inextricably bound up with the survival of community, and what role we can each play if the worst comes to pass.*

In 2016, Refuge transformed the North Melbourne Town Hall into a relief centre for 24 hours in response to a hypothetical flood. In 2017, Refuge ran a similar exercise in response to a hypothetical heatwave, responding to the city's increasing risk of experiencing 5 consecutive days over 40°C. In 2018, Refuge partnered with the Doherty Institute and participated in a pandemic simulation exercise with the City of Melbourne. Refuge asked: what happens to the social and environmental fabric of a city through the risk of contagion or quarantine? It explored health effects of climate change, epidemics, grief, stigma and anxieties invoked by the language of disease. Participants and visitors kitted up in full personal protective equipment, masks, gloves and suits.

In 2019, Refuge explored the issue of displacement prompted by climate change and extreme weather. This was to be in 2 parts, with the second to occur in 2020. However, due to lockdowns in Victoria, it did not go ahead and was postponed to 2022, the final Refuge. It explores the confluence of multiple climate crises and asks: how can we share resources equally in times of hardship when the worst comes to pass?

VICSES Footscray Unit provided information and advice; the Controller was part of discussion panels and ran a workshop on local evacuations, Street Plan: The Big Brainstorm. In 2021, they

Refuge 2017: Volunteers conduct a walk through of a heatwave simulation game.

Image: Faye Bendrups

Refuge 2018: SES volunteers received pre-pandemic experience in the pandemic simulation.

Image: Faye Bendrups

Refuge 2018: Introducing the concept of physical distancing at the pandemic simulation.

Image: Refuge

worked with Latai Taumoepeau's project, Mass Movement, and participated in a symbolic walk and a mass gathering representing movements of climate change refugee Pacific Island groups whose islands are at risk of catastrophic inundation. The SES members also participated in a multi-day workshop that involved local communities experimenting with the construction of temporary shelters as part of the Portage: Shelter2Camp project. This workshop was devised by Jen Rae and guided by local Australian Indigenous, Papua New Guinea and Sudanese residents who shared their construction methods for building nomadic or temporary structures.

Refuge 2021: Displacement. SES personnel building a temporary shelter.

Image: Faye Bendrups

The Research Unit in Public Cultures at the University of Melbourne noted that a distinguishing characteristic of Refuge is 'its rejection of command-and-control approaches to decision-making and vertical communication systems in favour of horizontal communications and the embrace of collective decision-making'.[2] It was overwhelmingly agreed that the 'playing in the dark' strategy that unfolded during Refuge enabled exciting new pathways for emergency management planning.[3]

Transport solutions to enhance operational capability

During the bushfires south of Perth in the summer of 2013–14, it was identified that many of the firefighting assets were driven from the fire ground back to their base 2 to 5 hours away. This meant that not only were the assets unavailable for firefighting during this period, but that fatigued crews were driving themselves back after their firefighting shift was completed. The acquisition of 8 buses for the transport of SES and firefighting volunteers was an initiative of SES volunteers in Western Australia (WA SESVA).

In early 2014, 3 SES volunteers met with BHP Billiton to discuss sponsorship. During these discussions, the SESVA team outlined the role and support to the community by the SES volunteers and the other services and put forward a proposal for around $100,000.

One of the proposals involved assisting the firefighters by transporting them to and from the assembly areas, thus leaving fire trucks and equipment near the fire ground and decreasing the amount of downtime of equipment. This would require strategically located buses. The benefits included leaving the assets at the fire front while swapping the crews in the field and transporting the firefighters safely to and from the assembly areas. The proposal meant that 5 buses would be located in the outer metropolitan area to support firefighters as well as SES, one bus to be central in Perth and 2 located in the Pilbara for rescue support and changing SES crews during extended Karijini Gorge rescues and road crash rescue crews on remote highways.

As a result of these discussions, the SESVA put a proposal to BHP Billiton for a community grant to supply 8 buses, including maintenance, registration and licensing for 5 years. The project for the supply and delivery of the 8 buses was managed by the SES Volunteers Association.

The metropolitan-based buses were delivered in December and January 2014–15 with the delivery of the Newman and Karratha buses in February of 2015. One of the key aspects of this project was the fast turnaround time from initial discussions to the delivery of the buses of only 10 months. Since then, the buses have been extensively used in all type of emergencies, especially for bushfire support in delivery of firefighters to staging areas, and the swapping of crews in remote areas during rescues and road crash rescue activities.

A fleet of commuter buses ferry personnel to and from fire grounds.

Image: Gordon Hall

Conclusion

There are many ways volunteers can contribute new perspectives, new ideas or new initiatives to the emergency management sector; whether developing future leaders, negotiating with multinationals or taking creative chances on novel approaches to disasters. Imagine the added value to the sector if their skills and experience – hiding in plain sight – could be collated, recorded and capitalised on. We challenge the sector: Let's harness the potential of volunteers and maximise the innovation and collaboration possibilities they represent.

Endnotes:

1. The Refuge Project, at: www.artshouse.com.au/ourprograms/refuge.

2. MacDowall L & Fraser S 2018, *Refuge 2017 Evaluation: Heatwave, Melbourne: the University of Melbourne. At: https://sites.research.unimelb.edu.au/__data/assets/pdf__file/0009/3505806/RFQ03545-Centre-of-Visual-Art-Refuge-2018-Evaluation-Pandemic_v4.pdf*.

3. Yue A, Trimboli D & Di Biase T 2017, *Refuge 2016 Evaluation Report, Melbourne: The University of Melbourne. At: https://arts.unimelb.edu.au/__data/assets/pdf_file/0008/2269619/Refuge-Evaluation-Report-LR.pdf* .

Protecting communities with better warnings and communications

Nathan Maddock
Bushfire and Natural Hazards Cooperative Research Centre

A new online documentary series using the latest research from the Bushfire and Natural Hazards Cooperative Research Centre about warnings, public information and recovery helps communities to prepare, respond and recover from hazards.

The series, Driving change: the evolution of communications and warnings in emergency preparedness, response and recovery[1], follows communications and engagement practitioners meeting researchers to learn how they can apply evidence-based knowledge to their work.

The series is structured around 3 themes: preparedness, response and recovery. It includes an introduction that explains the how and why behind the evolution of communications and warnings in recent years. Each theme includes videos that give viewers an idea of the topic and the full feature or in-depth interviews with researchers. The documentaries give a big-picture view of the effects of CRC research on policy and practice and how it can be used.

Dr Richard Thornton, CEO of the Bushfire and Natural Hazards CRC, said, 'We know that emergency services agencies have used this research to improve their practices and what they deliver to their communities; whether that is educating kids in the classroom, informing the warnings that go out when bushfires flare or helping to plan for post-disaster recovery.

'But we also know that as the role of providing public information expands to different types of organisations, more and more, people and different types of organisations outside of traditional emergency response will need to do this in the future.

'This series showcases how the research is being used and the difference it is making to guide those who need to do this in the future,' he said.

The series will be a valuable source of information for anyone volunteering or working in warnings, public information, community engagement, education or recovery roles and is well-suited to team training or upskilling sessions.

AIDR Executive Director, Amanda Leck, said, 'The series will be used as companion guidance for the Australian Disaster Resilience Institute's handbook collection. There are some real synergies between the research covered in the documentaries and the handbooks.

Our handbooks are underpinned by research and bring this together with good practice from across Australia. These videos will support the handbooks and assist the sector to utilise research and improve practice.

'With the research contributing substantially to handbooks, such as public information and warnings, community engagement for disaster resilience and community recovery, the series will be a significant resource for anyone learning about best practice and how to use research in their roles for preparing, responding or recovering from emergencies', she said.

Children from Harkaway Primary School share their knowledge of bushfire to Neil Munro and Dr Briony Towers.

Image: Bushfire and Natural Hazards CRC

Preparedness

Child-centred disaster risk reduction

How can children best participate in emergency planning? According to Dr Briony Towers, the key is making the learning place-based and designing learning activities that draw on the natural and social environment that children are in every day, tailoring learning to personal interests and priorities. The presentation with Dr Towers and Neil Munro, Country Fire Authority, explores how disaster education at Harkaway Primary School on Melbourne's urban fringe is upskilling and empowering children to prepare for a bushfire at home, at school and in their town.

Managing animals in disasters

Around 62% of Australian households have pets and a majority of these owners consider their pets to be part of the family. How can people keep their pets safe during an emergency and to what extent do pets change a person's response? Honorary Associate Professor Mel Taylor shows that accounting for animals can lead to animal-ready communities and better emergency preparedness.

Response

Effective risk and warning communication during natural hazards

Warnings are a critical component of emergency management and the evolution of policy and practice has highlighted the power of warnings to save lives and a need to learn more about why some warnings are more successful than others. More organisations outside of traditional emergency response agencies have greater responsibility for public information and warnings. Cathy Buck, Disaster Management Coordinator at the Sunshine Coast Council in Queensland explores research findings with Professor Vivienne Tippett and Professor Amisha Mehta, Queensland University of Technology, to see how research has improved warnings issued by from the Queensland Fire and Emergency Services.

Flood risk communication

The sight of people walking, driving or playing in floodwaters is a source of great frustration for the emergency services planners. With populations in flood-prone areas growing and the frequency and intensity of flood events increasing, flood safety is still important. Katie Moulton from the New South Wales State Emergency Service shares the psychology behind people's responses to floods and warning messages with Honorary Associate Professor Mel Taylor and Kevin Jones, Unit Commander of the Hawkesbury SES, as they visit areas flooded in the Hawkesbury region of New South Wales in March 2021.

Cathy Buck from the Sunshine Coast Council (left) and Kath Ryan (right) discuss how Queensland Fire and Emergency Services used the research to improve warning messages.

Image: Bushfire and Natural Hazards CRC

Recovery

Understanding and using recovery-capitals research

Knowledge on effective recovery has changed significantly in the past 2 decades and continues to develop through research and practice. However, recovery is an area that has traditionally been poorly understood and applied by response agencies. This research produced a disaster-recovery guide for people, organisations and governments managing emergency recovery that supports wellbeing and provides evidence-based guidance to aid decision-making. Rowena Frost, Municipal Recovery Manager for the Surf Coast Shire Council in Victoria discusses research findings and the recovery guide with Professor Lisa Gibbs, University of Melbourne as well as research to improve relief and recovery of local communities.

Endnote

1. Driving change: the evolution of communications and warnings in emergency preparedness, response and recovery. At: www.bnhcrc.com.au/communications-warnings-video-series.

An integrated system to protect Australia from catastrophic bushfires

Associate Professor Marta Yebra
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The Australian National University

Australia has experienced catastrophic bushfire conditions that exceed known firefighting technologies, leading to significant ecological, economic, health and social costs. We need a novel approach that harnesses modern technologies and that is successful in reducing the risk of large-scale bushfires under extreme conditions.

During the 2019–20 bushfire season, extensive areas were burnt largely because of an inability to detect and extinguish ignitions in remote areas before the fires spread and became uncontrollable. A large proportion of these fires were ignited by lightning strikes. The Australian National University (ANU) is undertaking advanced interdisciplinary research to develop an innovative national system to detect bushfires as soon as they start and extinguish them within minutes.

In collaboration with ACT Parks and Conservation Service and the ACT Rural Fire Service, ANU has developed an integrated research initiative encompassing 6 programs from fire prevention to suppression as illustrated in Figure 1.

Program 1: Prevention and risk reduction aims to evaluate the effectiveness of ecological fire-risk reduction strategies and develop the next generation of fire-risk models. Australian development of the ANU OzFuel infrared smallSat mission addresses the recommendations for efficient national monitoring of fuel conditions, which are common to independent national and state inquiries while complementing national and international missions dedicated to rapid fire detection. This is the first step towards a coordinated effort to monitor eucalypt fuel conditions from space. OzFuel will provide critical bushfire earth observation data to support increased bushfire situational awareness and preparedness of government, frontline organisations and communities.

Program 2: Lightning forecasting and detection aims to develop capacity to rapidly identify which lightning strikes within an individual storm are most likely to cause an ignition. This allows for faster responses to fire detection and suppression. This capability relies on a revolutionary approach to both measuring and characterising lightning strikes and locating them accurately. Extensive research will be undertaken on the role of short- and long-term live and dead fuel moisture content together with other key factors that affect the probability of ignitions.

Figure 1: Key themes of the ANU Bushfire Research Initiative.

Program 3: Ignition detection is the core work being done by the ANU-Optus Bushfire Research Centre of Excellence, which is developing an optimised, integrated, layered, hi-tech solution to detect small fires. In the case of early fire detection, there is currently no single remote sensing platform that can do the job of surveying vast areas and detect a small fire. Geosynchronous equatorial orbit (GEO) satellites provide surveillance across Australia but may not identify small ignitions given current spatial resolution. Low Earth Orbit (LEO) satellites can detect smaller fires but only image the same location twice a day, at best. Optical and thermal detectors on both GEO or LEO satellites cannot 'see through' clouds. Drones have dynamic coverage and can be directed to high-risk areas, detect smaller fires than satellites and fly below cloud cover. Cameras on towers and on-ground sensors have limited spatial coverage per camera but can be strategically located in areas of elevated risk or conservation value. Given the advantages and disadvantages of each of the approaches, an approach that combines all these detection options is required for successful ignition detection.

This year, ANU has commenced the development and deployment of some of these technologies.

- The Ground-Based Low-Power IoT (Internet of things) Sensor Networks for Bushfire Detection and Situational Awareness project aims to design and implement a scalable ground-based IoT fire-detection system in the ACT using low-power wireless sensor devices. It will also provide situational awareness for reporting and predicting fire movement and risk.
- Automated detection using artificial intelligence (AI) and cameras on towers is being jointly developed with the Minderoo Foundation, the ACT Rural Fire Service, BushfireLive, Insight Robotics and the ANU-Optus Bushfire Research Centre of Excellence. Cameras have been deployed on 4 fire towers across the ACT to assess the viability of automated monitoring for early bushfire detection. In Australia the last major study of automated bushfire detection was conducted in 2010.[1] The trial showed early promise but demonstrated that automated bushfire detection was not ready for deployment. There has since been a revolution in imaging and image-processing technologies including high-quality cameras, a large expansion in parallel GPU computing and fast image processing and new techniques for deep learning. This has led to an exponential improvement in the performance of algorithms on vision problems such as detecting smoke or heat in an image using RGB and infrared cameras. Early results suggest that ANU methods leads to a higher rate of true positives than the baseline Faster R- CNN (Convolution Neural Network) object detection method.
- Drone networks are a cornerstone for fast identification, location and verification of bushfire ignitions due to lightning during dry thunderstorms. Drones provide enhanced detection and location of lightning strikes, detailed close-up sensor feedback to enable verification of ignition and tactical support for suppression activities following ignition verification. The current practice following dry lightning strikes is to deploy manned fire-spotting aircraft over lightning strike areas the morning after a dry lightning storm. The delay in deployment relates to resourcing issues and restrictions on night flying. Drones can operate in time scales suited to successful ignition suppression. This project includes Beyond Visual Line of Sight of a single drone over the Brindabella Range in the ACT; onboard thermal camera technology; and an initial study capability to verify ignitions into the ACT Rural Fire Service data systems to provide situational awareness. The potential of drones to provide a communications hub for mobile firefighting services will be demonstrated.
- A comprehensive evaluation project compares different methods and technologies to determine the scenarios where each technology is most effective. This project will also establish a performance baseline of 000 emergency calls, observers in towers and current satellite capability. A comprehensive 5-year evaluation will include a substantial number of fires of different nature for purposeful results and conclusions.

Program 4: A data analytics and communications platform aims to create actionable intelligence by integrating high-resolution fuel availability information into the RedEYE FirePrep decision-support tool. This will identify areas where new ignitions are likely to result in rapid fire propagation that affects built and natural assets. Together with Zirkarta, the ANU-Optus

ANU-designed prototype water glider used to suppress fires while they are still small.

Image: Jack Gooday

Bushfire Research Centre of Excellence is building a platform to communicate real-time fire-risk predictions to detection technologies (Program 3) so that detection focuses on areas of higher risk. Fire detection data will be integrated and shared with operations centres and field-based responders in real time through sophisticated mapping technologies. Fire detections will also trigger drones to provide visual verification of detected fires and collect data to power AI to improve the assessment of fire risk and individual detection technologies.

Program 5: Safe and rapid suppression addresses the need to rapidly extinguish ignitions by developing an innovative suppression vehicle. ANU has designed and prototyped GPS-guided water gliders to suppress fires when they are small. Current techniques for aerial firefighting involve low-level flying, which is dangerous and requires extensive preparation and coordination that can limit the speed of response. Most lightning ignitions occur late in the day when aerial suppression may be difficult due to safety and regulatory issues. ANU has developed a safe and innovative approach to water bombing from high altitudes that provides very rapid response and high accuracy and control over the spread of the water during the day and at night.

Simulation studies of the approach to rapid detection and suppression of lightning ignitions indicate that the system can manage thousands of strikes and hundreds of consequential ignitions over forests of southeast Australia. Specifically, a 4-hour snapshot of simulation of the use of 200 drones to inspect 4,200 lightning strikes over 24 hours (see Figure 2) revealed an average detection time of less than 12 minutes. Using 1,000 drones, a detection time of less than 6 minutes was achieved, allowing for rapid deployment of response teams. If technology allows us to increase the speed of drones and we can combine the identification of the highest risk events (e.g. dry lightning in high-slope locations with significant fuel loads), this will result in significant decreases in response time or the number of drones needed.

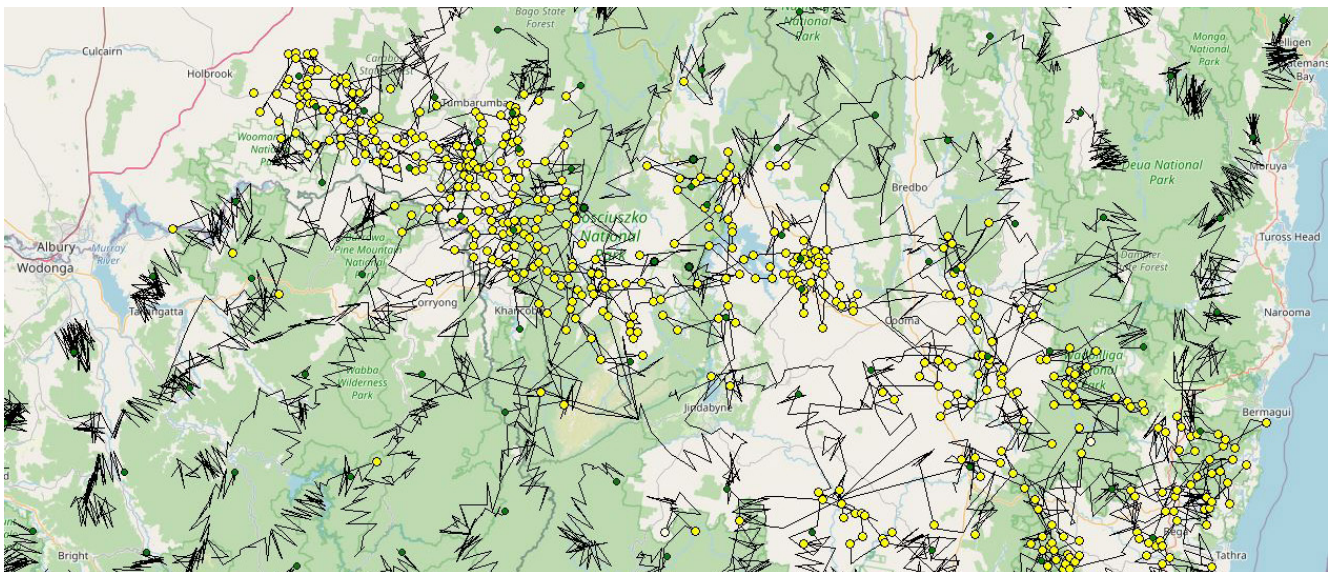
Program 6: Legal and economic analysis includes laws and regulations on surveillance and listening devices, privacy and telecommunications. Workplace laws may also need amending if new air- or space-borne devices are deployed to detect small fires. This program researches existing regulatory regimes for airborne technologies and performs economic analysis of options for detection and suppression.

Conclusion

Major bushfires are costing lives as well as infrastructure and important ecosystems around the world. Human health is under threat from prolonged exposure to bushfire smoke. We urgently need innovative approaches to detect and rapidly extinguish bushfires before they become hazardous and widespread. Current approaches are not always effective, especially during extreme weather conditions. We must accelerate the development of technologies to meet this challenge well ahead of future catastrophic bushfire seasons.

Endnote

1. Matthews S, Sullivan A, Gould J, Hurley R, Ellis P & Larmour J 2012, *Field evaluation of two image-based wildland fire detection systems. Fire Safety Journal, vol. 47, January 2012, pp.54–61. At: www.sciencedirect.com/science/article/abs/pii/S0379711211001457*.



Key:

Yellow dots are lighting strikes. Green dots are drones. Black lines are drone trajectories.

Figure 2: A simulation for rapid detection and suppression of lightning ignitions.

EM-LINK sharing spatial data: an example of collaboration in emergency management

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In the midst of the 2019–20 summer bushfires, responders on the ground and in incident management teams were feeding information into state-based mapping systems. At the Crisis Coordination Centre (CCC) in Canberra it became apparent that a single, national feed showing bushfire boundaries - which did not currently exist - was urgently required.

Given the active bushfire crisis, state and territory jurisdictions did not have the capacity to build bespoke bushfire feeds for the Australian Government. The CCC approached EM-LINK[1] to receive the bushfire boundary feeds from the jurisdictions that had them and to perform a gap analysis of jurisdictions that needed urgent support to produce a temporary bushfire boundary feed.

Responding to an identified need – the beginning of EM-LINK

After Black Saturday in 2009 and the recommendation to share emergency management spatial data, Common Operating Pictures (COPs) were developed across Australia to allow multiple jurisdictions to access a single identical display of information. There was a need for spatial data that could be applied to a range of spatial systems and allow agencies to visualise both the incident and the associated warnings information.

With large-scale fires and floods occurring at a higher frequency, it became important for there to be visibility at the national level of incidents beyond an incident point. Australian Government agencies were unable to see the extent of the impact, especially if it crossed jurisdictional borders. This hampered the national response in providing resources and financial assistance to regions and affected communities.

In 2012, Emergency Management Spatial Information Network Australia (EMSINA) led a project to bring together the incident feeds from states and territories into a National Situational Awareness Tool (NSAT) that was available to chief officers and Australian Government agencies. Emergency management agencies provided their bushfire incident points, bushfire areas and warning points. Over the years, the data provided by agencies grew to include some flood data and a range of other emergency management related datasets.

From NSAT to EM-LINK

The NSAT allowed emergency management agencies to access data feeds from neighbouring jurisdictions to provide visibility on current incidents and assess their potential threat. During incidents, data custodians are often involved in operational response, so it is difficult for other agencies to access specific datasets.

In 2017, at the request of Emergency Management Australia (EMA), Geoscience Australia translated NSAT from a static document that was manually updated once per year, into an online platform that allowed agencies to log in and maintain their data feed records and links in the system. This made the system much more current and allowed other agencies to access the restricted data easily in a range of formats to include in their own systems. The new catalogue was rebranded as EM-LINK.

Emergency management data in EM-LINK is catalogued into themes including bushfire, flood, cyclone, biohazard, weather, earthquake, tsunami, volcano and multi hazards. This has allowed users to see their neighbour's incident feeds for a shared situational awareness, facilitating informed and consistent decisions based on the same authoritative data. Users are able to subscribe to themes to be notified of new data becoming available. The spatial feeds are presented in a logical and searchable manner. Each hazard type has a page and the web services available are grouped by state or jurisdiction. Additional supporting spatial data is provided which includes base maps, exposure information and links to tools and open data sites.

How EM-LINK assists emergency managers

Emergency management jurisdictional data contacts are usually operationally focused during times of emergency. EM-LINK has freed up internal resources to focus on operations, while other agencies can discover and self-serve data from their neighbours without delay. Accessing each state's operational data can enable a consistent national picture and allows agencies to maintain situational awareness and plan cohesive cross-border strategies. This also stops duplication of effort in mapping fire boundaries and avoids problems of timeliness and data quality. Mappers are able to access the most current and accurate data easily, even if it has been captured by another jurisdiction. Importantly, each feed is well described with metadata that explains the usage, currency and update frequency of the data, as well as the custodian and any access constraints.

During the bushfires of 2019–20, Geoscience Australia worked with states and territories to create a data aggregator that took feeds hosted in EM-LINK and compiled them into a national feed for bushfire boundaries. However, EM-LINK did not contain a feed for every jurisdiction. Some simply did not have the capability to host web services of their fire boundaries. A great deal of hasty and after-hours work was undertaken by Geoscience Australia and emergency management staff to serve data for the national feed. This work was manual, unsustainable and imposed on states already overwhelmed by bushfire response operations.

Access to EM-LINK

The national bushfire boundary feed was consumed by all levels of government. Requests for access increased markedly and EM-LINK was no longer only accessed by state and federal agencies, but was opened to non-government organisations, industry, researchers and the media. The appetite for the data has been voracious. During the 2019–20 fire season, there were 1.78 million feature requests. Interest has come from sectors that have not previously shown an interest in emergency response information.

Currently, there are about 140 emergency management-related web service profiles. There are also approximately 650 active subscribers from state and territory governments, industry, education and not-for-profit agencies. The national bushfire boundary feed was kept open for approximately 6 months after the major fires were extinguished to aid recovery agencies. However, due to the unsustainable nature of the product, in July 2020 the hosting via EMSINA's ESRI-sponsored ArcGIS online account ceased. The data and coding was handed over to the National Bushfire Recovery Agency as the Australian Government agency with the biggest interest in hosting a national feed into the future at the time. Geoscience Australia is currently responsible for delivering the national bushfire boundary feed and is working collaboratively with EMSINA and Australian Research Data Commons.

The future of EM-LINK

Even though data feed owners can log into EM-LINK directly to maintain the currency of their data feeds, this is a manual task and requires a human to audit feeds that are 'broken' or have been modified. Future iterations of EM-LINK will be hosted on a modern spatial platform and limit the need for manual updates by 'scraping' the metadata of each feed as it is hosted by the originating agency. The National Metadata working group is nearing completion of metadata standards and a tool accessed via the EMSINA website will allow agencies to create compliant metadata for their feeds. When the feed or the metadata changes in the authoritative agency source, EM-LINK will reflect these updates. There are challenges in bringing together national datasets to be used in Australian Government and state COPs and web mapping systems. These include differences in metadata, standards, attribution, accessibility and licensing across each jurisdiction. The 2019–20 bushfires highlighted some of these issues at state boundaries in how data was displayed and shared between states across different platforms.

Currently, EMSINA is working with EMA to identify and prioritise where funding may be targeted to allow all jurisdictions to provide near real-time feeds for the major incident types. EMSINA, Geoscience Australia and the Australian Research Data Commons are collaborating on a project to build an ongoing and sustainable national bushfire history capability. The first step in the roadmap is the national bushfire boundaries, both those active now and what has been affected by fire this season to date. A capability gap analysis was completed with state jurisdictions in 2020 and is being updated. Work packages are being built and prioritised for funding which aims to bring jurisdictional and Australian Government data sources to a consistent level. This would enable the creation of a national minimum viable product which can be continuously improved with further investment over time.

Endnote

1. EM-LINK is a catalogue of national emergency management spatial web services providing a comprehensive and current listing of authoritative emergency management related geospatial web services for a chosen hazard or region. It was built as a joint initiative between Emergency Management Australia, Geoscience Australia and the Emergency Management Spatial Information Network Australia.

An archetypal perspective on delaying evacuation

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Emergency services organisations have struggled to convince people confronted by a bushfire that leaving well in advance of the threat is the safest response.[1] Since Black Saturday, the message that leaving is the safest option[2,3] and that delay is potentially fatal[4,5] has been increasingly highlighted. However, many people at risk from bushfire delay or intend to delay protective action.[6]

The Country Fire Authority (CFA) post-season data shows an unweighted average (2018–21) of 45.4% of respondents intending to delay to:

- do as much as possible to protect their property but leave when they feel threatened (24.8%)
- wait to see what the fire is like before deciding whether to stay or leave (12.9%)
- wait for police, fire, or emergency services to give them advice and direction (7.7%).

Our systematic review of the literature identified 6 reasons why people delay protective decisions in bushfires including purposive processes reflecting archetypal attitudes and response to bushfire.[7,8]

Archetypes

An archetype is a typical example of a particular kind of person because they have all their most important characteristics[9] and is representative of a group. The archetypes present an array of perceptions and behaviours in relation to bushfire that have been previously identified in the literature. Applying an archetype lens allows a holistic assessment of factors that influence delay. Factors include risk and stakeholder perception, perception of the effectiveness of defending or leaving, bushfire experience and self-reliance.

Method

The 2021 CFA post-season survey provided the data. It was a telephone survey of 900 randomly selected residents of extreme (VFRR) bushfire-prone areas in Victoria. A K-means cluster procedure[10] of IBM-SPSS[11] identified 7 archetypal groupings. Explanatory discriminant function analysis was used to demonstrate the validity of the clusters.[10] Table 1 summarises the archetypes intended response to bushfire.

Findings and discussion

Each of the 7 archetypal groupings was consistent with previously identified archetypes based on people who had recently experienced bushfire.[12] New insights were gleaned from those living in 'extreme' bushfire-prone areas who had not necessarily experienced bushfire. Given what we know about the archetypes, we can examine the reasons for their delay with greater focus and detail. We can interpret the reasons for delay. We ask: What does it mean for this archetype to: 'Do as much as possible to try and protect your property but leave if threatened by fire, or 'Wait to see what the fire is like…or 'Wait for police, fire or emergency services to tell you what to do…?'

The **Dependent Evacuator** is unable to carry out protective action on their own due to age, disability or lack of resources. They believe they lack bushfire knowledge and capability, as does their household, their neighbours and the media. They are reliant on the fire services, whose knowledge and expertise they rate extremely highly. Fifty-three per cent of Dependent Evacuators delay their protective response to prepare their property so it can survive in their absence (53.1%) and assess the fire (25%) so they know help is required and wait for assistance (21.9%). Delay results from organising themselves and preparing property to leave, ensuring it is necessary to leave in recognition of the effort and dislocation involved and contacting and waiting for someone to assist them.

Many people at risk from bushfire delay or intend to delay protective action.

Image: Charles Connelly, CFA

Responsibility Deniers believe that they should not be expected to take responsibility during a bushfire and believe the emergency services are responsible to protect them and their property. They respect the knowledge and advice of the authorities and expect to be directed or guided by them. Fifty-one per cent of Responsibility Deniers delay leaving, expecting that the fire authorities will deal with the problem. They delay until they feel threatened by the bushfire (53.7%) to assess the fire threat (23.1%) or for the emergency services to tell them what to do (23.2%). They recognise they need to respond to the threat only when it becomes imminent and they realise that the emergency services are not coming, or when the emergency services arrive and direct them to leave.

The **Threat Denier** believes there is no threat from bushfire and no likely impact on their property and consequently to themselves. They believe no protective action is required[13] so, from their perspective, there is no delay. Fifty-eight per cent intend to delay their protective response, taking minimal actions around their property expecting there will be no threat (54.7%). They wait and see how the fire develops, expecting it will not pose a danger (26.7%) and expecting emergency services to assist but believing they will not need to turn up (18.6%).

The **Community Guided** interact with their networks including neighbours, members of their local bushfire group or influential others such as brigade members, to get information, discuss options and come to a shared view about the most appropriate response to the bushfire threat. They see these trusted sources as knowledgeable, informed and able to advise them about bushfire. They assess, share and act on these inputs as part of their process of cooperatively taking responsibility and deciding on an appropriate protective action. Thirty-seven per cent intend to delay their action, including 70% who cooperatively monitor, discuss, prepare and coordinate a community response until there is a mutual perception of a need to act. Twenty-three per cent jointly assess the fire. These processes take time and delays protective action.

Worried Waverers want to remain and defend. They extensively prepare their property and equip and train for bushfire fighting. But they believe their lack of experience leaves them highly vulnerable to failure. They worry that they will be unable to protect their home from destruction and themselves from injury or even death. They believe that others around them, including emergency services personnel, lack capability and are ill-prepared for bushfire and that they will not receive official warnings or assistance. They feel they are on their own and lack adequate knowledge, information and advice about bushfire. They waver between a determination to stay and use their knowledge and equipment to save their property and leaving to protect their personal safety. They are unable to select between these 2 highly valued outcomes and decisional delay[14] results. Fifty-seven per cent delay their protective action to prepare to defend their property until they perceive the threat exceeding their preparation and capacity (53.6%), to assess the fire threat (39.3%) against their capability, or to get advice from the emergency services to resolve their uncertainty (7.1%).

Table 1: Intended protective action in bushfire

Intended protective actions during bushfire.		Archetype EI	RD	WW	CE	DE	CG	TD	Total
Stay and try and protect your property throughout the fire	Count	62_{a}*	6_{b}	8_{c}	$12_{b,c}$	$3_{b,c}$	$5_{b,c}$	$13_{b,c}$	**109**
	Expected Count	12.2	25.0	6.6	21.4	8.1	18.3	17.5	**109.0**
	% within Archetype	68.1%	3.2%	16.3%	7.5%	5.0%	3.7%	10.0%	**13.4%**
	Adjusted Residual	16.2	-4.7	0.6	-2.4	-2.0	-3.7	-1.3	
Do as much as possible to try to protect your property but leave if threatened by the fire	Count	10_{a}	51_{b}	$15_{a,b}$	49_{b}	$17_{a,b}$	$36_{a,b}$	41_{b}	**219**
	Expected Count	24.6	50.2	13.2	42.9	16.2	36.7	35.1	**219.0**
	% within Archetype	11.0%	27.4%	30.6%	30.8%	28.3%	26.5%	31.5%	**27.0%**
	Adjusted Residual	-3.7	0.1	0.6	1.2	0.2	-0.2	1.3	
Wait to see what the fire is like before deciding whether to stay and defend or leave	Count	16_{a}	22_{a}	11_{a}	22_{a}	8_{a}	12_{a}	20_{a}	**111**
	Expected Count	12.5	25.5	6.7	21.8	8.2	18.6	17.8	**111.0**
	% within Archetype	17.6%	11.8%	22.4%	13.8%	13.3%	8.8%	15.4%	**13.7%**
	Adjusted Residual	1.1	-0.8	1.8	0.1	-0.1	-1.8	0.6	
Wait for police, fire or emergency services to tell you what to do on the day	Count	$2_{a,b}$	22_{b}	$2_{a,b}$	$7_{a,b}$	$7_{a,b}$	3_{a}	$14_{a,b}$	**57**
	Expected Count	6.4	13.1	3.4	11.2	4.2	9.6	9.1	**57.0**
	% within Archetype	2.2%	11.8%	4.1%	4.4%	11.7%	2.2%	10.8%	**7.0%**
	Adjusted Residual	-1.9	2.9	-0.8	-1.4	1.5	-2.4	1.8	
Leave as soon as you know that there is a fire threatening your town or suburb	Count	0_{a}	71_{b}	10_{b}	58_{b}	23_{b}	57_{b}	37_{b}	**256**
	Expected Count	28.7	58.7	15.5	50.2	18.9	42.9	41.0	**256.0**
	% within Cluster Number of Case	0.0%	38.2%	20.4%	36.5%	38.3%	41.9%	28.5%	**31.6%**
	Adjusted Residual	-6.9	2.2	-1.7	1.5	1.2	2.8	-0.8	
You would not be home because you intend to leave on days of high fire danger	Count	1_{a}	$14_{a,b}$	$3_{a,b}$	$11_{a,b}$	$2_{a,b}$	23_{b}	5_{a}	**59**
	Expected Count	6.6	13.5	3.6	11.6	4.4	9.9	9.5	**59.0**
	% within Archetype	1.1%	7.5%	6.1%	6.9%	3.3%	16.9%	3.8%	**7.3%**
	Adjusted Residual	-2.4	0.2	-0.3	-0.2	-1.2	4.7	-1.6	
Total	**Count**	**91**	**186**	**49**	**159**	**60**	**136**	**130**	**811**
	Expected Count	**91.0**	**186.0**	**49.0**	**159.0**	**60.0**	**136.0**	**130.0**	**811.0**
	% of Total	**11.2%**	**22.9%**	**6.0%**	**19.6%**	**7.4%**	**16.8%**	**16.0%**	**100.0%**

*Each subscript letter denotes a subset of Cluster Number of Case categories whose column proportions do not differ significantly from each other at the .05 level.

Archetype Key:
DE=Dependent Evacuator, **RD**=Responsibility Deniers, **TD**=Threat Deniers, **CG**=Community Guided, **WW**=Worried Waverers, **CE**=Considered Evacuators, **EI**=Experienced Independents

Considered Evacuators intend to leave as soon as they are aware of a potential threat, well in advance of the bushfire, as the best way to protect their personal safety, which is a high priority over protecting their property. They characteristically plan and prepare in advance, including pre-packing evacuation bags, organising valuables and memorabilia, arranging pet transport and identifying safe escape routes. But the implementation of their plan may contribute to delay. Their plan may include monitoring information and warnings, gathering belongings and pets and preparing property for survival in their absence. Forty-nine per cent intend to delay, primarily as a result of pre-evacuation activities (62.8%), while assessing the fire threat (28.2%) or waiting for emergency services advice as part of their plan (9%). Feeling well-organised and needing to follow their plan may undermine a timely departure. Implementing the plan, including monitoring the fire, final actions to protect property and assessing the safety of evacuation routes, may delay leaving.

Experienced Independents are committed to property defence. They extensively prepare and equip. They have previous bushfire fighting experience and believe that they can succeed. But they recognise defence may fail due to the intensity of the bushfire, failure of equipment or the sudden incapacity or injury of the defender(s). They typically reassess risk and adjust their defensive strategy if the threat to personal safety becomes too great. Time spent in a failed defence represents delay for the Experienced Independent. Thirty-one per cent intend to delay primarily to assess the extent of the danger posed by the fire (57.1%) and to defend until the threat is too great (35.7%). Delay occurs through the Experienced Independent's recognition that property defence could fail.

Implications

By applying an archetypal lens to the question of protective action delay, diffuse and seemingly unconnected factors, many of which are reported in the literature, can be drawn into a comprehensive and holistic picture of individual behaviour and response in bushfire.

Recognising the diversity of archetypal attitudes and responses in bushfire and delay as part of a process of purposive prioritising of action rather than indecisiveness, emergency services can better understand their audience and reimagine and adapt bushfire safety policy and programs. The objective should be to better meet the diverse needs of people at risk from bushfire, so their actions and decision-making enhances their safety, the safety of their household and of their community. Using an archetype lens can also improve policy and programs by:

- clarifying for whom, in what circumstances, in what respects and how a program could be designed to most effectively meet the needs of the audience
- targeting programs at specific audiences
- tailoring the communication and delivery of programs to more effectively address the needs of identified audiences
- clarifying and refining program objectives, and the outcomes that are expected.

Programs based on the archetypes need to be developed, implemented and evaluated. The CFA has started to integrate this research into its community safety approaches.[15] Further research to refine and extend the archetypes is also required.

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Mental health and wellbeing in young adult fire and emergency service volunteers

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In Australia and New Zealand, fire and emergency services organisations call on volunteers to protect local communities. To ensure the viability of these essential resources, it is crucial to involve volunteers in roles that can be sustained.

In recent years, increased attention has been given to mental health and wellbeing for fire and emergency services volunteers, which is an essential element of retention and sustainable engagement. A 2018 study in Australia showed that over half of volunteer fire and emergency services personnel are aged over 55 years.[1]

It is, therefore, necessary to understand how to attract younger volunteers and how to improve and support the wellbeing of the voluntary workforce. Despite this, to date, there remains a paucity of research, information and practice guidelines on optimal support mechanisms specifically aimed at younger volunteers.

The Positive Mental Health in Young Emergency Service Volunteers research project aimed to understand factors associated with the mental health and wellbeing of young adult volunteers (aged 16–25 years) in fire and emergency services organisations. The project would provide information on mental health outcomes and psychological skills associated with those outcomes. A further aim was to translate results into a wellbeing framework that was applicable and feasible to be implemented across the sector with resources relevant to a young adult cohort.

The project commenced with a rapid systematic review of international literature on the mental health and wellbeing experiences of young adult fire and emergency services personnel. This was accompanied by analysis of data from 'Answering the Call'[1], a 2017 Beyond Blue national mental health and wellbeing survey of police and emergency services. The analysis considered participant volunteers aged between 18 and 25 years as well as data from young adult firefighters aged between 18 and 25 years from the 2016 South Australian Metropolitan Fire Service Health and Wellbeing study.[2]

To develop an understanding of recent mental health experiences and support needs, an online survey was conducted with current young fire and emergency services volunteers (n=192). This quantitative survey investigated mental health related outcomes, volunteer role experiences (including during the 2019–20 bushfire season) along with the perceived availability and usefulness of support services.

Leadership perspectives were provided through one-on-one semi-structured interviews (n=12) with senior leadership personnel from 12 agencies across Australian state and territory jurisdictions as well as a focus group comprising fire unit leaders and brigade captains. Perspectives on mental health needs, including facilitators and barriers to accessing available supports, were sought from young adult fire and emergency services personnel (n=20). This was achieved via a series of 6 focus groups with representation from all states and territories. Full details of study methodology are available in the final report.[3]

Study outputs

Following the phases of data collection, a knowledge synthesis was undertaken to integrate findings across phases. Results from each phase were tabled collectively to identify converging

Example pages from the Care4Guide.

threads, linking findings across multiple research phases, representing a synthesised understanding of risk, protective and modifiable factors involved in young volunteer mental health and wellbeing. The knowledge synthesis resulted in 3 outputs:

- The Young Volunteer Wellbeing Framework is intended as a best-practice guide for agencies to support practices already in place or provide options to shift practices to promote and maintain the mental health of young volunteers.
- An Agency Implementation Guide to be used to implement the Young Volunteer Wellbeing Framework with indicators intended as examples of possible practices organisations may implement with their own actions to meet relevant goals within the framework.
- Care4Guide to mental health for young fire and emergency service volunteers provides information and tips for volunteers to facilitate positive mental health skills, identify support pathways to promote connections and social support and ways identify and access mental health supports.

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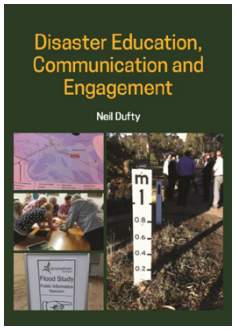
Disaster Education, Communication and Engagement



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The title of the book could quite reasonably be extended to read—or how to go beyond just putting information and templates on my agency website'.

In his introduction, author Neil Dufty describes his book as offering '…a bridge between academic theory and research, and disaster learning practice' intended to enable '…practitioners to prepare effective disaster learning plans, programs and activities'. With its linking of education, communication and engagement as central to effective community-based disaster risk reduction, the book is a very welcome addition to the quite limited material available about how to develop and implement effective community-focused safety programs.

In my opinion, the book will be of particular value to 2 readerships coming new to the field of community engagement within emergency management agencies and related organisations. Those with a background in community development or adult education, and those with a background in emergency planning and response. For the former, Part I provides a comprehensive primer covering the important definitions, topics, issues and concepts that constitute the world of emergency management. For the latter, Part II provides a very accessible account of how to think about, and go about, providing effective programs at local levels to raise resident preparedness for disaster events.

This is not to say that only half the book will be useful to each readership! For those with an operational background, Part I emphasises the social dimensions of disaster vulnerabilities, the importance of working at the local level and the limited effectiveness of a top-down command-and control approach to the community engagement and education endeavour. For those with a background in community development or adult education, Part II is replete with 'how to' ways of going about communicating and engaging at local levels to address both risk awareness deficits and awareness—preparation gaps.

Turning to specifics, I think that the account in Chapter 4 of applying a program logic-model approach to disaster education programs is very useful. The introduction to the rather contested concept of disaster resilience in Chapters 5 and 10 is refreshingly concise. The framework for tailoring disaster education, communication and engagement programs suggested in Chapter 6 provides a helpful way to organise thinking about the complexities likely to bedevil developing a collaborative program in a particular location with its unique issues.

The typology of education, communication and engagement methods presented in Chapter 9 I found quite inspirational. Apart from the 2 readerships I have mentioned, the book is well-suited to be a text or a reference for advanced undergraduate and postgraduate courses in emergency management and natural hazard risk mitigation. Although such courses seem to be rather sparse on the Australian higher education scene, at least in comparison with North America, the UK and Europe. For any second edition, I suggest that it include an author index and a database of illustrative reports about education, communication and engagement programs that have been implemented in Australia

The world-weary cynic, which I have become, cannot conclude without a statement of the bleeding obvious: disaster education, communication and engagement programs such as those advocated in this book will only make a meaningful difference to community safety (in a world of global warming and increased danger from natural hazards) if they are adequately funded and resourced by all levels of government.

Focusing post-disaster research methodology: reflecting on 50 years of post-disaster research

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Abstract

The 50th anniversary of cyclone Althea at Christmastime this year, 2021, prompts a reflection of a corresponding 50 years of post-disaster research by the Centre for Disaster Studies at James Cook University. Importantly, this reflection is on what is achieved through rapid-appraisal studies immediately following a disaster. This paper builds on earlier research into the methods and types of post-disaster surveys; taking into account new technology and the emergent issue of climate change. The paper identifies general findings and issues that have been uncovered through post-disaster surveys. What is seen is a continuity of the effects of disasters across decades and across events. Thus, it is important to interview people in affected communities for debriefing and also to enhance communication, education and awareness. Survey methods across a range of disasters during the last 2 decades are reviewed to identify research and survey approaches. The methods and approaches of post-disaster surveys should be driven by community needs and characteristics and surveys must propose focused research questions and purpose to be effective and contribute to better practice.

Introduction: remembering Althea

James Cook University was founded in 1970 and its researchers within the disciplines of engineering and geography have focused on hazard and disaster research. In 1971, Townsville was devastated by Cyclone Althea and December 2021 will mark the 50th anniversary of that disaster event. It provides an opportunity to record cyclone affects as part of hazard awareness and preparedness campaigns. Cyclone Althea was followed 3 years later by the destruction of Darwin by Cyclone Tracy. This major event in Australia's history of disasters generated the research findings that led to cyclone-resistant buildings that are safer as well as increased awareness in Australia through the communication of cyclone research.

Other researchers within James Cook University have participated in disaster research. This year, the diversity of the university's disaster researchers will be grouped under a new 'umbrella' multi-disciplinary collaborative research centre with over 100 members, called the Centre for Disaster Solutions. Both the current Centre for Disaster Studies (CDS) and the Cyclone Testing Station (CTS) are expected to retain their identities within this larger centre, not least due to their legacy of knowledge, established reputation and practical experience. A significant part of that legacy has been the capacity to carry out direct and valuable research during and immediately after disaster events.

Both the CDS and the CTS were established with objectives to undertake rapid-response post-disaster studies, including fieldwork observation and measurement of impacts. Consistent with standard emergency management practice, observation, documentation and analysis of lessons identified from disaster events enables adaptation and the development of relevant policy recommendations. Both the CDS and the CTS have made significant contributions to this process. Research and reports generated over the decades

have added to the depth of evaluation of environmental, societal and structural preparation and response to natural hazards.

This article reflects on the post-disaster experience of the CDS and its colleagues in the social and physical sciences. After more than 50 years of this research at James Cook University, it is appropriate to reflect on the history of rapid-response studies to examine disaster effects and methods of research.

A history of research

Table 1 provides a list of known rapid-appraisal studies undertaken by CDS researchers and allied disciplines at James Cook University following specific disaster events.

The research from major disasters in the early- and mid-1970s reflects the work of both engineers and geographers. After the formalisation of the CTS in 1977, separate engineering, structural impact assessments and wind-load reports were produced and are published on the university's website.[1] The studies listed in Table 1 were carried out in the days and weeks immediately following a disaster. Most of the studies are recorded in research reports that were provided to emergency managers and stakeholders at debriefing meetings. Some studies formed part of higher-degree research and are contained within theses. Many of the immediate post-disaster studies have been incorporated into academic journal articles and book chapters, often analysed in conjunction with other disasters and related to other literature (Oliver 1980). Given that most early studies only exist in hard copy format, Table 1 lists studies that can be tracked down and a publication identified. Most of the paper-based publications and associated grey literature developed before the 1990s is held by the CDS and James Cook University library.[2]

Severe Tropical Cyclone Althea devastated parts of North Queensland just before Christmas 1971 and was one of the strongest storms ever to affect the Townsville area.

Image: courtesy David Whitehouse and the Cyclone Testing Station

While the CDS and affiliated researchers have become increasingly constrained by time and funding, they have been less restricted by issues of research access and lengthy approval processes that government organisations often face. To enable rapid-response research and surveys after an event, the CDS maintains human ethics approval covering the conduct of post-disaster studies (renewed every 3 years) to carry out surveys. Any person undertaking this kind of fieldwork follows clear protocols and is trained and mentored by a researcher with relevant experience, including regular debriefing. A significant ethical emphasis is on the avoidance of stress and trauma for respondents. Consistent with the literature (Elmir *et al.* 2011, Oliver-Smith 1996), the conduct of surveys and interviews after a disaster has invariably been associated with catharsis providing people an opportunity to tell their story. In some circumstances the research may become, or may benefit from, participatory methods. Gibbs and co-authors (2018) discuss participatory research in bushfire-affected communities. If researchers are working in their local communities or identify issues or processes that are core to their applied research participation within the community they may be extremely effective in bringing about change or enhanced recovery. However, this research brings more stringent ethical demands and may be difficult to organise in the short period of a post-disaster study.

To ensure the value, relevance and appropriateness of any study undertaken, CDS researchers collaborate with relevant agencies and organisations to develop research instruments and questions. The aim of the CDS has been to provide practical knowledge and a better understanding of issues related to the needs of stakeholders.

Post-disaster findings

An analysis of post-disaster studies up to the early 2000s (King 2002) was commissioned by Emergency Management Australia to conduct an evaluation of post-disaster studies and methods. The study identified 7 groups of affects and issues including:

- the unequal distribution of the impact, both spatially and socially
- loss of services during the event
- lack of expectation and anticipation of the effects
- late or minimal preparation
- post-event community and neighbourhood response
- confusion concerning warnings and information in the media
- community coping capacity and resilience.

Subsequent studies reflect and repeat these themes. Significant numbers of post-bushfire surveys carried out under the auspices of the Bushfire Cooperative Research Centre and, later, the Bushfire and Natural Hazards Cooperative Research Centre affirm similar themes concerning awareness, preparedness, attitudes and knowledge and actions, especially concerning

1. James Cook University Cyclone Testing Station webpages at: www.jcu.edu.au/cyclone-testing-station.
2. Reports are available on the CDS website at: www.jcu.edu.au/centre-for-disaster-studies/about. Many pre-1990s reports are available on request from the CDS.

Table 1: Post-disaster studies in which the Centre for Disaster Studies and its colleagues participated.

Year	Disaster	Place	Key researcher	Institution/ Publication series	Research method*
1970	Cyclone Ada	Whitsundays, Qld	Trollope & Oliver	CTS	Eng. ES
1971	Cyclone Althea	Townsville, Qld	JCU/Hopley/Oliver	CTS, CDS	Eng. ES
1974	Cyclone Pam	North Queensland	Hopley & Harvey	JCU Geography Department	ES
1974	Cyclone Zoe	North Queensland	Hopley & Harvey	JCU Geography Department	ES
1974	Cyclone Wanda	North Queensland	Hopley & Harvey	JCU Geography Department	ES
1975	Cyclone Tracy	Darwin, NT	JCU/Walker & Trollope	CTS, CDS	Eng ES
1979	Cyclone Kerry	Mackay, Qld	Oliver & Walker	DIR	Eng ES
1979	Cyclone Peter	Cairns, Qld	Volker, Reser & Innes	DIR	Quant Qual
1981	Hurricane Allen	Caribbean	Oliver & Trollope	DIR	Eng ES
1982	Cyclone Isaac	Tonga	Oliver & Reardon	DIR	Eng ES
1982	Cyclone Max	Darwin, NT	Britton	DIR	Qual
1982	Bushfires	Tasmania	Britton	DIR	Qual
1983	Ash Wednesday Bushfires	Victoria	Britton & Oliver	DIR	Qual ES
1986	Cyclone Winifred	North Queensland	Oliver	?	ES
1989	Cyclone Aivu	Burdekin Shire, Qld	Butterworth *et al.*	BH, JCU	Quant Qual
1990	Cyclone Winifred	North Queensland	Butterworth	DIR	Quant Qual
1988	Floods	Clarence River, NSW	Britton	CDS	Quant Qual
1992	Cyclones Mark & Betsy	North Queensland	Sofield	JCU Tourism Department	Qual
1997	Cyclone Gillian	Townsville, QlD	King	CDS	Qual
1997	Flood	Cloncurry, Qld	King & Goudie	CDS	Qual
1997	Cyclone Justin	Cairns, Mareeba and Innisfail, Qld	King	CDS	Qual
1998	Floods (Cyclone Syd)	Townsville, Qld	King *et al.*	CDS	Qual
1998	Floods	Gulf of Carpentaria, Qld	Berry	CDS	Qual
1999	Cyclone Rona	Cairns, Port Douglas Wujal Wujal and Mosman, Qld	Berry	CDS	Qual
2000	Cyclone Rosita	Broome, WA	Berry	CDS	Qual
2000	Cyclone Steve	Cairns, Qld	Berry	CDS	Qual
2001	Cyclone Abigail	Mornington Island, Qld	McLachlan	CDS	Qual
2002	Civil War	Sierra Leone	King	CDS	Qual
2002	Terrorism	Bali	Gurtner	CDS	Qual
2003	Cyclone Zoe	Tikopia, Solomon Islands	Berry	CDS/ UNOCHA	Quant Qual
2004/5	Tsunami	Phuket, Thailand	Gurtner Nott	CDS JCU	Qual
2005	Tsunami	Maldives	Shaig	CDS	Qual
2006	Cyclone Larry	Innisfail, Qld	Goudie/Glick	CDS	Quant Qual
2006	Cyclone Monica	Darwin, NT	King *et al.*	CDS	Qual
2007	Tsunami	Cairns and Townsville, Qld	King	CDS	Qual
2008	Floods	Mackay and Charleville, Qld	Apan *et al.*	NCCARF**	Quant Qual
2011	Floods	Brisbane, Qld	Bird *et al.*	NCCARF***	Quant Qual
2011	Floods	Emerald and Donald, Qld	Bird *et al.*	NCCARF***	Quant Qual

Year	Disaster	Place	Key researcher	Institution/ Publication series	Research method*
2011	Cyclone Yasi	Townsville, Cairns and Mission Beach, Qld	Vachette King & Nott	CDS JCU	Qual ES
2012	Tornado	Townsville, Qld	Cottrell *et al.*	CDS	Qual
2015	Cyclone Pam	Vanuatu	Vachette	CDS	Qual
2016	Cyclone Winston	Fiji	Miller	CDS	Qual
2017	Cyclone Debbie	Bowen, Airlie Beach and Proserpine, Qld	Gurtner & Vachette	CDS	Qual
2017	Cyclone Debbie	North-East Australia	Gurtner	CDS	Qual
2019	Monsoonal floods	Townsville, Qld	Gurtner	CDS	Qual
2020	COVID19 Pandemic	Australia	Gurtner	CDS	Qual

Notes:

DIR - Disaster Investigation Report series that is an early monograph series of the CDS

CDS - Centre for Disaster Studies Research report

BH - Behavioural Sciences, James Cook University

***Research Methods:**

Eng.=Engineering field measurements

ES=Earth Science and Physical Geography Field measurements

Quant=quantitative social science

Qual=qualitative social science including observation and non-parametric quantification

**NCCARF funded, University of Southern Queensland with CDS

***NCCARF funded, Risk Frontiers with CDS

decision-making around stay and defend or leave (McLennan, Paton & Beatson 2015; Whittaker *et al.* 2013; McLennan *et al.* 2013; McLennan & Elliott 2011; Whittaker & Handmer 2010). With digital technologies, scientific innovation and an expanded capacity for data collection and synthesis, warnings have become more complex over the past 2 decades. Increasing public access to the Internet, with the proliferation of web-based technologies, apps and social media has led to concerns from emergency managers about the wide and relatively unchecked dissemination of conflicting, misleading or inaccurate information. Despite such concerns, an online survey of over 4,000 community members conducted by the CDS following Cyclone Debbie in 2017, found that most people made decisions based on information provided by informal and official 'trusted' information sources. Even with the evident limitations of web-based technologies (access to a compatible device, sufficient power, data download limits, technical competence, language capabilities) electronic media has the capacity to deliver timely, up-to-date and localised content better than traditional media. In contrast to previous generations, most people, particularly in highly populated areas of Australia, have access to numerous forecast and hazard maps, updates regarding local conditions and live videos.

Emergency management organisations have turned to web-based technologies and social media to expand public accessibility for warnings and information (Bird, Ling & Haynes 2012; Shan *et al.* 2019; Willems, Forbes & Simmons 2021). As trust, reliability and credibility is established, institutional websites such as the Bureau of Meteorology and local council-operated 'disaster dashboards' are regularly accessed and consulted. For the community, social media has proven to be a resource to share local information, advice and provides support. Over the past 2 decades, warnings and information have transformed in both their effectiveness and complexity.

Consistent with changes in priorities and focus at the international level, building community resilience and risk reduction has resulted in Australia's *National Strategy for Disaster Resilience* (Attorney-General's Department 2011). The strategy makes it a priority for emergency services organisations to move beyond response and recovery efforts towards public awareness and preparedness. This approach has enabled an exchange of support, resources and communication that empower communities to be involved in their own safety rather than relying on emergency services agencies and service providers. However, people and communities were always resilient. The observation from repeated post-disaster studies demonstrates that the level of inherent resilience has not changed, but there is better capacity to use and focus that resilience. Alongside this resilience of society is the need to enhance climate change adaptation.

Beyond the original 7 groups of disaster affects (King 2002) there are emergent issues of social media and information technology and climate change adaptation, although both are modifications of resilience and warnings, respectively. Further, there is increasing recognition of the effects of hazard evacuations. Extensive short-term evacuations, displacements and relocations have taken place before and after events such as the Cyclone Yasi and the Queensland floods in 2011 and the monsoonal floods in Townsville in 2019.

Post-disaster studies are aimed at capturing local experiences and informing emergency managers of shortcomings, successes and improvements that might be made to education, awareness campaigns, preparation and protection, warnings, uptake of messages, evacuation, shelter and management policy.

Researchers also gain insight into emergency management performance and processes and can bring experiences to other agencies outside emergency management, such as areas of planning (King *et al.* 2016), social welfare (Quinell 1977), psychology and health (Zotti *et al.* 2013) and the roles played by allied professionals. The value of this research output is strongly determined by the purpose and research instrument employed.

Methods of post-disaster studies

Direct involvement in disasters is a powerful experience that informs and structures an understanding of the event. However, it can be subjective and must be guided by strong purpose, objectives and replicable methods. At the same time, researchers are in a relationship with stakeholders and partner organisations that have priorities and needs (King 2002). Methods employed in post-disaster studies must be objective, especially because of the subjective milieu of widespread destruction and trauma.

Tierney (2019) reviewed an extensive number of post-disaster studies, many of which were also identified in King's (2002) post-disaster review that analysed 130 studies from a number of countries and research funding schemes. The review identified types of hazards that had been studied and the global regions covered. There were different approaches and methods, partly influenced by the disciplinary background of the researchers. Research methods employed in these 130 studies mostly fell into 6 categories:

- case studies
- interviews and focus groups
- use of secondary sources
- post trauma studies
- observations
- economic analyses.

The choice of research methods is influenced by the disciplinary background of the researcher and also by the familiarity of the researcher with the disaster location and regular involvement and experience in assessing the effects of disasters. There are studies where the researcher is visiting the disaster-affected community for the first time or is working in an unfamiliar or new location. Emphasis in this context is placed on sampling and the representative nature of the survey to support and justify findings. This is especially important as part of a needs assessment or when using a survey to ascertain what has happened. Post-disaster studies conducted by researchers at the CDS have varied extensively according to the disciplinary background of the researcher, ranging from scientific field measurements carried out by physical geographers and environmental scientists to quantitative and qualitative surveys conducted by social scientists.

On the other hand, researchers who regularly carry out post-disaster studies or who are working in their community are broadly aware of what has happened and do not need to use a survey to measure every detail but focus on issues and processes. Researchers have moved into disaster studies from previous careers in developing countries and were familiar with Rapid Rural Appraisal methods. There is a contrast between statistically representative samples of affected population and of rapid appraisal of emergent issues to contribute promptly to debriefing and lessons learnt.

Henderson and co-authors (2009) analysed surveys carried out in New Orleans after Hurricane Katrina. Most of these studies employed strict quantitative methods with rigid attention paid to sampling of the population. The surveys used a range of methods: census-type surveys, stratified random samples, convenience sampling (surveys carried out at centres and institutions such as evacuation centres) and purposive sampling to target minority and ethnic groups using organisations such as churches and welfare agencies. The surveys employed face-to-face, drop-off and pickup and telephones, both landline and mobiles. Henderson and co-authors (2009) recommended the importance of following strict social science quantitative methods that address sampling error coverage. However, they also recommended a sampling approach that relates to the purpose of the survey.

Whittaker and Handmer (2010) examined 9 post-disaster studies that were presented to the Victorian Bushfires Royal Commission following the Black Saturday bushfires in 2009. This analysis pointed to issues of awareness and understanding, decisions about stay or go and actions during the fire. They summarised a variety of methods, noting differences in studies that derived from the aims of the research. These varied according to the emphasis, for example, whether the survey recorded actual experiences of survivors or people's attitudes and awareness towards a hazard. Some studies were quantitative, some were qualitative and they consequently employed different sampling approaches including random, opportunistic, household face-to-face and telephone (Whittaker & Handmer 2010).

Steinfort (2017) stressed the need to employ a strong research method and the education and training of researchers. Zotti and co-authors (2013) reviewed an extensive literature of post-disaster studies relating to health perspectives, which stressed the need for consistency of research instruments. Lindell's (2013) assessment of post-disaster studies underlined the importance of consistency across survey instruments to improve comparisons. Lindell's (2013) analysis of disaster-impact models identified differences in research methods according to both the emergency management phases and zones of distance from the primary impact; derived from Dynes (1970). CDS climate change adaptation research that reviewed specific past disaster events (Boon *et al.* 2012) adapted Bronfenbrenner's social- ecological systems as a structure of support networks for individuals and communities. Any disaster is multi-dimensional in time and space.

Although not yet post-disaster studies, researchers have attempted to analyse effects and challenges of the COVID-19 pandemic. Pandemic studies illustrate the use of a range of mixed-methods social science surveys. Botton, Hoffmann and Vera-Cossio (2020) carried out extensive household surveys in developing countries. Dietrich and colleagues (2020) studied household economic effects of the pandemic and Hensher and Beck (2020) analysed travel during the early lockdowns in

Australia. A CDS survey constructed by Gurtner (Gurtner & King 2021) was an online survey of early consequences and knowledge of the pandemic and preparedness for it at the household level. Li and co-authors (2020) analysed COVID awareness categorised by demographic characteristics and Internet use.

Since 2010, research methods have expanded to the use of the Internet and social media as new approaches for data collection. Online research is relatively cheap to conduct and, as shown during pandemic lockdowns, use has increased of the Internet and social media platforms for communication and interaction. As Bird, Ling and Haynes (2012) illustrate from the Queensland 2010–11 floods, the use of social media both for researchers and communities emerged as a powerful tool. They also suggest that social media will not replace conventional survey methods or means of communication but will provide supplementary support and information.

Beyond the use of social media to recruit survey respondents, it also provides a rich source of secondary data of societal attitudes, issues and priorities. Jamali and co-authors (2019) used social media in a case study of Hurricane Sandy. Shan and co-authors (2019) reported use of the Chinese version of Twitter, Weibo, to carry out rapid-damage appraisal after a disaster. They accessed user information from multiple sources rather than contacting people as survey respondents.

Changing technology has transitioned from landline telephones to mobile phone use. Before 2000, CDS used telephone surveys as most households had conventional phones and users were listed in phone directories, as also attested to by Henderson and colleagues (2009) in the United States. The shift to mobile phone use has occurred in the last 15 years, but mobile numbers are not broadly available in directories that can generate random samples within geographical regions.

Building resilience to disaster encourages enhancement of social capital (Aldrich 2012), which may include participatory research where the researcher works actively within communities. This allows for information discovery and to transform that knowledge into action that achieves tangible outcomes of communication, awareness and planned behaviour as well as long-term recovery (Gibbs *et al.* 2018, Easthope 2018).

Observational assessments of damage (Adams, Levitan & Friedland 2014) use information technology and drones to record damage to structures. Drone photography has provided immediacy but is hampered by relatively short times in the air owing to battery constraints. Google Earth is a remarkable and recent database of the whole planet that has been used to establish systematic sampling frameworks to carry out post-disaster surveys.

Organisational websites such as the Bureau of Meteorology with its tracking maps, warnings and modelling of hazards and point-of-time casting is widely used during events and is accurate and widely available. Internet access has jumped from desktops in homes to personal availability on smart phones and mobile devices. Information, communication and networking have created widespread access and secondary information for researchers as demonstrated by Shan and co-authors (2019).

Forecasts in the future of more extreme weather events due to climate change, especially floods, drought, bushfire and heatwaves appear more likely (IPCC 2021). Not only are more extreme events expected in coming decades, but they will bring new and emerging issues, challenges and novel community

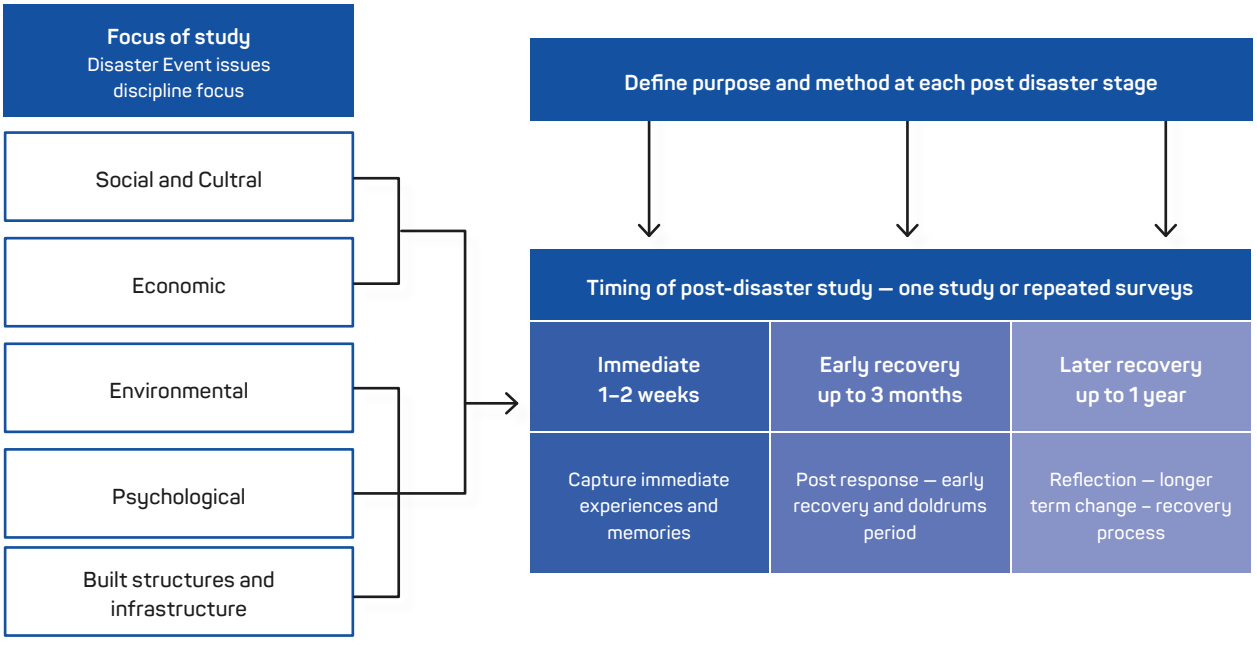

Figure 1: Post-impact assessment purpose and methodology.

Source: modified from Cottrell & King (2010)

approaches. It will remain important to survey communities after a disaster, using replicable and testable instruments, but equally it is important to use emerging technology and methods. Ideally, a mixed-method approach to post-disaster consequences may balance responses and information. Additionally, repeated surveys after many disasters also provides a longitudinal pattern of findings on behaviour and communication.

CDS researchers have used social-impact assessment methods over the last decades for its flexibility breadth and rapidity of delivery. Figure 1 is adapted from a social-impact assessment checklist (Cottrell & King 2010). It asks the question of what the research is attempting to find out. The emphasis is not on research methods (quantitative or qualitative) but on the research purpose. The intent of the research should guide the specific research questions, the survey instruments and type of delivery.

The purpose of post-disaster studies is more important than an evaluation of the representativeness of the sample. In the immediate post-disaster context there is rarely the time or resources to do extensive surveys. The post-disaster survey should focus on issues and processes that have a relevance to emergency management agencies in terms of warnings, preparation and education and also identify problems and experiences that were specific to the event.

Figure 1 summarises a question prompt list that requires definition of the purpose of the survey as each starting point. Only 2 criteria are used for illustration in this model; overall focus broken down into categories then structured into different time periods. The type of survey will vary according to the time that it is carried out after a disaster. The focus of the study shifts as communities move through different phases after the event. It is possible to add further dimensions of space–impact zones (Dynes 1970) and social ecological systems that support and configure individuals and communities.

Conclusion

This paper considered 50 years of post-disaster research at the CDS at James Cook University. Anniversaries of predictable natural events provide important opportunities for raising awareness, preparedness and education for future events. A long history of multi-hazard assessments provides its own longitudinal research outcomes. Each disaster contains elements of other disaster effects, sometimes in the same community but frequently affecting a new population and providing a comparison between places.

Post-disaster studies identify commonly recurring groups of affects. Some disaster issues can be addressed by changes in practice, but many will repeat with each event and need to be part of education of the community for safe preparation. This paper reviewed common types of research methods and changes that have responded to technology, but a significant theme in post-disaster studies and reviews of such studies is the importance of consistency, standardisation of survey instruments and the use of sound research techniques.

Of greatest significance is a clear purpose that defines a research question. In answering specific research questions, a mixed-methods approach is often a sound approach. Post-disaster studies usually do not have time or resources to blanket the whole community. Targeted, issue-defined questions provide useful outcomes that may contribute to changes in policy and practice. Findings from post-disaster studies have influenced codes, policies, legislation and emergency management generally. It is consequently important for researchers to work closely with emergency managers and response and recovery agencies. Post-disaster studies are not pure academic research, they must be of use to society and institutions

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Fighting to save an international icon – K'gari (Fraser Island)

Corinne Mulholland
Office of the Inspector-General of Emergency Management Queensland

Abstract

The Office of the Inspector-General of Emergency Management (IGEM) undertook a review into a bushfire event on K'gari (Fraser Island), Queensland in 2020 that attracted worldwide media attention. The review examined the preparedness and response to the bushfire to identify examples of good practice and opportunities for improvement. The fire started on 14 October 2020 as a result of an illegal campfire on the island. The bushfire burned for 8 weeks, burning over 50% of the island's vegetation. K'gari is the world's largest sand island and is a UNESCO World Heritage Listed site. It features pristine and ancient rainforest areas, sand dunes and lakes. It also presents challenges for traditional firefighting efforts due to the heavy canopies of forests and narrow and sandy 4WD tracks. The island is home to the traditional owners, the Butchulla people, who were part of the Incident Management Team and Incident Control Centre during the event. They provided advice and guidance on the use of fresh and salt water for waterbombing operations and the location of culturally significant sites. Their Land and Sea Rangers were also involved in the firefighting response. This paper summarises the report of the post-event review that was tabled in the Queensland Parliament on 27 May 2021.

Introduction

K'gari is the world's largest sand island, located along the Queensland coastline approximately 300 km north of Brisbane. The island was listed as a UNESCO World Heritage site in 1992. Today, over 90% of the island is designated as a national park and managed by Queensland Parks and Wildlife Service (QPWS). The island features a small number of freehold and leasehold areas including townships located at Orchid Beach, Eurong, Happy Valley and Kingfisher Bay. The majority of the island's 182 residential and commercial property owners do not live permanently on the island but visit intermittently or use their properties to operate holiday letting and tourism businesses. K'gari attracts over 300,000 visitors annually. Thus, there is an ongoing need to manage the important cultural and conservation values of K'gari with the increasing numbers of visitors.

This review (IGEM 2021) was of a vegetation fire that started on 14 October 2020. The fire was reported following an illegal campfire near Orange Creek, at the north-eastern side of the island. Fire authorities identified several factors contributing to the fire spreading quickly being high temperatures, strong and dry northerly winds, vegetation structures and types, difficult terrain and limited access via dry, loose sand tracks. During the subsequent 8-week firefighting response, the bushfire travelled from the north of the island southwards towards Kingfisher Bay. The fire posed a threat to townships, government buildings, significant cultural sites for the Butchulla people as well as tourist facilities including campgrounds at Cathedral Beach and the iconic Kingfisher Bay Resort and village. The fire burnt approximately 85,000 hectares (more than half the island) and, fortunately, there was no loss of life and no homes were damaged. Difficulties experienced by responding agencies included widespread mobile phone and internet blackspots, dry and flammable vegetation, inaccessible terrain and narrow sand tracks.

Inspector-General Alistair Dawson and staff from IGEM join Winston Williams and Scott Bell from Happy Valley Rural Fire Brigade and Russell Postle from Happy Valley Community Association to inspect affected areas.

Image: Corinne Mulholland

Conducting the review

The review focused on the preparedness and response aspects of the event. Bushfire hazard mitigation activities were considered given the significant effect these have on preparedness. In commencing the review, IGEM undertook the largest community engagement program in its 6-year history. This included targeted discussions with the Butchulla people including meeting with staff and board members of the Butchulla Aboriginal Corporation and co-designing and co-delivering a Butchulla People's Forum in Hervey Bay. It was important for the Butchulla People's Forum to be held on the mainland in recognition of the cultural, economic and financial barriers that many Butchulla people face in accessing the island. There was a strong desire from the Butchulla Aboriginal Corporation to increase the level of consultation and dialogue between QPWS, QFES and the corporation in relation to land and fire management on K'gari and in accordance with their Native Title Determination. The corporation also partnered with QPWS and other agencies to map areas of cultural significance to inform future bushfire mitigation and response activities on the island.

Five community and business forums were conducted, one each at Orchid Beach, Happy Valley, Kingfisher Bay, Urangan and Rainbow Beach with 147 attendees in total. IGEM also received and considered 78 written submissions from community, environmental, business and tourism representatives. Issues raised in submissions related to management of the island as a national park rather than a world heritage site, the maintenance of fire lines and breaks, frequency and scale of planned hazard reduction burns and wanting to see better integration of cultural burning practices on the island. Overwhelmingly, participants indicated they wanted to see state agencies work closer with the community and local businesses to plan and prepare for bushfires on the island and to undertake planning and hazard mitigation practices that align with K'gari's status as a world heritage site. Traditional owners, local community, business and tourism operators also wanted more communication from QPWS and QFES about decisions that may affect them before, during and after bushfire events.

IGEM convened a virtual forum of researchers and academics with specific interests in K'gari as part of the review's data-collection phase. The researchers noted a lack of cultural burning

undertaken on K'gari in recent years and acknowledged efforts to implement traditional fire practices with the Butchulla Aboriginal Corporation. They highlighted the important role of Butchulla QPWS rangers, as well as the Land and Sea Ranger program, and indicated that the cultural experience of these rangers should be integrated into the overall fire practices and management of the island.

Written submissions were also invited from all Queensland Government departments, agencies and interest groups across the emergency management, environment and land management sectors. IGEM also held face-to-face interviews and discussions with personnel from agencies relevant to the review including first responders, incident controllers, park rangers, senior officials from QPWS and QFES, disaster managers from councils and the Queensland Police Service. A wide range of documentation, operational doctrine, legislation, policies, bushfire plans, event records, media reports and situational reports were also reviewed and analysed.

The review was mapped and themed against the Standard for Disaster Management in Queensland[1] (the DM Standard). This included shared responsibilities for:

- bushfire risk
- bushfire mitigation planning
- community engagement
- information and education, public communications and warnings
- training, exercising and resource planning
- information sharing and intelligence
- response operations, including command, control and coordination
- proactive collaboration and coordination between responsible entities.

As part of a desktop analysis, IGEM considered the observations, insights and recommendations of the 2018 and 2019 Queensland Bushfire reviews (IGEM 2019) and the Royal Commission into National Natural Disaster Arrangements.[2] IGEM completed a literature review of emergency and disaster events that have occurred in national parks and world heritage sites in Australia as well as internationally. This analysis complemented a desktop review of relevant agency plans and supporting documentation, policies and processes.

Recommendations

The review made 38 recommendations and identified opportunities for QPWS and QFES to better interact with stakeholders, the Butchulla people and the local community to plan and undertake hazard mitigation. During the review, participants raised concerns about the level of bushfire preparedness and hazard mitigation activity on the island. They described a perceived decrease in the number of fire breaks and trails on the island and a lack of maintenance, a lack of coordinated bushfire and community engagement activities and the inability to seek and gain their own approvals to undertake clearing or planned burns around the townships. The review recommended an assessment of firelines, tracks and trails be undertaken to establish an adequate network and roles and responsibilities for maintenance be agreed and documented.

This was particularly relevant across multiple land tenures on the island with landowners benefiting from closer engagement as part of a reinvigorated Locality Specific Area Fire Management Group on K'gari. QFES is expanding the Fraser Coast Area Fire Management Group and the K'gari Locality Specific Area Fire Management Group to include land management agencies and owners, the Butchulla Aboriginal Corporation and other community associations so that membership reflects the community.

The review found inter-agency arrangements for cost sharing and the use of firefighting assets during the bushfire response caused some confusion. Accordingly, during the data collection phase of the review, questions were raised about waterbombing assets that could have been deployed earlier. Waterbombing operations did not commence until 9 November 2020 or day 27 of the firefighting effort. The review recommended that the *Queensland Bushfire Plan* (State of Queensland 2020) and inter-agency arrangements between QFES and QPWS be regularly reviewed with stakeholders as well as after major bushfire events. It also recommended that QPWS and QFES agree on prearranged fiscal protocols and establish predetermined financial delegations for QPWS incident controllers to reduce confusion and improve the timely deployment of firefighting resources.

The review process found an opportunity to make bushfire risk and planning information readily available to the community. The review included a recommendation for all Area Fire Management Groups in Queensland to make their Bushfire Risk Mitigation Plans, bushfire risk mapping and methodology easily understandable and easily available. All plans should be dated to show currency and incorporate mechanisms for community feedback.

Participants at the community forums expressed stronger compliance regimes were needed to deter illegal campfires on K'gari. During visits to and tours of the island, IGEM found minimal fire-compliance signage. While there are some locations where campfires are permitted including at Dundabara and Waddy Point, the review recommended an appraisal of all campfire locations on K'gari including all signage on and off the island and maps and visitor permit information to provide consistent information about campfires. Another recommendation was the consideration of novel solutions to encourage visitor compliance, for example, the use of Remote Piloted Aircraft, expanding the use of automatic number plate recognition technology and using mobile phone check-in apps to support visitor management.

1 Standard for Disaster Management in Queensland, at https://www.igem.qld.gov.au/sites/default/files/2019-12/NEW%20Standard%20for%20Disaster%20Management%20in%20Queensland%20v2.0.pdf.

2 Royal Commission into Natural Disaster Arrangements, at https://naturaldisaster.royalcommission.gov.au.

IGEM identified good-practice examples that included:

- community consultative committees at each township established by Fraser Coast Regional Council
- community planning undertaken by the Happy Valley Rural Fire Brigade and community associations at Orchid Beach and Happy Valley
- embedding representatives of the Butchulla people into the Incident Management Team and Incident Control Centre during the bushfire response
- the Enhanced Fire Management Project implemented by QPWS.

The review found that significant community preparedness and planning were undertaken by residents, property and business owners in readiness for a bushfire event. The organisation and levels of engagement achieved by the Orchid Beach Progress Association, Happy Valley Community Association and Kingfisher Progress Association to bring their communities together, undertake specific bushfire mitigation activities and share information was impressive. These associations were aided by expert advice and assistance from the officers and volunteers from the Orchid Beach and Happy Valley rural fire brigades. In the review, IGEM also acknowledged the efforts of the Kingfisher Bay Resort and Village management and the River Heads Rural Fire Brigade.

The review included a case study on the Happy Valley Community Association that developed a Hazard Reduction and Fire Management Plan for the township. The plan divided the township into sectors and outlined hazard mitigation activities including planned burns, clearance of fire control lines and creating safe access to the helipad. Fraser Coast Regional Council, as part of its Community Coordination Committee initiative, allocated funding to install 2 water tanks in the township. These were installed just prior to the K'gari bushfire event. Planned burns were also undertaken by the Happy Valley Rural Fire Brigade over 3 months in the lead-up to the start of the bushfire season. A hazard reduction burn on the block owned by the Department of Education was conducted in August 2020. During the bushfire in 2020, the fire-front approached this block, slowed and stopped at this point where it met the previously burnt area.

The report acknowledged the extensive work that later went into enacting the Incident Action Plan for the township. As conditions continued to worsen in late November 2020, members of the Happy Valley Rural Fire Brigade and the Community Association enacted the Incident Action Plan. Approximately 50 residents and property owners who decided to remain in the township were allocated tasks and responsibilities to undertake as part of the plan. Brigade members also had developed a written options analysis for QFES that included creating a fire break, clearing tracks and undertaking backburns. These efforts, along with the response from agencies and township's communication plan, assisted in the defence of Happy Valley. Since the fire, residents and the Rural Fire Brigade from Eurong are engaging with the Happy Valley Community Association and Rural Fire Brigade to apply their learnings around mitigation and response.

During the K'gari firefighting response, a liaison officer role from the Butchulla Aboriginal Corporation was added to the Incident Management Team. Incident controllers have indicated that the addition of a member from the Indigenous local community in the Incident Management Team helped greatly with operational advice on culturally significant sites and localities and being able to describe their peoples' connections to country. A recommendation from the review was that those responsible for land and fire management consider liaison officer roles for local Indigenous people in incident management.

The way forward

The K'gari Bushfire Review (IGEM 2021) made 38 recommendations, which are all supported or supported in principle by the Queensland Government. IGEM has commenced monitoring, evaluating and reporting on the progress of agencies in responding to the review's recommendations.

Acknowledgment

IGEM acknowledges the Butchulla people as the traditional owners and custodians of K'gari and respects their connection to the land, sea and community.

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About the author

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Abstract

To carry out their roles, first responders need to have appropriate skills. It is important to identify and train in key skills appropriate for the tasks that first responders will perform. Once these skills have been acquired, they need to be maintained otherwise they will decay to the point where performance of the skill is no longer acceptable. This means that emergency services organisations need programs that appropriately maintain the skills of their volunteers and employees. To deliver cost-effective training, these organisations need a good understanding of what key skills are required for tasks that are regularly performed, why and how quickly these skills decay and how these skills can be maintained. To help emergency services organisations better understand these important concepts, this paper reviews relevant literature on skill decay and skill maintenance. Task decomposition methods and training needs analysis are introduced to assist organisations determine what key skills they require. This provides information to make sound, evidence-based decisions about recurrent training programs that can maintain the skills required by first responders and retain efficacy in the organisation.

Understanding skill decay and skill maintenance in first responders

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Introduction

The acquisition and maintenance of personnel skills is a critical element in the effective performance of any organisation. However, skill acquisition and retention is more crucial for first responders where poor performance may result in adverse outcomes that may affect individuals, their colleagues, organisations and communities (Boyle & Eastwood 2018; Flin, O'Connor & Crichton 2008; Vaughan, Stoliker & Anderson 2020; Villado *et al.* 2013; Youngquist *et al.* 2008). The lack of skill maintenance opportunities and the resulting skill decay is a particular challenge when people are not able to practise skills on a regular basis, as is the case for many volunteers (Hughes *et al.* 2020, Vlasblom *et al.* 2020). This issue has become more evident since the arrival of COVID-19 and the resulting pandemic restrictions that have reduced the opportunities for personnel to undertake recurrent training. Programs to maintain skills typically occur within the context of broader organisational pressures, including changing priorities and limited resources. The costs of recurrent training, access to facilities, environmental constraints and a distributed workforce all present difficulties to skill maintenance programs. Examining current literature can help organisations improve their understanding of what the key skills are for tasks that are regularly performed, why and how quickly these skills decay and how these skills can be maintained.

Method

Relevant literature was identified using the search terms: 'skill decay', 'skill atrophy', 'skill maintenance' and 'skill acquisition'. Databases searched included Ebscohost, ScienceDirect (Elsevier SD Freedom Collection) and Science Database (ProQuest). The literature was explored for relevance and applicability to first responder organisations, then organised thematically to identify key theoretical areas.

Skills and tasks

According to Johnson and Proctor (2016) a 'skill' reflects complex learnt behaviour necessary to respond to some form of goal-oriented task. Skills are not innate, rather, they must be learnt and require careful coordination of perception, cognition and action to achieve the required task (Kluge *et al.* 2016). There are many skills in which first responders are trained so they can effectively undertake mission-critical operations. Understanding the range of skills necessary to perform the work of a first responder is an essential element of suitability of skill attainment and retention measures. Skills become the practical enabler of task achievement, enacted by individuals or teams to achieve goals.

Skills can be classified along different dimensions such as physical and cognitive, natural and synthetic (or artificial) and closed-looped and open-looped (Arthur *et al.* 1998). Physical tasks require manual effort or exertion (such as moving a patient), while cognitive tasks are characterised by perceptual input, mental operations, problem-solving and decision-making. The task environment will determine if it is natural or synthetic with natural tasks existing within an uncontrolled or 'real-world' environment while synthetic (or artificial) tasks occur in a controlled environment (Arthur *et al.* 1998; Driskell, Willis & Copper 1992). Closed-looped tasks capture those that are managed or controlled by process, often being a fixed set of tasks with a clear beginning and end. An example of a closed-looped task in firefighting is the donning/doffing procedure for compressed air breathing apparatus. Open-looped tasks are less process driven actions focused on problem-solving or similar considerations that are continuous in nature and do not have a clear start and end. Open-looped tasks may include incident size-up and ongoing management of safety at the incident. It is important to identify the different types of skills required for task performance because different types of skills decay at different rates (Arthur & Day 2013). Generally, cognitive tasks decay faster than physical tasks, synthetic tasks decay faster than natural tasks, open loop tasks decay faster than closed loop tasks and accuracy tasks decay faster than speed related tasks (Arthur *et al.* 1998).

Skill decay

Skill decay is defined as the loss or decay of trained or acquired skills (including knowledge) after periods of non-use (Arthur *et al.* 1998). Skill decay is a particular problem for volunteer first responders who may not use skills on a regular basis, although there is evidence that it can also be problematic for full-time employed first responders (Skelton & McSwain 1977, Zautcke *et al.* 1987). It is important for first responder organisations to understand how skills decay and how to maintain these skills so that appropriate and timely training can be provided.

Semb and Ellis (1994) demonstrate that while learners retain significant amounts of knowledge after learning and training, retention decreases as a function of time. Stothard and Nicholson (2001) display this as a forgetting curve or skill decay curve (Figure 1), which represents the declining nature of skill retention. Skill decay curves provide an effective method to predict the rate at which a skill is likely to decay (Vlasblom *et al.* 2020).

Skill decay curves vary as a function of task-type, cognitive demands, the conditions of learning the task and frequency and types of interference (Arthur & Day 2013, Gronlund & Kimbell 2013). This means that an organisation must have a good understanding of the critical skills that are required in first responder roles to assess and determine decay rates.

Arthur and co-authors (1998) identified factors that directly relate to and impact on skill decay. These factors provide a framework from which skill retention and decay can be explored and managed. Not all factors will be relevant to every skill and associated task, however, collectively they provide a comprehensive structure to determine the variabilities between skills that directly inform how skills decay. These factors include:

- type of skill
- methods of testing
- evaluation criteria
- the retention interval
- conditions of retrieval
- the degree of overlearning (Arthur *et al.* 1998).

The methods of testing and the evaluation criteria used to assess skills are of less interest for a general discussion of skill decay. Thus, the focus here is on the retention interval (which includes consideration of the different types of skills) and the conditions of retrieval. The degree of overlearning is relevant to skills maintenance and is considered in that section.

Retention intervals

Figure 1 shows that skills decline as time increases away from initial learning. Arthur and co-authors (1998) examined retention intervals relative to skill decay and found that as the length of time associated with a retention interval increases so does the extent of skill decay. Relative to one skill assessment they tested, they found that an average performance level of 92% below that of the original assessment level was produced after 365 days

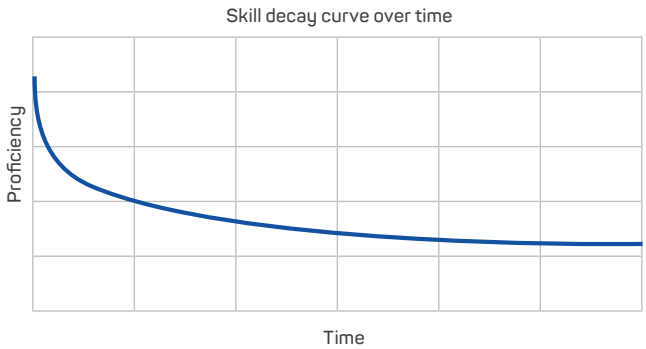

Figure 1: Skill decay curve showing the decline in skill proficiency is rapid soon after attainment if the skill is not maintained.

Source: Stothard and Nicholson (2001)

of non-use. Different types of skills will decay at different rates (i.e. they will be retained over a longer or shorter time interval). Generally, cognitive tasks decay faster than physical tasks, synthetic tasks decay faster than natural tasks, open loop tasks decay faster than closed loop tasks, and accuracy tasks decay faster than speed related tasks (Arthur *et al.* 1998).

Conditions of retrieval

Arthur and co-authors (1998) identified that skill retention is dependent upon 2 factors:

- how the information was initially encoded
- the types of cues present at retrieval.

How the information is encoded is largely based on the manner of training delivery and opportunities to compare the new skill to previously learned information (Arthur *et al.* 1998). When a skill is used after training, the cues present in the current situation that indicate the need to use the skill will affect whether the skill can be recalled and used. If the cues present in a situation are similar to the training scenarios, it is likely that the skill will be recalled. However, if they are very different, then it is likely that the skill will not be recalled. Higher fidelity training that accurately matches the cues and psychological demands that are likely to be experienced in real-world situations will result in better retention of skills (Stothard & Nicholson 2001). This is described by the concept of identical elements (Thorndike & Woodworth 1901) and can be framed in terms of improved transfer of training (Saks & Belcourt 2006, van der Locht *et al.* 2013).

Skill maintenance and refresher training

Figure 1 shows that the majority of skill decay occurs relatively soon after acquisition, with the loss stabilising over time (Stothard & Nicholson 2001). The rate at which a skill decays (represented by the skill decay curve) is important to understand when setting refresher training intervals. The use of refresher training is a method to break a retention interval and periodically increase skill performance relative to a standard or criterion. Figure 2 depicts a standard decay rate of a skill in dark blue with the impact of individual or team refresher training on performance in light blue. The required standard of performance for the skill is shown in orange. The upward gradient of the orange line highlights that operational environments continue to evolve across multiple dimensions (e.g. ongoing changes to technology and equipment, procedures and types of threat or risk). This aspect means that first responders whose skills have decayed significantly may suffer a larger gap between the skills they hold versus the skills required to perform their role effectively.

Figure 2 shows that the period associated with non-use of a skill is directly related to skill decay. However, the effective spacing or distribution of refresher training improves skill retention for a period of time before it again decays.

The period between training sessions is the 'interstudy interval' and is represented by the periodic increase in performance

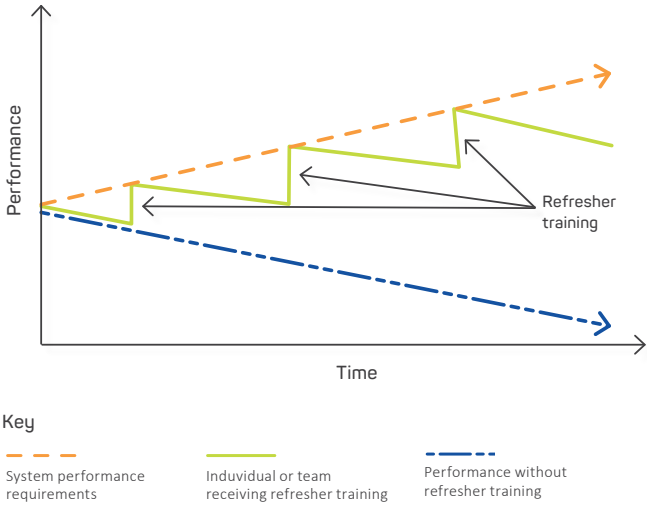

Figure 2: Performance, skill decay and the impact of refresher training.

Source: Hayes (2014)

associated with refresher training in Figure 2. The spacing of interstudy intervals has been explored by Arthur and co-authors (2010). Results showed that longer interstudy practice intervals can enhance performance and promote long-term skill retention in certain circumstances. While initially this may appear to act in opposition to the theory of skill decay, such considerations highlight the criticality of managing skills on an individual basis with knowledge of skill decay as a product of time and the benefits of carefully distributed practice.

Overlearning

One method often used to improve skill maintenance is overlearning. Overlearning is where additional training is provided in excess of that required for initial proficiency; reducing the likelihood that a response will decay and be forgotten (Arthur *et al.* 1998). A meta-analytic study investigating the effects of overlearning found that to demonstrate a reduction in skill decay required a threshold of at least 50% overlearning and that overlearning was more effective for reducing decay in cognitive than physical skills (Driskell, Willis & Copper 1992).

Kluge and co-authors (2016) examined the role of overlearning, specifically the benefits of retentivity and symbolic rehearsal. Skill retentivity refers to the maintenance or sustainment of skills in the absence of practice while symbolic rehearsal captures the imaginary practice of a skill without actually performing it (Kluge *et al.* 2016). The study indicated that symbolic rehearsal was unable to prevent skill decay, however, it was able to attenuate the severity of decay. As such, the role and function of symbolic rehearsal should not be overlooked within training systems, especially when other forms of more complex training may not be available or are unable to be performed.

Rohrer and Pashler (2007) explored the benefits of overlearning over time. They found that the effects of overlearning were clearly identifiable after one week, but the benefits were almost undetectable after 4 weeks. Similarly, Driskell, Willis and Copper (1992) found that the duration of the benefits from overlearning were somewhat limited (i.e. less than 38 days). While the benefits of overlearning may be short lived in some situations, where a critical skill needs to be carried out without error, overlearning may be useful if sufficient resources are available (Rohrer & Pashler 2007).

Individual differences

The level of skill performance attained by an individual is largely the result of training quality, practice and experience. This establishes the point from which skill decay commences (Johnson & Proctor 2016). However, for each individual there are likely to be large differences in the quality of training received, opportunities to practice skills and the experience they develop. Individuals also vary in their ability and motivation to learn and perform skills. These differences in the performance of skills need to be factored in to decisions about refresher training frequency (Stothard & Nicholson 2001). Determining the point at which individual or team refresher training is required means that the relevant performance standards (or criterion level of performance) are met with acceptable levels of competency. To support first responders who have differing access to high-quality training, large differences in practice opportunities and widely differing levels of expertise, it is sensible to build flexible systems that support the differences in skill performance that may exist within organisations.

Non-technical skills

Non-technical skills are cognitive and social skills (such as teamwork, decision-making, situational awareness, leadership, fatigue and stress management) that complement the technical skills required to carry out the work (Hayes *et al.* 2021). Non-technical skills play a critical role in first responder operations (Flin, O'Connor & Crichton 2008). First response is fundamentally a teamwork activity that coordinates technical skills in a time-constrained, dynamic environment.

In many first responder domains, training competency frameworks and operational guidelines have focused on technical skills relating to practical (technical) activities with a limited focus on the role, function and importance of non-technical skills (Civil Aviation Authority 2017, National Fire Protection Association 2015). Technical skills are activities such as effective application of medical procedures, pitching a ladder to make ready and haul-aloft equipment or undertaking a primary or secondary search in a smoke-obscured building. These technical skills will only be effective if they are supported by good teamwork, decision-making, situation awareness and leadership (i.e. non-technical skills).

The execution of non-technical skills may be implied in some existing technical competencies, for example, an officer's training in incident management and supervision may help them to undertake incident size-up (situation assessment) to inform decision-making about the initial action plan. However, this is not the same as being trained to recognise, interpret and anticipate events and to understand the limitations and pitfalls inherent in the process. Situation awareness is more than being aware of the external environment and becomes difficult to achieve as the complexity and dynamics of a situation increases (Endsley 1995). Situation awareness is developed and practiced through specific training and is a skill that benefits from increased competency development and maintenance programs.

Teamwork is set of non-technical skills that are critical for effective response. If first responders do not communicate effectively, cooperate and coordinate their activities properly, then the operational outcome will be poor; putting responders and the public in danger. Arthur and co-authors (2013) identified the criticality of teamwork relative to skill retention and the importance of differentiating between teamwork (facilitation of interaction among members in the accomplishment of team tasks) and taskwork (team effort to understand and perform the requirements of the task). Performing refresher training on taskwork does not necessarily mean that teamwork is sufficiently addressed relative to reasonable standards or criteria. Training systems should require non-technical skills as a component of the performance of technical skills and as a set of skills that need to be trained and maintained in their own right.

Task decomposition and training needs analysis

It is essential that first responder organisations have a thorough understanding of the skills and tasks that are required in any given activity. This helps to determine the particular skill requirements for each task based on how critical that task is (Arthur *et al.* 1998). Several techniques (such as job analysis and task analysis) exist that deconstruct work activities to understand the component parts (Frederiksen & White 1989, Johnson & Proctor 2016, Moore 1999). These methods are a systematic and reliable way to identify the key skills required to carry out tasks and provides information that directly informs instructional and training design (Fine & Wiley 1971, Moore 1999, Salmon *et al.* 2010). Principled task deconstruction can be used to order tasks based on how critical they are and identify mission-critical tasks compared to tasks aligned with lower-level goals (Johnson & Proctor 2016).

Training needs analysis can also be used to identify learning needs like course planning, delivery and evaluation (Gould *et al.* 2004). As a process, training needs analysis guides the collection, analysis and interpretation of data to define:

- when formal instructional actions are the best option (or not) to remedy gaps in competencies
- the profile of who needs to be trained
- what content should be taught (Kraiger *et al.* 2014).

Figure 3 shows a schematic of the role needs assessment and task analysis can play in holistically determining training needs for an organisation and highlights the information dependency

between needs assessment and task analysis. The process commences with organisational analysis to identify the areas that need improvement and the target groups within the organisation who can provide input and data relevant to the analysis. The areas requiring improvement inform the task analysis and also inform the redesign of policies and procedures required for training needs as determined by the task analysis. Once the areas needing improvement are identified, the target groups complete a gap-analysis of the difference between the knowledge, skills and attitudes needed compared with those that currently exist. The outcome of the analysis feeds into the redesign of policies and procedures and, collectively, indicate the training need as a final outcome.

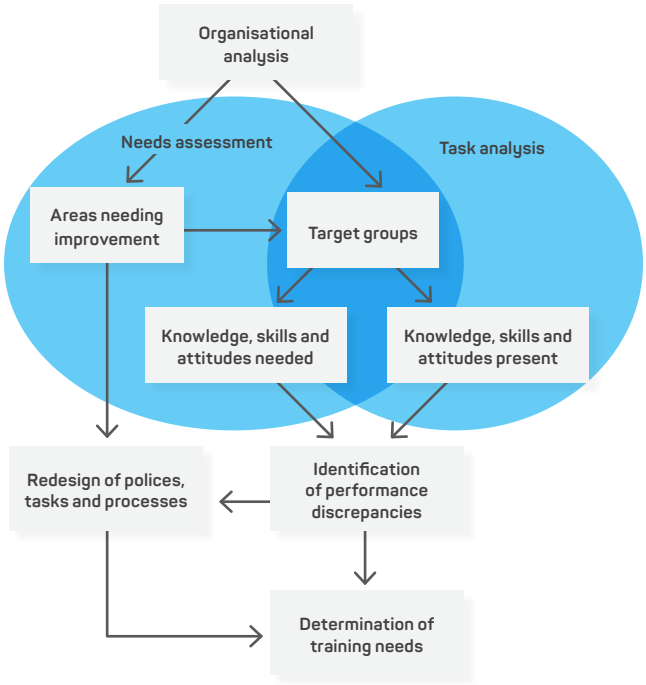

Figure 3: Determining training needs is a network of analysis and decisions based on Needs Assessment and Task Analysis.

Source: Johnson and Proctor (2016)

There are helpful tools and guides that can assist in completing task analysis including 'A guide to task analysis' by Kirwan and Ainsworth (1992), tools for the application of hierarchical task analysis by Hone and Stanton (2004) as well as a practitioner's guide to cognitive task analysis titled, Working Minds, (Crandall, Klein & Hoffman 2006). The selection of task analysis tools and processes should be considered carefully for their suitability for the contexts in which they might be applied.

Conclusion

Skill decay and skill maintenance present real challenges to the effective performance of first responders. This paper has highlighted some important concepts that first responder organisations need to consider and provided information on how to understand and manage skill sets for first responders. By considering the nature of skills, their decay rates and appropriate maintenance schedules, first responder organisations can make evidence-based, defensible decisions around investments in skill maintenance programs. This brings benefits to first responders who receive the best training possible at the most appropriate times so they can more effectively carry out their work in communities.

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Abstract

The importance of volunteers within the fire service in most countries is unquestionable. However, the retention of volunteers is problematic and finding ways to retain experienced and qualified volunteers is becoming increasingly important. While previous international research has focused on volunteer retention and understanding why volunteers leave, very little is known about 'boomerang' volunteers: volunteers who return to the service after a break. These 'boomerangs' are a valuable staffing resource, as they tend to require less socialisation, onboarding and training. The latter is particularly relevant for the fire service, as the resources required to train and develop the necessary skills are significant. This study investigated volunteers in the Finnish Fire Service who have taken a break from the service and returned. Similar to Australia and New Zealand, Finland's emergency services are highly reliant on volunteers, particularly in rural areas. This research examined the reasons why breaks were taken and what volunteers experienced most helpful on their return. Drawing on these findings, practical recommendations are made for fire service organisations for effective volunteer practices that take boomerang behaviour into account.

Boomerang volunteers in the Finnish Fire Service

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Introduction

The backbone of the emergency fire services globally, particularly in rural areas, consists of trained volunteers rather than paid staff (Degel *et al.* 2014). These trained volunteers and the resources needed to develop the necessary skills are significant. However, the retention of volunteers is problematic and volunteer fire service numbers have been declining in Australia and elsewhere (Corydon Consultants 2006, Cowlishaw *et al.* 2014, West & Murphy 2016). As the challenges of recruiting and retaining a sufficient number of fire service volunteers intensifies, finding ways to hold on to experienced and qualified volunteers is increasingly important (Beatson & McLennan 2005).

While international research considered volunteer retention and reasons why volunteers leave, there is little about returning or 'boomerang' fire service volunteers. The lacuna in the volunteer literature is somewhat surprising given that 'returning volunteers may … contribute to the effectiveness of a nonprofit by reducing the costs associated with the screening and training of new volunteers' (Lee, Won & Bang 2014, p.230). Therefore, this research examined whether and why volunteers in the fire service take breaks and importantly, what they found to be helpful (or challenging) on their return to the service.

The study was situated in Finland, where the reliance on emergency services volunteers is considerable. Similar to Australia and New Zealand, Finland has significant rural areas that are entirely reliant on volunteer fire brigades.

Breaks and returning from a break

Much research has focused on the retention of volunteers and reasons why volunteers leave (e.g. Catino 2015, Cote *et al.* 2014, Smith 2014). In the general volunteering literature, research has investigated returning *episodic* volunteers: volunteers who engage in short-term volunteering assignments, such as specific events or projects (Hustinx & Lammertyn 2003). These studies note that 'little is known about … what needs to be done in order to successfully 'bounce-back' or return a volunteer for further volunteering tasks' (Bryen & Madden 2006, p.1). Further, Bryen and Madden (2006) found that episodic volunteers were more likely to return if their original motivation to volunteer was met during the initial volunteering experience. However, it has also been noted that 'the results may not apply to other volunteering settings that is, regular volunteering'

(Lee, Won & Bang 2014, p.238). Given the scarcity of literature on boomerang volunteers, insights can be found in employee literature.

Human resources (HR) practices recognise the existence of 'boomerangs' or 'rehires' (Snyder & Stewart 2015). The concept of boomerangs describes employees who return to a former workplace after having left (Apy & Ryckman 2014). Boomerangs are a potentially valuable staffing resource (Apy & Ryckman 2014, Shipp *et al.* 2014) and boomerang recruitment is a cost-effective and successful recruitment strategy (Hart 2009). Not only are boomerangs a 'known quantity', but they tend to assimilate more easily into the organisation's culture; understand policies and practices; require less socialisation, training and onboarding and are generally more productive (Hart 2009, Shipp *et al.* 2014).

Shipp and co-authors (2014) investigated the differences between boomerangs (employees who quit and later return) and alumni (employees who quit but do not return) and found that the groups 'have different perspectives on their employment experiences and thus, different reasons for (and risks of) leaving, even after controlling for alternative explanations such as demographics or performance concerns' (Shipp *et al.* 2014, p.448). Building on work by Lee and Mitchell (1994), they identified different decision paths for employees leaving their job, which 'summarize how employees interpret their work environments; how they identify decision options; and how they enact responses' (Lee & Mitchell 1994, p.60). The authors argue that the different characteristics of these paths offers clues about who will return and who will not. For instance, they found that boomerangs were more likely to be classified as 'Path 1' leavers than alumni. Employees on Path 1 experience a shock[1] that is combined with the existence of a plan, such as when an employee becomes pregnant and chooses to leave employment. Other examples are spousal relocation or a change in marital status (Shipp *et al.* 2014). A noteworthy characteristic of leavers on Path 1 is that the shock itself results in the decision to leave, but this happens with little deliberation and minimal evaluation of the job experience or satisfaction (Holtom *et al.* 2005, Mitchell & Lee 2001, Shipp *et al.* 2014). As these shocks may be unavoidable and because plans to leave are not related to dissatisfaction with the job or the company, these leavers may be open to returning to the organisation at a later stage (Shipp *et al.* 2014). So rather than ignoring Path 1 leavers because they represent unavoidable turnover, organisations should be aware of the potential that leavers may eventually return. Shipp and colleagues (2014) also found that volunteers leaving for reasons related to dissatisfaction are more common for alumni than boomerangs. The research suggests that boomerangs quit earlier than alumni in their original tenure, 'paradoxically suggesting that employees who quit earlier may be the very employees who will return in the future' (Shipp *et al.* 2014, p.421).

Due to the potential importance of boomerang volunteers in the fire service, this study investigates whether volunteers in the Finnish Fire Service took breaks from their service, the reasons for these breaks and what hindered or helped their return to the service. Whether breaks were preventable by the fire service was also considered.

Method

Participants and procedure

A nationwide survey on fire service volunteering in Finland was conducted in 2012 as part of a larger research project on volunteer firefighter attitudes and motivations. A link to an online survey was sent to all Finnish volunteer fire brigades and was distributed to their volunteers. Participation in the survey was voluntary.

The survey included 4 questions relevant to this paper. Participants were asked whether they had taken a break from their fire service duties (yes/no), and if so, how many breaks they had taken (number and length recorded). They were also asked to describe the reasons for taking the break and what made their return easy or difficult (open-ended questions).

A total of 942 participants started the survey with 762 (81%) completing the section relevant to taking breaks. Of the full sample, 81.7% of participants identified as male and participants were spread across all age groups. Almost a quarter of the participants (24.4%) had been involved with the fire brigade for over 20 years, whereas only 2.5% were new recruits (less than 1 year).

The number of breaks and the length of each break were recorded and descriptive statistics were calculated. Responses to the open-ended questions were coded using thematic analysis. The number of participants who were coded as mentioning a theme was calculated (e.g. reason for taking a break was a move to another location). This provided quantitative data on the reasons why breaks were taken and what may have made a return to the service easy or difficult.

The research was reviewed and approved by the University of Canterbury Human Ethics Committee [HEC 2011/137].

Findings

Reasons for taking a break

Out of the 762 participants who responded to this question, 31% (n=236) had taken at least one break from the fire service. Males and females had similar rates of break taking (31.7% males, 28% females had taken a break[2]) and the age distribution of break takers was similar to those who had not taken a break. Of the participants who had taken a break, 17.3% had taken one break, 4.2% had taken 2 breaks and 2.4% had taken 3 breaks. The average time for a break was 2 years (SD=3.10), ranging from a few weeks to almost 30 years.

Table 1 shows the reasons for taking a break and the frequency that reasons were mentioned, as well as the analysis of whether the break may have been prevented by the fire service.

The reasons for taking breaks were varied, although consistent themes emerged. The most commonly cited reason for taking a break was moving to another area (26.3%). The reasons for

1. A 'jarring event that initiates the psychological analyses involved in quitting a job' (Lee *et al.* 1999, p.451).

2. This difference is not statistically significant.

the move varied, but they were commonly related to work and study. The second most common reason for taking a break was work and study and school commitments (17.2%). Participants reported that they perceived work or educational commitments as high, rather than high demands from the fire service. Military service was also mentioned (15.1%) as there is mandatory conscription for men in Finland. These reasons were coded as unpreventable by the fire service.

The reasons why volunteers took a break did not relate to their length of time in the fire service (i.e. volunteering tenure). The difference in the length of the break taken depended on the reason for the break ($F(10, 204)=2.10$, $p=0.026$)). Post hoc analyses revealed that breaks due to unsatisfactory activities were longer ($M=5.40$ years, $SD=5.50$) than when taking a break for most other reasons:

- negative atmosphere, $M=2.10$ years, $SD=2.92$
- lack of energy/motivation, $M=1.49$ years, $SD=1.86$
- health concerns, $M=0.61$ years, $SD=0.73$
- work/school-related activities, $M=1.99$ years, $SD=2.14$
- military service, $M=0.91$ years, $SD=0.20$
- other hobbies, $M=1.37$ years, $SD=1.18$.

In addition, moving to another location resulted in longer breaks ($M=2.98$ years, $SD=4.53$) than when taking a break due to health concerns ($M=0.61$ years, $SD=0.73$) or military service ($M=0.91$ years, $SD=0.20$).

Return to service

To understand what makes the return to service easy or challenging, participants responded to an open-ended question about the factors that made the return easy or difficult.

The responses were coded into themes and the number of participants mentioning each theme was calculated.

The most frequently stated factor for making a return to the service easier was social factors (63% of participants who responded to this question). That is, volunteers rated having familiar, friendly faces to return to as important: ‘familiar faces’, 'familiar team who welcomed me back’. In addition, a positive climate in the fire service was considered valuable: ‘good team spirit at the brigade’.

Another factor mentioned by 12.3% of participants included being familiar with the role requirements, that is, being familiar with the routine and skills required: ‘basic tasks remained the same’, ‘I knew the basics’, ‘familiar tasks’.

Some suggestions offered by participants that would make a return easier were keeping in touch with the brigade during the break and having a brief training session on return to make sure skills are up to date.

When asked what made the return to the fire service challenging, the most frequently cited response (29.3% of participants who responded to this question) was that ‘nothing’ was perceived as difficult in returning. This may indicate that those volunteers who decided to return to the fire service after a while away are doing so with very few barriers. It is important to note however, that our sample included only volunteers who had actually returned after a break.

The second most common challenge (22.6% participants who responded to this question) was that some skills had been forgotten during the break: ‘I'd forgotten many things during the break’, ‘felt like I was left behind with training’.

Finally, 19.5% of respondents found certain social factors to be challenging on their return, such as changed personnel,

Table 1: Reasons for taking a break in order of frequency.

Rank order	Reason for taking a break	Frequency	Percentage of those who have taken a break	Preventable vs. not by fire service (PREV/not PREV)
1	Move to another city/region	61	26.3	not PREV
2	Work/school-related activities	40	17.2	mostly not PREV
3	Military service	35	15.1	not PREV
4	Health concerns	18	7.8	not PREV
5	Other hobbies	17	7.3	some possibly PREV
6	Family commitments	17	7.3	some possibly PREV
7	Lack of energy/motivation	13	5.6	PREV
8	Negative atmosphere in department	12	5.2	PREV
9	Other	12	5.2	
10	No satisfactory activities	5	2.2	PREV
11	Lack of time	2	0.9	some possibly PREV

personality clashes with others or feeling a psychological distance from team members: 'chemistry between people', 'getting back 'in' to the group', 'poor team spirit'.

Discussion

These findings show that taking breaks is a not an infrequent occurrence within the volunteer fire service, with close to a third of the sample confirming they had done so. This research suggests that understanding volunteer leaving and boomerang behaviour is an important part of the volunteer recruitment and retention practice.

The majority of volunteers take breaks for reasons that are unrelated to the volunteer experience or the fire service itself. As suggested by Shipp and co-authors' (2014) work with paid employees, this is the group that is most likely to 'boomerang' (i.e. Path 1 leavers). The most frequently mentioned reasons like moving to another location, study or work commitments or military service are difficult to prevent from an organisation's perspective. These reasons are largely unavoidable and are unrelated to dissatisfaction with volunteering for the organisation, and importantly, these leavers may return to the service at some later time. Health issues and family commitments were also mentioned and as these causes are unrelated to the volunteer experience, they are largely unpreventable by the service. However, there are some actions the fire service can take to help make balancing family commitments and health issues and volunteering easier to achieve.

Overall, the findings suggest that some participants took a break because they were dissatisfied with volunteering or the fire service. It is noteworthy that those (although only a few) volunteers who took a break because of a lack of satisfactory activities took significantly longer breaks as compared with most other reasons for break taking. The importance of providing interesting activities for fire brigade volunteers has been noted in relation to volunteer barriers (Malinen & Mankkinen 2018). Importantly, the present study did not collect data from those volunteers who had left and did not return. It is quite possible that those volunteers who experience high dissatisfaction with the fire brigade may not return from their break or simply leave the service. Our finding that most breaks are taken for unpreventable reasons should be interpreted with caution, and promoting a psychologically safe and positive culture in the fire service should remain a priority for service leadership. We also recommend research on those who have taken a break from volunteering and decided not to return.

The study revealed some key elements that make returning to volunteering easier. These include social factors, such as familiar people and friends, a positive climate and familiarity with the role requirements. Importantly, these are factors that the fire brigade has influence over.

Implications for fire service

An understanding of the different reasons why volunteers take breaks can guide the objective and the nature of the HR approach to volunteers and can inform leadership practices. Different reasons require tailored retention practices if the fire service, and volunteer organisations generally, want to maximise retention and support 'boomerang' behaviour in volunteers.

For instance, for volunteers who leave for unpreventable reasons, the objective from the organisation's perspective is not necessarily to prevent these breaks from happening, but to set the stage for returning. The fire service can pre-emptively discuss different scenarios of returning with those planning on taking a break. For example, when a volunteer moves to another location, it may be helpful for the service to provide details of fire departments the volunteer could join at the new location, and departments in the new location could be contacted and a meet and greet could be facilitated.

To set the stage for an easy return, the fire department can ensure that the volunteer remains socially connected to the service by regular communications and invitations to social events at the station. Some participants expressed that they would have benefited from refresher courses once they returned to the service. If this is not routine practice, this is something that fire services may consider implementing to ensure volunteers feel that they possess the knowledge and skills necessary. This suggestion is supported by Lee, Won and Bang (2014), who found proficiency and familiarity with the role requirements help ease re-entry.

Other reasons for taking a break, such as health issues and family commitments, may not be preventable by organisations, but there may be actions that can be taken to ensure an easy return or to reduce the length and number of breaks. For instance, the HR practice can focus on helping volunteers with balancing family commitments/health challenges and volunteering. Indeed, previous research found that volunteers' child care responsibilities constitutes a significant barrier for volunteering (McLennan *et al.* 2007, Malinen & Mankkinen 2018). Although the fire service may not have direct influence over such a barrier, it is important to be aware of the competing commitments of volunteers with care responsibilities and, when possible, offer flexible types of volunteering opportunities. Fundraising tasks, for example, could be one such area. Similarly, for those with physical health challenges, the service could arrange volunteers to be engaged in less physically demanding duties.

While in the minority, various reasons for taking a break were also reported where the fire service can play a role in preventing absences. This includes reducing any negative atmosphere or lack of interesting training activities. These breaks may be preventable through leadership practices or culture changes that address the atmosphere and relationships in the service. The HR practice could, for example, focus on monitoring volunteer satisfaction. Regular, anonymous surveys that investigate volunteer motivation and enthusiasm, as well as the perception of the work culture highlight issues that can then be addressed.

Conclusion

This study took a subset of questions from a larger survey of fire services volunteers in Finland to draw out factors about why volunteers leave and return. The aim was to identify why volunteers took breaks and what facilitated their return, to assist in retention and attraction policies. This study can

inform emergency services organisations as well as volunteer organisations in other sectors on volunteer management and offers suggestions as to how to optimise return and retention of highly-skilled volunteers.

While volunteers taking breaks is often unpreventable, there are various HR-related actions that can encourage volunteers to return, increasing the likelihood that skills are retained. These findings related to fire services but could also extend to any organisation wanting to attract past volunteers back to the organisation.

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Experiences of heat stress while homeless on hot summer days in Adelaide

Abstract

Historically, heat waves have resulted in more Australian deaths than any other natural hazard and continue to present challenges to the health and emergency management sectors. While people experiencing homelessness are particularly vulnerable to adverse effects of heat waves, little research has been reported about their hot weather experiences. This paper reports findings from interviews with 48 homeless people sleeping rough in Adelaide CBD on very hot days. While the majority reported drinking a litre or more of water in the previous 24 hours, 79% reported experiencing one or more heat stress symptoms. The research highlights that the protective actions people sleeping rough can take during hot weather are limited by their circumstances and may not be sufficient to prevent dehydration and heat stress. The levels of dehydration and heat stress symptoms suggest that immediate responses could include making drinking water more readily available. It may be helpful to provide information which highlights heat stress symptoms including indicators of dehydration. The role of outreach in providing connections, support and advice is most likely to ameliorate the risk of heat stress. However, the long-term response to protect people from heat stress is access to housing.

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Introduction

Hot weather and health

The World Health Organization has noted that while heatwaves are among the more dangerous of natural hazards this danger does not always receive widespread public attention because the resulting death tolls are not obvious immediately.[1] It is estimated that during the period 1998–2017, more than 166,000 people around the world died due to heatwaves (Wallemach & House 2018), including more than 70,000 who died in Europe during the 2003 heatwave (Robine *et al.* 2008). In Australia, large numbers of disaster-related fatalities are typically thought of as being associated with highly visible environmental hazards such as bushfires, cyclones and floods. However, over the period 1900 to 2011, there were more deaths resulting from periods of extreme hot weather (4,555) than from all other natural hazards combined (3,655; Coates *et al.* 2014).

Heat stress is an umbrella term for a number of physical symptoms and illnesses that result when the body is unable to cope with exposure to excessive heat. These include dehydration, cramps, fainting and exhaustion. Severe dehydration can lead to hypernatraemia, renal failure, cardiovascular complications and death (Flynn, McGreevy & Melkerrin 2005). The most severe form of heat stress is heat stroke, which occurs when core body temperature rises above 40 degrees and can result in multiple organ failure and death (Leon & Bouchama 2011). To help mitigate the dangers to health posed by heat waves, the Bureau of Meteorology has established a Heat Wave Knowledge Centre (Bureau of Meteorology 2020) and issues local heat wave assessments.

In South Australia, the responses by authorities to periods of extreme heat are guided by the *Extreme Heat Strategy* (SA Health 2016) that assigns a lead coordinating role to the State Emergency Service (SES) and response roles to local health networks and the SA Ambulance Service. To mitigate risks to the public, information about safety in the heat is

1. World Health Organization. At: www.who.int/health-topics/heatwaves#tab=tab_1.

provided on several websites, notably those maintained by SA Health, the Red Cross and ABC Emergency.

Extended periods of hot weather have widespread adverse impacts on public health and present challenges to emergency services organisations, especially ambulance and emergency medical services (Nitschke *et al.* 2011, Nitschke, Tucker & Bi 2007). During the 2018–19 summer, Adelaide experienced both its highest daily maximum and highest nightly minimum temperatures recorded (Bureau of Meteorology 2019). It is expected that in many Australian regions periods of very hot weather will increase in frequency and severity, associated with climate change (Binskin *et al.* 2020) resulting in greater demands on the emergency management sector.

Heat stress can largely be prevented if the dangers are understood and simple protective measures are taken such as seeking out cool environments, reducing physical activity and drinking sufficient water (Akompab *et al.* 2013). However, effective preventive behaviour relies on:

- knowledge about heat-stress risk, indications of dehydration and what actions to take
- availability of, and the ability to access, drinking water and cool environments.

Hot weather, health and homelessness

It is recognised that the adverse effects of natural hazard effects are neither uniformly nor randomly experienced by members of affected communities. Some individuals are more vulnerable to negative effects than others (Tierney 2019). For example, the dangers posed to elderly people by heatwaves have been researched extensively (Leon & Bouchama 2011). Another group that is at risk from extreme weather is the homeless (Aldridge *et al.* 2018). Every and Thompson (2014) concluded that homeless people lacked the resources needed to cope well in times of adverse weather. Every and Richardson (2018) also found that, in Australia, there was a lack of disaster risk and response information and no education specific to the needs of people experiencing homelessness. The *Extreme Heat Strategy* (SA Health 2016) does not mention homeless people as a vulnerable group in its list of those at risk during heat emergencies. The aim of this paper is to investigate heat stress in a sample of rough sleepers in Adelaide. The findings contribute further evidence for best-practice responses to homeless communities in extreme heat.

The term 'homelessness' covers a spectrum of inadequate accommodation circumstances ranging from sleeping in the open (sleeping rough) to various forms of precarious and inadequate shelter arrangements (Kidd, Greco & McKenzie 2020). At the time of the Australian *Census 2016*, the Australian Bureau of Statistics (ABS 2018) reported that 116,427 people were classified as being homeless and that the level of homelessness in South Australia was 37 persons per 10,000 head of population. Homelessness, particularly in large population centres, is recognised as a serious societal problem that governments struggle to address effectively (Parsell *et al.* 2013). In a 2018 report the ABS noted:

> *Homelessness is not just the result of too few houses. Its causes are many and varied. Domestic violence, a shortage of affordable housing, unemployment, mental illness, family breakdown and drug and alcohol abuse all contribute to the level of homelessness in Australia …. Homelessness is not a choice. Homelessness is one of the most potent examples of disadvantage in the community, and one of the most important markers of social exclusion…* (ABS 2018, p.1).

It should be noted that many people who are experiencing homelessness have morbidities that make them particularly vulnerable to adverse effects of extreme heat events. These can include poor physical and mental health issues and side effects of associated medications, and drug and alcohol dependencies (Hansen *et al.* 2008, Kovats & Hajat 2008).

Despite the vulnerability of homeless people to extremes of weather, there is limited published data about heat-stress experiences. In the United States, Kovats and Hajat (2008) reported that of the 13 deaths during a heatwave affecting Phoenix, Arizona, in 2006, 11 were homeless people. Sanchez (2011) interviewed 28 people experiencing homelessness in Phoenix during the summer of 2010 in a study investigating heat-related concerns and coping strategies. The most frequently reported heat-stress symptom was fainting. The most frequently reported coping strategies were seeking shade shelter and seeking refuge in air-conditioned buildings and public transport. Obtaining supplies of drinking water was a major concern. Nicolay and co-authors (2016) surveyed 644 homeless people in the Tampa Bay area of Florida about access to services and awareness of heat-stress symptoms. Awareness levels were found to be low and dizziness was the only symptom nominated by more than 50% of respondents. In an Australian study, Cusack and colleagues (2013) interviewed 25 homeless people and 16 providers of homelessness services in Adelaide about the health needs of the homeless during extreme weather events. That study found that sunburn, dehydration and other heat-stress symptoms such as fainting were major concerns. Access to drinking water and shelter were also reported as problems. In a second Australian study, Every, Richardson and Osborn (2019) found that people experiencing homelessness were vulnerable to losing shelter and access to services during extreme weather events. At that time, no published Australian research could be located that reported findings from homeless people about their heat stress and dehydration experiences on very hot weather days.

Aim

The aim of this exploratory study was to gather information from a sample of homeless people sleeping rough in Adelaide about their experiences of heat stress and dehydration on very hot days.

Method

This research was approved by the Central Queensland University Human Research Ethics Committee: reference number 0000021344.

Design and methodology

The study was a single sample, cross-sectional, descriptive field survey using a structured interview methodology. Participants were people experiencing homelessness (as rough sleepers) in the Adelaide CBD. The study was conducted during days when the maximum temperature was predicted to be greater than 35 degrees Celsius in early January 2019.

Measures

A structured interview guide and recording form was used to assess heat stress and self-reported levels of dehydration based on the Heat Stress (Basic) Calculator developed by WorkSafe Queensland (n.d.). The interview guide assessed environmental risks (heat, humidity and wind), and personal risks for heat stress (clothing, and length of time outdoors). The guide included questions about 7 symptoms indicative of heat stress, being:

- sunburn
- having a dry mouth
- feeling thirsty
- having a headache
- feeling dizzy or lightheaded
- feeling sleepy
- experiencing muscle cramps.

Participants were asked to report the amount of water they drank during the previous 24 hours. They were also asked to recall the colour of their urine the last time they urinated and compare their recollection with a 4-level urine colour comparison chart developed by New South Wales Health (2019). The range of colours showed that very pale-yellow coloured urine indicated being hydrated and very dark yellow/brown urine indicated being very dehydrated. A copy of the survey guide and recording form can be provided on request to the authors.

Weather details were recorded at the time of the interview (temperature, relative humidity and wind strength) that were sourced from a mobile phone weather app and noted on the recording form.

Procedure

Weather details at the time of the interview (temperature, Relative humidity, and wind strength) were sourced from a mobile phone weather app and noted on the recording form. Potential participants were approached in the Adelaide CBD at locations known to be places where people experiencing homelessness congregated during hot days. They were provided verbal and written information about the interview and those who agreed to take part provided verbal consent to complete the survey.

Approximately 55 people were invited to participate and 48 of those agreed (87%). Most participants completed the interview within 10 minutes. Their responses were noted on a paper recording form. Participants were given a bottle of water and a flavoured ice block on completion of their interview. They were also provided with an information leaflet about the services and support available during heatwaves.

Analysis

The IBM-SPSS version 25 software tool was used to generate descriptive statistics and explore bivariate correlations among the variables.

Results

The sample of 48 comprised 42 men and 6 women. Their average age was 47.5 years (SD 12.52, Median 39, Range 19–78). Table 1 summarises the weather data at the time of the interviews and responses to the interview questions. The mean temperature over the 6 days of interviewing was 39 degrees, well above the daily average daytime summer temperature for Adelaide of 29 degrees. Only one of the 48 interviews was conducted when the air temperature was less than 35 degrees. The majority of participants wore a single layer of light clothing. Most had been outdoors for more than 2 hours, were in part or no shade and had been recently doing moderate to heavy workload activities. While more than half reported drinking a litre or more of water in the previous 24 hours, participant judgements of their (recollected) urine colour compared with chart colours suggested that 81% were appreciably dehydrated. Seventy nine per cent of the participants reported experiencing at least one of the 7 heat-stress symptoms, more than half reported feeling thirsty and more than a quarter reported feeling dizzy or lightheaded.

Table 2 shows the intercorrelations (as Spearman's *rho*) among scores on the 7 heat-stress symptoms. Correlations with reporting sunburn were mostly low and the correlation between sunburn and headache symptoms was negative. After excluding sunburn, scores for the remaining 6 symptoms were summed to form a 6-item heat stress total symptoms scale (HSTSS6).

The internal consistency (Cronbach's α) was 0.71; M=2.1, SD=1.84, Range=0–6. There was limited evidence of meaningful associations between indicators of heat stress and heat-stress risk factors: 3 correlations were significant at the $p<0.05$ level: HSTSS6 score with air temperature (*rho*=0.33) and negatively with reported water consumption in the previous 24 hours (*rho*=-0.30) and recollected urine colour with time outdoors (*rho*=0.33). The limited evidence of links between heat-stress symptoms and personal risk factors suggests that the experience of heat stress for an individual results from complex interactions among the multiple environmental and personal risk factors they reported.

Table 1: Heat-stress environmental and personal risk factors; dehydration indications and heat- stress symptoms (*n*=48).

Environmental risk factors at the time of the interview	Result
Temperature in degrees Centigrade	M=39.3 SD=12.52 Range=34–45
Percentage relative humidity	M=15.4 SD=1.78 Range=13–17
Wind strength:	
No wind (1)*	42%
Light (2)	37%
Moderate (3)	0%
Strong (4)	21%
Personal risk factors at the time of the interview	**Result**
Layers of clothing being worn:	
Single light layer (1)	73%
Single moderate layer (2)	15%
Single thick layer (3)	6%
Multiple layers (4)	6%
Clothing thickness, how much air do they allow in?	90%
Permeable: e.g. cotton (1)	10%
Not permeable: e.g. thick coat (2)	
Location at the time of the interview:	
Indoors (1)	0%
Outdoors, full shade (2)	14%
Outdoors, part shade (3)	71%
Outdoors, no shade (4)	15%
If outdoors, length of time:	
Less than 30 minutes (1)	2%
30 minutes to 1 hour (2)	8%
1 to 2 hours (3)	8%
Greater than 2 hours (4)	82%

Personal risk factors at the time of the interview (cont.)	Result
Current activities:	
Light: e.g. sitting (1)	23%
Moderate: e.g. walking (2)	69%
Heavy: e.g. walking uphill with a pack or gear (3)	8%
Water drunk in the last 24 hours:	
More than a litre (1)	42%
About a litre (2)	19%
About 500 mls: 2 cups, one bottle of water (3)	23%
About 250 mls: one cup (4)	10%
None (5)	6%
Dehydration indications	**Result**
Recalled urine colour match:	
Hydrated (1)	8%
Somewhat dehydrated (2)	11%
Dehydrated (3)	48%
Very dehydrated (4)	33%
Heat-stress symptoms	**Result**
Experiencing any of the following: (no = 0, yes = 1)	2%
Feeling thirsty	40%
Feeling sleepy	35%
Dry mouth	29%
Feeling dizzy or lightheaded	23%
Headache	21%
Muscle cramps	19%
Sunburn	

*Figures in parentheses are coding values.

Table 2: Intercorrelations (Spearman's *rho*) among heat-stress symptoms (*n*=48).

Symptom	1	2	3	4	5	6	7
1. Feeling thirsty	-	0.29*	0.30*	0.29*	0.28	0	0.11
2. Feeling sleepy		-	0.20	0.61**	0.47**	0.42**	0.27
3. Dry mouth			-	0.10	0.22	0.26	0.20
4. Feeling dizzy or lightheaded				-	0.41**	0.35*	0.16
5. Headache					-	0.33*	-0.14
6. Muscle cramps						-	0.15
7. Sunburn							-

Note: *p<0.05, **p<0.01

Discussion

The findings of this study suggest that participants were in environmental conditions likely to create heat stress, as indicated by the temperature and the amount of time they were outdoors. The protective actions they adopted present a mixed picture. Most wore one layer of permeable clothing, were in part shade, but had engaged in moderate to heavy levels of activity. Most had reportedly drunk a litre or more of water in the previous 24 hours. These findings suggest that people who are sleeping rough respond to hot weather conditions as best as their circumstances allow. However, each of the 7 heat-stress symptoms was experienced by appreciable percentages of the participants (19–52%). In addition, despite the majority of participants reportedly drinking more than a litre of water in the last 24 hours, most, as indicated by the self-report urine test colour comparison, were dehydrated or very dehydrated and more than half reported that they felt thirsty.

Limitations of this exploratory study are acknowledged. The Don Dunstan Foundation Adelaide Project Zero[2] tracks the numbers of people known to be sleeping rough in Adelaide each month and during 2019 these varied considerably, ranging from (approximately) 140 to 280. This sample was smaller than desirable, probably representing between 17% and 34% of the city's homeless and was one of convenience. The findings should be viewed as indicative only. Also, there are many forms of homelessness and the findings are restricted to people who were sleeping rough. Cities vary considerably in their characteristic summer weather patterns, built environments, infrastructure and welfare services and it is uncertain how these findings might apply more broadly. However, this exploratory survey indicates there is a need to respond to heat stress for people sleeping rough.

This may include developing health information targeted towards the specific needs of people experiencing homelessness. The current public health information about heatwaves made available by SA Health (2019) recommends:

- staying indoors in a home prepared for hot weather (e.g. with blinds, fans, air conditioning)
- only going outside in the cooler parts of the day
- wearing light clothing and a hat
- using sunglasses and sunscreen
- drinking plenty of fluids.

Of these recommended protective behaviours, only the wearing of light clothing was immediately relevant for most study participants. Seeking shade shelter and not undertaking heavy physical activity, although not mentioned in the SA Health material, are potentially available heat-stress preventive behaviours for homeless people.

The findings point to some ways in which public health information could be modified to better assist people experiencing homelessness. Most current information assumes that people have ready access to accommodation providing a cool environment using fans or air conditioning. Appropriate information could be added to existing material that highlights the importance of seeking shade shelter, wearing light clothing, reducing physical activity and drinking more than a litre of water each day. Information should emphasise the signs of heat stress such as thirst and feeling faint and the importance of seeking medical assistance if distressed.

Accessing drinking water and cool environments can be challenging for people experiencing homelessness. Outreach by providers of homeless services has been demonstrated as an effective way to support people sleeping rough in extreme weather conditions (Every *et al.* 2019). These services need to be supported by funding bodies to ensure homeless people have regular access to the amounts of water required to stay hydrated during hot weather and to publicly available cool environments. In view of predicted average temperature rises associated with climate change, local governments to review the provision of public drinking water fountains and public access cool environments as public health issues independent of the particular needs of the homeless.

2. Don Dunstan Foundation. At: www.dunstan.org.au/adelaide-zero-project.

Conclusions

The findings provide local governments and emergency management organisations with information about the experiences of a sample of homeless people sleeping rough during hot weather. This could assist homelessness service providers and public health organisations to review the information and support they make available to ensure this takes into account the circumstances of people experiencing homelessness, including appropriate recommended protective actions, the need to consume more than one litre of water per 24 hours in heatwave weather and the common symptoms of heat stress. They could also consider whether their outreach activities to provide extra water and information about accessible cool environments could be expanded. Advocacy groups representing the homeless may use the research to emphasise the health risks posed by hot weather in their endeavours to secure a larger stock of appropriately supportive housing (Hewett & Halligan 2010, McLoughlin & Carey 2013).

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Abstract

Engaging with Indigenous peoples is clearly on the agenda of natural hazard leaders in southern Australia, but there is very little research, policy or practical experience to support this work. Indeed, with a few important exceptions, natural hazard organisations and research institutions have had little engagement with Indigenous peoples, their organisations or research priorities or protocols. While there are substantial gaps in the research evidence, it is important to start identifying the issues at hand and consider what might be done in response. This paper provides a brief overview of the fraught relations between Indigenous and non-Indigenous people in Australia and some common misunderstandings. The paper includes specific suggestions for current research, policy and practice, noting that natural hazard agencies and research institutions are influential and closely related. It is clear there are challenges. However, changing practice is essential to foster more respectful terms between Indigenous peoples and Australia's natural hazard and emergency management sector.

Indigenous peoples and natural hazard research, policy and practice in southern temperate Australia: an agenda for change

Peer Reviewed

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Introduction

The broad scope of natural hazard research, policy and practice includes concerns relative to Indigenous peoples. However, with a few important exceptions, natural hazard agencies and research institutions have had little engagement with Indigenous peoples, especially in southern Australia (Thomassin *et al.* 2018, Smith *et al.* 2021). To understand this, statistics and maps were published showing the Indigenous groups affected by summer bushfires in 2019–20 in Victoria, New South Wales and the Australian Capital Territory to show their numerical presence and unique rights, geographies and population profiles (Williamson *et al.* 2020). In addition, 2 important bushfire inquiries were reviewed (McLeod 2003, Teale *et al.* 2009) and revealed that Indigenous peoples were included only as an historical footnote, as well as in a brief cultural heritage reference (Williamson *et al.* 2020, p.14–15). A research review into the recommendations of 55 post-disaster inquiries did not mention Indigenous peoples at all, not even whether they were absent or not in the recommendations (Cole *et al.* 2017).

This lack of engagement is undergoing significant change. During and after Australia's 2019–20 summer bushfires, Indigenous peoples' fire management practices made national and international headlines and were included in the terms of reference and scope for the Victorian, New South Wales and Australian Government inquiries (Binskin *et al.* 2020, Lay 2020, Owens & O'Kane 2020). The Victorian Government established an Aboriginal reference group to advise the newly created agency, Bushfire Recovery Victoria, thereby signalling a grasp of issues greater than just fire management (State of Victoria 2021, p.10). Clearly, Indigenous engagement is now on the agenda of public sector decision-makers involved in natural hazards and disaster resilience in southern Australia. However, there

is very little existing research, policy or practical experience to inform this work. For example, aside from work by Williamson, Markham and Weir (2020), there has been no research on Indigenous peoples and disaster relief and recovery policy in southern temperate Australia. Yet, Indigenous peoples are working within and navigating natural hazard policy, practice and research. Recognised as first nations people, traditional owners and traditional custodians, Indigenous peoples bring to this work their own land, societies, laws and customs.

The terms Indigenous people is used to signify individuals and Indigenous peoples is used to signify political-legal groups.

This paper shows how engaging with Indigenous peoples can be more than an agenda item for natural hazard institutions; it challenges and changes the agenda itself. By natural hazard institutions, we include disaster resilience, relief and recovery, as undertaken across the public sector and by research bodies. Building the competencies of these institutions is an integral step towards supporting Indigenous-led and collaborative approaches in natural hazard research, policy and practice (e.g. Sangha *et al.* 2019). There is a clear need to transition from the commitments of a few individuals to investing in structural and procedural support (Smith *et al.* 2021; Weir, Neale & Smith 2021; Sangha *et al.* 2019; Ali *et al.* 2021); otherwise, Indigenous people remain explaining their relevance and always with the pressure to conform to dominant, non-Indigenous approaches (Ellemor 2005, Smith *et al.* 2021). This wastes time, risks employee burnout and perpetuates platitudes (Freeman *et al.* 2021). However, this situation is not unique to the natural hazard sector but is indicative of fraught relations held between Indigenous and non-Indigenous people and government organisations, research institutions and in society broadly.

There are many opportunities to research and work differently in southern temperate Australia. This is where the majority of Indigenous people live and also where most natural hazard risks are, as acknowledged by the sector because of non-Indigenous settlement and development patterns (Weir, Sutton & Catt 2020). It is also where most of our research experience has been gained.

This paper does not replace the priorities of Indigenous peoples, instead it emphasises the appropriate centring of Indigenous voices on Indigenous issues. It is acknowledged how Indigenous identity and authority is understood in relation to context and is often negotiated in intra-Indigenous forums that non-Indigenous people are not privy to (Sullivan 2020). These are complex matters beyond the scope of this paper. However, they require investing in Indigenous governance (Freeman *et al.* 2021). Indigenous people are first nations, traditional owners, traditional custodians, communities, community leaders, public servants, elders, politicians, researchers, citizens and residents. Indigenous peoples are also diverse in ability, class and sexual orientation. Notably, in comparison to Indigenous men, Indigenous women are marginalised in areas of land and natural hazard management (Cavanagh 2021).

Distorted relations

The absence of Indigenous peoples and their priorities in natural hazard research, policy and practice is not unique, but part of Australia's psyche of distorted relations (after McGregor 2017). Late 19th and early 20th Century Euro-American logics of racial superiority positioned Indigenous people as backward, uncivilised and presumed their way of life would inevitably give way to white superiority (Moreteen-Robinson 2015). Fundamentally, Indigenous people were not expected to be part of modern Australia. Instead, Indigenous peoples' political-legal entities were incorrectly presumed and relied upon to be absent (Strelein *et al.* 2001).

A suite of consequences has resulted, as critiqued by generations of Indigenous people whose advocacy and action has led to more just terms. This includes the High Court of Australia *Mabo* decision[1] and the subsequent recognition of native title rights. The 20th Century saw a resurgence in Indigenous peoples' cultural and political standing and Australia's adoption of principles of non-discrimination in law and policy. All government jurisdictions in Australia have legislative mechanisms recognising the rights and authority of Indigenous peoples with respect to their land, water, cultural heritage, governance and more. For example, in Victoria the *Aboriginal Cultural Heritage Act 2006* and the *Traditional Owner Settlement Act 2010*. Further, Victorian, Queensland and Northern Territory jurisdictions are currently undertaking discussions with Indigenous groups about treaties.

Indigenous people now have ownership and management rights and interests to almost half the continent, including important lands in southern temperate Australia (Altman & Markham 2015). In NSW, for example, Local Aboriginal Land Councils are becoming the largest landowners in some local government areas. It is anticipated that all conservation lands will have formal arrangements with Indigenous people within the next 20 years (Norman 2018). In Victoria, it is government policy that all lands will have formally recognised Traditional Owners. As a body, these land tenure changes have profound implications for how Australia is understood and governed. For example, land title is often assumed to be either private or public, but almost half the continent is under communal title, requiring a rethink of models that regulate and fund land-management responsibilities (Weir & Duff 2017). Land tenure changes have been a catalyst for environmental research institutions and funding bodies, with some now prioritising Indigenous people and Indigenous research methodologies across their programs (Moggridge 2019).

Nonetheless, there remains consequential matters that must be overcome to secure more just terms between Indigenous and non-Indigenous people. One is the viewpoint that distorted relations only require work by, for, and with Indigenous people instead of understanding that addressing distorted relations is everyone's responsibility. This means that non-Indigenous people must also examine their assumptions, institutions and processes (McGregor 2017). Thus, public sector and research institutions must examine how they may benefit from discriminatory structures and processes, both those they work with as well as

1. Mabo v Queensland (No 2) [1992] HCA 175 CLR 1.

those they have created and sustain. These are not always easy to identify. There is much in the status quo that is simply taken for granted from non-Indigenous viewpoints. For example, the assumption that Indigenous people are regarded as community stakeholders to governments and in research projects. This leaves Indigenous people with the choice of participating in public sector and research activities on these terms, or not participating at all (Hemming *et al.* 2010). Instead, specific engagement protocols can be established with Indigenous peoples, also known as self-determination mechanisms. These recognise and support the self-determining authority of Indigenous peoples, including first nations, traditional owners and traditional custodians.

Another consequential matter is the assumption that Indigenous knowledge is local knowledge. Indigenous people have land-centred knowledge-governance systems, known as Country (Kwaymullina 2016, Cavanagh & Stanley 2021). Key elements include inter-generational ethics within and between Indigenous groups and reciprocal relations with species and natural processes that acknowledge co-dependency (Reo *et al.* 2017, Latulippe & Klenk 2020). The most important relationships are held between people and the land and then relationships between people (Graham 2007). This is knowledge that is recognised and shared regionally, nationally and globally. It has useful points of intersection with sustainable development approaches to disaster resilience, which is the general trend of natural hazard research, policy and practice in Australia and internationally (COAG 2011, Lambert & Scott 2018). However, to categorise Indigenous knowledge as local knowledge, is to exclude it from influencing these and many other influential forums.

The paucity of research about natural hazards and Indigenous peoples reflects the pan-continental Indigenous experience of being co-located with a nation established on non-Indigenous terms and priorities (Weir, Sutton & Catt 2020). In southern temperate Australia, aside from Williamson, Markhan and Weir (2020) and the small literature on Indigenous fire management, only 2 other papers were found. These were on general cultural heritage matters, mainly European-settler, and identify the lack of expertise in Indigenous heritage in natural hazard research and practice (Graham & Spennemann 2007, Laidlaw *et al.* 2007). In northern and central Australia where Indigenous peoples are the majority landholders and often the majority residents, and, aside from the Indigenous fire management literature, the research is limited to a handful of papers (e.g. Haynes *et al.* 2014, Veland *et al.* 2010, Ali *et al.* 2021, Sangha *et al.* 2019).

Today, Indigenous people face a skewed political economy when meeting with governments, universities and private companies. While some parties work to change the terms of these meetings (Muller *et al.* 2019), Strelein and co-authors (2019) note:

> *The interests of traditional owners inevitably end up secondary to those of proponents who, via access to greater resources or superior socio-political positioning, are able to more effectively navigate bureaucracies and secure support from key actors.* (p.17).

Fundamentally, when addressing systemic problems, it is critical for policy makers, legislatures, research leaders and others to acknowledge the context; what has come before and continues to inform the present (Bodkin-Andrews & Carlson 2016, Doyle *et al.* 2018). Without acknowledging how distorted relations has been created and perpetuated, Indigenous peoples will continue to be type cast as the problem. For example, Indigenous people are often described as vulnerable in disaster contexts with no mention of the assimilation policies that have undermined Indigenous people's existence as peoples, families and individuals, affecting their collective wellbeing (Krieg 2009). By not acknowledging the influence of discriminatory structures and processes, the provision of external expertise is legitimised (Ellemor 2011). When typecast as vulnerable, Indigenous peoples' strengths in kinship, governance and culture are not recognised and supported with self-determination mechanisms. These are not productive grounds for establishing and sustaining collaborative and Indigenous-led approaches.

An agenda for change

The extensive literature on forming better relationships between Indigenous peoples, governments, universities and others (Kwaymullina 2016, McGregor 2017, Muller *et al.* 2019, Reo *et al.* 2017) identified 2 inter-related priorities:

- To centre Indigenous peoples on matters of importance to them. This involves equitable sharing of resources and decision-making authority, including greater access to and ownership of land.
- To decentre non-Indigenous dominance of matters important to Indigenous people, by reducing the discriminatory assumptions, structures and processes that are the legacy of distorted relations.

In this centring/decentring work, there are immediate steps that can be taken by natural hazard agencies and research institutions. For example, appointing Indigenous people as staff, board members and establishing reference and advisory groups and creating enabling and accountability structures and processes, such as reporting and training (Weir, Neale & Smith 2021). Institutional leadership is critical because these are systemic matters that involve inter-personal understandings and communication among staff (Ellemor 2011, p.6). Institutions are formed by people and misunderstandings are common between Indigenous and non-Indigenous people. There will be uncomfortable and enlightening encounters in shifting the status quo (Freeman *et al.* 2021). This is about beginning with who is at the table, who is supported to be there and what meanings and interpretations are heard and considered appropriate. From here, questions can then be discussed about what matters, what might be done about it and by whom.

For example, when recovery funds are being designed with farmers and businesses in mind, it is essential that Indigenous peoples' specific priorities are considered as well. These may be for the restoration of culturally important species and places as well as supporting early access to Country to gauge what has happened. The model for funding needs to be fit-for-purpose, co-designed with Indigenous people and funds prioritised

for Indigenous organisations. This work involves considering Indigenous peoples' priorities, worldviews, organisational forms, skill sets, resources and legal responsibilities (Weir & Duff 2017). The majority of existing models supporting Indigenous people on Country are designed for northern and central Australia and may not be fit-for-purpose in southern temperate Australia (Smith *et al.* 2021).

Research institutions and funding bodies must cease externalising Indigenous people from research (understood only as case studies) and acknowledge that Indigenous peoples have their own research expertise, organisations and priorities. This includes research processes and methods, design and governance and data sovereignty (AIATSIS 2020, Maiam nayri Wingara & Australian Indigenous Governance Institute 2018, NMRHC 2018). Research institutions must support these while examining the structures and processes of their own disciplines, professional associations, institutions and curricula (Cavanagh & Stanley 2021, Hemming *et al.* 2010, Weir *et al.* 2018).

To increase awareness, understanding and experience, important events such as NAIDOC, Mabo Day and Sorry Day provide context and vision as do texts by Indigenous authors and institutions such as AIATSIS (2018). There are also many resources online, including:

- **Forums, organisations and peak bodies** – traditional owner groups, land councils, corporate native title bodies, Elders councils; tv and radio broadcasting bodies; land and water representative organisations and networks; research bodies; and specific appointments such as the Aboriginal and Torres Strait Islander Social Justice Commissioner.
- **Policies** – Caring for Country[2], Cultural Burning (Steffensen 2020) and land-based approaches to healing collective and individual trauma (Lowitja Institute 2020).

These suggestions and are not a result of comprehensive research but reflect particular expertise. Indeed, there is a need for comprehensive research about the Australian context (Thomassin *et al.* 2018). This paper cites the narrower matter of fire management and not the broad suite of natural hazards work that includes planning, preparation, response and recovery as well as resilience.

Research, policy, practice and cultural change

Public sector and research institutions are influential and closely related bodies. The content of university research and curricula largely determines the evidence available to it and the public sector, the qualifications of university and public sector staff and the kinds of researchers employed by government agencies (Weir *et al.* 2021b). Together with research-industry collaborations, the public sector and universities have built what is considered 'normal' in research, policy and practice. The absence of Indigenous people and their priorities in this area is indicative of the absence of Indigenous people as staff, especially in executive roles. This is a suggestion because there is no research evidence to draw on, nor are sufficient records kept (Neale *et al.* 2019).

The surge in interest in Indigenous peoples' fire management since 2020 is the most recent opportunity for natural hazard agencies and research institutions to undertake and demonstrate authentic change with Indigenous peoples. In this, Indigenous people risk their fire management practices being co-opted and appropriated without support for the governance, knowledge, Country and kin that give meaning to these practices. This is another experience of dispossession. While it is generally better to make mistakes than not try, Indigenous people have good reason not to trust governments and research institutions. There are extensive histories and geographies of erasure and Indigenous people will avoid non-Indigenous institutions because of experiences of racism and associated trauma (Doyle *et al.* 2018). As Neale and co-authors (2020) warn:

> *… government, and research institutions should not ask Indigenous people, who live with two centuries of colonisation and discrimination, 'How can your knowledge improve our resilience?' Instead, they should ask 'How can we support Indigenous peoples and their engagements with natural hazard management as part of their and our resilience?'*

Unfortunately, many findings from inquiries into the summer bushfires in 2019–20 are still qualified and constrained by assumptions that do not understand Country. Country is the domain of all living things, including all people (Graham 2007, Cavanagh & Stanley 2021). Country is the agenda, not an agenda item. It is the paper that the list is written on, not an item on the list. Understanding Country requires non-Indigenous people to be part of an open dialogue; one that does not presume where that dialogue might go.

With Country as the frame for knowing and governing, it is clear why Indigenous leaders argue that the land must come first in hazard mitigation. The current arrangement places human lives first, then property and the environment last. When Indigenous people foreground the land, this is not to dismiss human lives and property, but to appreciate that taking care of lives and property requires first taking care of Country (Steffensen, in Weir 2020). This is not unrealistic or naïve work. It is of profound importance and it is already influencing the natural hazard sector. It is leading to natural hazard practices and research that are not just uniquely Australian, as they already are, but also embedded in respectful relations with Indigenous people and Country.

There are challenges both in play and ahead. For example, the 2020 Royal Commission into National Natural Disaster Arrangements[3] was constrained by terms of reference focused solely on Indigenous fire practices (Binskin *et al.* 2020). It also recommended learning from Indigenous peoples' 'local knowledge', not understanding that Indigenous knowledge is not just local. These were opportunities lost. Nevertheless, the Royal Commission is a clear break from the absences that came before (Binskin *et al.* 2020). The concept paper for discussion published

2. See, for example, the Northern Land Council website for their Caring for Country policies.

3. Royal Commission into National Natural Disaster Arrangements, at: https://naturaldisaster.royalcommission.gov.au.

by the Bushfire and Natural Hazards Cooperative Research Centre, Framing a Disaster Resilience Research Portfolio, did not mention Indigenous peoples in its research themes, however, in response to feedback from Indigenous scholars, it has contracted work to alter the focus (BNHCRC 2021). Scholars writing about cultural burning practices in southern temperate Australia are tracking the movement from deficit approaches to building relationships with Indigenous peoples. All this work shows that it is possible to reduce the ongoing effects of distorted relations with Indigenous peoples across research, policy and practice structures and processes.

Conclusion

There will be irresolvable tensions in the relationships between Indigenous and non-Indigenous co-located political-legal groups. This tension should not be avoided or ignored but grasped as central to the pursuit of just terms, including in the context of natural hazards. While it is not possible to make good for all that has happened, it is possible and desirable that non-Indigenous people and institutions acknowledge what has happened, take these matters seriously and demonstrate good faith by undertaking to work otherwise.

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Abstract

Fires in underground mines may pose a challenge to fire and rescue personnel where the complex environment and multiple influences of a fire are poorly considered during pre-incident planning. A better knowledge of pre-incident planning in underground mines would improve the safety of personnel. This study on pre-incident planning in underground mines applied data from experiments, inventories and design fire studies. A number of questions were considered related to information sources, fire modelling, capturing complexity and using fire scenarios. When performing fire modelling, empirical models could be used to complement other modelling tools. The study found that for modelling of spatially extensive mine sections, the use of ventilation network-based mine fire simulations could be a better option. Using an analytical toolbox, an iterative testing of plans and an ongoing planning process, the pre-planning challenges for a mine can be mitigated. The purpose of this study was to examine existing pre-incident planning and propose information sources, tools and specific actions for future plans.

Pre-incident planning of fires in underground hard rock mines: old and new risks

Peer Reviewed

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Introduction

Fires in underground mines pose challenges that include the 3-dimensional feature of the mine, long distances filled with smoke and the limited number of routes to access the fire. Existing risks include smoke spread, falling rocks and fires affecting the ventilation flow. New risks may include the introduction of battery-powered mine vehicles with different fire behaviour, emission of toxic substances and the changing conditions that fire and rescue personnel will face.

A key tool during fire and rescue operations is pre-incident planning, which assists personnel in the decision-making process and can remedy the initial lack of information. The main issues with pre-incident planning in underground mines are the complex mining environment, the ever-changing layout of the mine and the highly transient and numerous ways a fire will behave.

This paper studies pre-incident planning in underground hard rock mines and proposes information sources, modelling tools and contents of these plans. Questions considered are: What information sources to use? How to use fire modelling? How to capture the complexity of the mine? Data and findings from fire experiments, inventories and design fire studies were applied in this study.

Earlier work on pre-incident planning has focused on pre-planning in general and does not address specific risks, challenges and conditions found underground. Perry and Lindell (2003) reviewed emergency planning and its relationship with training, practising and written plans. Chen and co-authors (2007) discussed critical issues to coordination in emergency contexts where response pre-planning was one of the highlighted issues. Byler and Hartwell (2009) conducted a study on the implementation of a fire incident pre-planning system and analysed existing tools to design a fire incident pre-plan worksheet. Baker (2011) looked at the general procedures and structures of pre-incident planning and discussed sections typically found in pre-incident plans. Seaton and co-authors (2019) studied the effective use of information resources at each phase of a chemical hazard emergency. However, studies on

pre-incident planning in underground mines are few. Kowalski-Trakofler and co-authors (2010) studied the initial response during an underground mine emergency and discussed the pre-planning in general terms. To fill this gap, this study is constrained to the pre-incident planning of fires in underground hard rock mines, as the risks differ compared to other types of mines.

Pre-incident planning of fires

A pre-incident plan comprises of collected and refined information on a certain object. The refined information could include fire modelling and simulations. The plan is used to aid fire and rescue personnel when determining an incident response and provides adequate and sufficient information. Further descriptions on pre-incident planning are in NFPA 1620 (NFPA 2020) and Perry and Lindell (2003).

The pre-incident planning process

The pre-incident process consists of stages as shown in Figure 1. The process starts with the gathering of data and site inventories, where risks are documented and layouts collected. An evaluation of the data takes place where it is decided what data to proceed with, what data to refine further and how to present the plan. The data refinement may include the use of a modelling tool or risk analysis. The next stage is the development and presentation of a draft plan, which will be tested and practised. The outcome of the tests may result in a revision of the plan before an operational version of the plan is ready for use. Planning is a continuous process as the layout of the object may change and new risks may arise. An occurring incident presents an opportunity to correct errors and improve the plan. Figure 1 is an example of this process and other approaches can be found in NFPA 1620 (NFPA 2020).

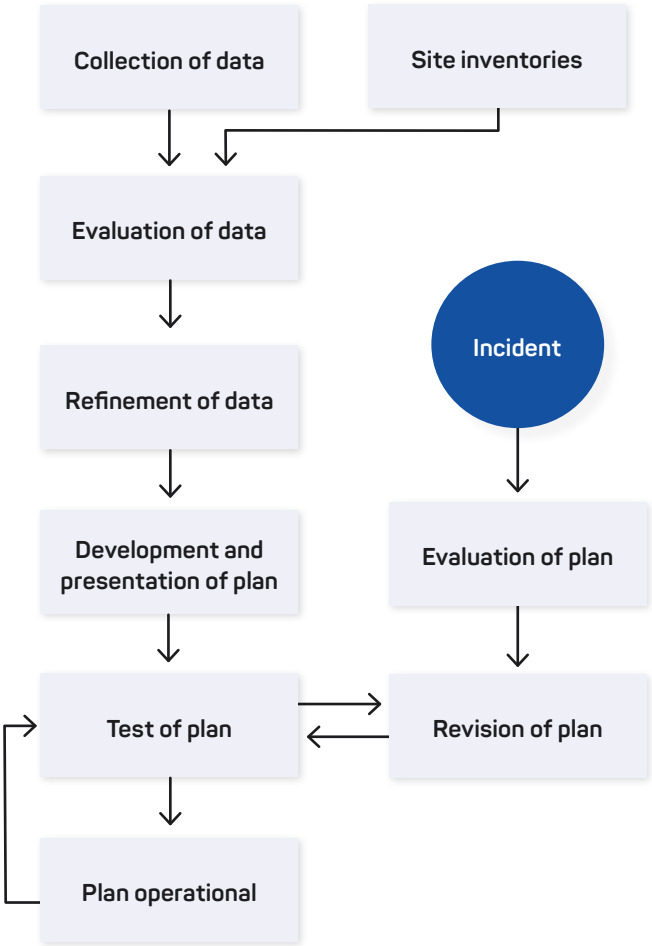

Figure 1: Example flowchart of a pre-incident planning process.

Data components

The contents of a plan will vary depending on the type of object. NFPA 1620 (NFPA 2020) lists the components of a pre-incident plan as:

- site considerations, such as the construction of building and external site conditions
- occupancy considerations, such as the means of egress and on-site emergency organisation
- water supply and fire protection systems, such as water hydrants and automatic sprinkler system
- special considerations such as hazardous materials and abandoned structures.

Fire experiments, inventories and design fire studies

Vehicle fires are the most frequently occurring fire in underground mines (De Rosa 2004, Hansen 2018). As such, 2 fire experiments were conducted in an underground mine involving a loader and a drilling rig (see Hansen & Ingason (2013)) for a full description of the experiments).

Hansen (2010a) conducted site inventories of underground mines to investige the location, frequency and configuration of combustible materials and fire protection systems.

A design fire study in underground mines was conducted by Hansen (2010b) that included derived design fire scenarios. Hansen (2019) also presented design fire scenarios using input parameters from the Australian mining industry.

Pre-incident planning: process, data, tools and contents

The components discussed and proposed should be regarded as a typical collection for underground mines, but not as a comprehensive list for all mines. The proposed tools, scenarios and components are not applicable to all mines. The characteristics of the mine and specific risks will dictate the extent and content of the planning process. In addition, legislation and organisations may vary from country to country and will influence the planning process and contents.

The pre-incident planning process

The nature of mines will be reflected in the planning process, where functions and areas of interest will differ. A key function

is mine ventilation, which is critical during the evacuation phase as well as the fire suppression and recovery phases. Mine plans will be an asset during the planning process as will details of mine water supplies, electrical power, communication and personnel responsible for fire protection systems. Details of each system, the redundancy of each system and possible alternative systems or backups are essential. Given the high risk of vehicle fires underground (Hansen 2018, De Rosa 2004), personnel responsible for the vehicle fleets should provide details on vehicle types and distribution of vehicles across the mine. Rock mechanics personnel may be able to provide details on the effects on the surrounding rock for a specific fire scenario. Fire and rescue personnel provide expertise on the management and coordination of an incident and the capability of fire and rescue organisations.

Site personnel could be control room personnel or personnel from a specific mine section. Control room personnel could be involved in the planning process particularly given the likelihood of a command post being established in the vicinity of the control room. Control room personnel may also provide a good overall picture of processes and flows of the mine. Personnel from the mine section may provide details on the localised processes, risks or inputs to cascading effects.

Ensuring personnel and diversity of functions are included in the planning improves the robustness of the plan, the knowledge of the plan and the overall readiness of the organisation. Pre-incident planning is an ongoing process as new sections of mine are changed and added and older parts are closed.

Information sources

A fundamental information source is a fire-risk analysis that includes valuable information about earlier fires, fire causes and points of origin. Hansen (2018) studied incident data from the mining industry in New South Wales, Queensland and Western Australia, which can assist in evaluating mine sections with different vehicles or equipment. The study found that the vehicle types most frequently involved in fires were trucks, loaders, drill rigs and dozers and the most frequent start position was the engine bay.

Results from the risk analysis are a good basis for deciding what risks to highlight in the plan and what risks and mine sections to analyse further. Including data from the mining sector helps to address uncertainties with a small number of incidents occurring in a mine or the uncertainties connected with a new risk being introduced.

The risk analysis provides a basis for developing design fire scenarios for different mine sections. The output from design fire scenarios provides a good basis for analysing fire behaviour and testing plans. While the actual risk analysis, design fire scenarios or modelling analysis may not be included in the plan, the findings from the analysis and scenarios should be included. The findings would be included when listing existing risks, describing how the mine ventilation system should be managed and what access routes should be used.

Given the complexity of underground mines and the added challenge of a fire, testing the plan is particularly important to reduce uncertainties. Complexity will increase demands on the testing process and an analytical approach is preferred. An analytical approach (design fire scenarios, modelling) identifies otherwise unforeseen developments or captures the multi-faceted nature of a mine fire. The use of design fire scenarios is a good tool for testing the plan as it is a tactical exercise and checkpoint during the process. The testing implies an iterative process between the refinement of data and testing of the plan (Figure 1).

The use of modelling tools, refined data, iterative testing of plans and the ongoing planning process will mitigate the challenges of a fire underground and will increase the efficiency of the response and the safety of people.

The design fire concept includes a comparison of existing or planned fire protection measures and the risk to personnel and mining operations for a given scenario. A design fire scenario should also be tested against the response of the fire and of rescue personnel as well as management of the mine ventilation and other factors. The heart of design fire scenario work is developing a heat release rate curve from which temperature distribution and smoke spread can be calculated and used as input to a fire model. Hansen (2015) provides information on the development of heat release rate curves. In applying the design fire concept, it is possible to evaluate the effects of a fire that has not yet occurred but could possibly occur. When identifying design fire scenarios for an underground mine, the unique risks and challenges should be covered. Hansen (2019) listed fire scenario characteristics in underground mines as:

- a fire with a rapid-fire-growth rate at an early stage, affecting the primary evacuation route/s
- a fire with extensive smoke production over a long time
- an extensive or fast-growing fire near an area with a large number of personnel
- a fire with continuous fire spread, resulting in a long-lasting fire with a high heat release rate
- a fire where the smoke control system fails to function, leading to extensive smoke spread
- a fire that goes undetected for a long time, resulting in a considerable fire growth and heat release rate
- a fire with longer and intermittent periods with high heat release rates and with sudden increases of heat release rates (the fire may cause problems during the smoke extraction and the rescue operation).

Most of these fire scenario characteristics do not contain information on the position of the fire. The position of the fire scenarios has to be determined for each mine based on the risks and layout. Several positions for each fire scenario should be applied to increase the robustness of the pre-incident plan. The decaying phase of the design fire scenario will be of great interest when evaluating the life safety aspect. The decaying phase may entail persistent smoke production, which will hamper evacuation of people from refuge chambers (Hansen 2019).

Unique information sources for underground mines could be the spatiotemporal distribution of the personnel underground. Due to long distances underground and extensive smoke spread, it is important to locate personnel so that fire and rescue resources can be directed in an efficient way. A positioning system underground is a great asset but having a good decision basis in the pre-incident planning will be important for prepositioning resources and assigning evacuation routes and assembly points.

Data on traffic flows and traffic patterns provides details on the transportation of hazardous materials and of large fuel loads. In addition to exposing transportation risks, the data could be used to develop design fire scenarios. The spatiotemporal distribution of mining vehicles provides data to analyse probable fire behaviour at different mine sections or when analysing possible evacuation flows. Manuals and design plans of vehicles and other equipment provide details on fuel load, which will be essential information when developing design fire scenarios.

Data refinement

The refinement of data includes conducting risk analysis and design fire scenarios. The refinement includes extraction of data from the design fire scenarios for processing when looking into cascading effects and alternative chains of events. The processing of data could involve taking the design fire scenarios further and modelling smoke spread and evacuation activities.

Fire modelling

Fire modelling is performed using either empirical models, a ventilation network based mine fire simulation software or a Computational Fluid Dynamics (CFD) software.

Applying empirical models can rapidly produce a result and can focus on a single phenomenon such as the fire's throttle effect or backlayering. Both the throttle effect and backlayering have a profound effect on smoke extraction and the rescue operation and should be included in the planning (Hansen 2020, Thomas 1968). Possible limitations of an empirical model are that the model is not valid for underground conditions or that steady-state conditions are assumed in the model. The latter can be remedied by using a quasi-steady process where, at any instance in time, the parameter can be described as if the surface or volume were exposed to a steady-state situation. When modelling large mines, the use of the quasi-steady process may become cumbersome and the use of ventilation network based mine fire simulation software could be an option. This can solve the complex mine ventilation system, where parameters are combined and solved iteratively (Hansen 2010a). It is thus possible to obtain fast and transient solutions even though the simulated system is vast and complex, which explains its frequent and long usage in the mining industry. Limitations of the software can be described using 2 assumptions (Hansen 2010a):

- unidirectional flows are assumed in the mine drifts and declines, which is seldom the case in the near field of the fire
- immediate and complete mixing of gases is often assumed, which rules out a stratified flow near the fire.

CFD models are used to predict fluid flows, heat transfer and other aspects during a fire. The setup of the input file for a mine can be time consuming, whereas ventilation network-based mine fire simulation software contains predefined parameters and can be specifically developed for mining conditions. With a CFD model, it is possible to model the area closest to the fire, accounting for multi-directional flows. Due to the high computational requirements of a CFD model, using a CFD model for an entire mine would be improbable and questionable. Instead, a CFD model should be used for the near field of the fire and provide input to ventilation network-based mine fire simulation software for the remaining parts of the mine where a unidirectional flow is more probable.

The results of the fire modelling provide valuable data when writing and testing the plan with respect to mine ventilation and evacuation safety. It is unlikely that a CFD simulation would be performed during an ongoing incident due to the high computational requirements. However, empirical models and ventilation network-based mine fire simulation software could be applied and available predefined scenarios in the software could speed up the process.

Evacuation modelling

When modelling evacuation, an egress simulation model could be used. Most models are intended for buildings and will not be suited for the underground where evacuation may take place on foot, by elevator and by vehicle. The evacuation process may include intermediate stops and using refuge chambers before evacuation to the surface takes place.

Given the generally low numbers of personnel underground, an unimpeded evacuation flow might be assumed. A simple equation-based approach could be used to calculate the movement of personnel by dividing the distance to a refuge chamber or intermediate assembly point with the assumed movement speed to obtain the movement time. This gives a rough estimate of the time needed and considerations are required with respect to physical obstructions and reduced movement speeds connected with increased numbers of personnel, as well as visitors and contractors who are less familiar with the surroundings.

Both the spatiotemporal distribution of mining personnel and vehicles serves as fundamental input data, describing the starting positions of the personnel and vehicles at the initiation of the evacuation. Typical movement speeds in different mine sections will be important information. Movement speeds applied in tunnels could be used, but the differences between 2 types of objects should be considered. A higher movement speed could generally be expected in a mine as personnel are familiar with the surroundings. The pre-evacuation time (time before an individual initiates evacuation after being notified) should be added to the movement time to obtain the time required for evacuation.

The time required to evacuate a mine section should be weighed against the time to untenable conditions in the mine section (provided from the fire modelling, see Porzycki, Schmidt-Polończyk and Wąs (2018)), where visibility can serve as a

suitable criterion due to extensive smoke spread underground. Results of the evacuation analysis and modelling provide valuable data when testing the plan and planning deployment of rescue resources, defining access routes and assembly points or mine ventilation management.

Cascading effects

A fire underground can spread beyond the start object and fire gases can affect installations further away. The ignition of adjacent fuel or the smoke spread may initiate further risks. These cascading effects need to be identified and analysed and included in the plan. When analysing cascading effects, input data from risk analysis of mine sections, descriptions of the production process and range of effects from a fire are valuable assets. Cascading effects could be identified and described in the plan, enabling fire and rescue personnel to break the chain of events and mitigate the consequences.

Alternative chains of events

One of the key parts of pre-incident planning is alternative chains of events, which increase the number of tactical options available and provide room for manoeuvre. The planning covers the different directions that an incident can take and developing backup plans and actions. The planning includes analysing possible scenarios and preparing tactical options to counter the sequence of events. Preparing tactical options includes obtaining or prepositioning specialised equipment and training of personnel for specific situations.

Underground mines with limited access routes and ventilation options increase the need for planning. The sensitivity and vulnerability in case of a system failure increases the need for a backup plan.

Components with an underground perspective

Access routes

Access routes must be carefully planned as the number of access routes may be limited and will need to serve as attack routes and as evacuation routes. Preferably, the routes should be divided into primary and alternate attack and evacuation routes to limit the risk of the 2 operations interfering with each other. When determining access routes, parameters such as the position of the fire and existing fire and smoke barriers should be considered. The selection of access routes should be synchronised with the management of the mine ventilation during a fire. The choice of access routes will not be static but will vary from fire to fire and during a fire.

When planning the evacuation by vehicle, the aim is to prevent traffic jams and ensure a steady traffic flow. There is also the possibility of vehicles driving through smoke with limited visibility. Designated access routes for specialised equipment and vehicles should be verified to ensure accessibility and the possibility of turning the vehicle around. Positions deemed critical could be identified in the plan and actions to facilitate the turnaround (such as lighting) should be considered. The inclination of the decline could be included if it affects the accessibility. The transportation time to reach positions underground could be included in the plan.

Fire protection systems

Plans should list existing automatic fire suppression systems as well as contain information on the design of the system. Information should be specific: is the suppression system designed to extinguish the fire or is it designed to contain the fire? A fire suppression system in a parking drift with large mine vehicles may be designed to contain the fire. This information is required when additional fire suppression resources are sent to the site and a prolonged smoke production could be expected.

The general lack of fire doors or barriers in a decline and the high frequency of vehicles makes a design fire scenario applicable (Hansen 2010a). The result will be helpful when planning for evacuation, alternative chains of events and the management of the mine ventilation.

Ventilation system

Pre-planning involving the ventilation system should include instructions on how to manage the ventilation system in case of a fire in a mine section. The instructions would specify what fans should be running or not and doors that should be open. The plan should also contain positions of fans, shafts, refuge chambers and places where fresh air can be found. The plan should be verified against design fire scenarios for the mine section. Backup actions should be planned in case of a loss of power or closed fire barriers. Sites critical with respect to the mine ventilation should be identified and monitored, and backup plan actions initiated if a barrier malfunctions or the smoke spreads in an undesired direction.

The fire growth rate and heat release rate of vehicle fires can be very high due to the fuel load on vehicles. A high heat release rate will cause backlayering and severe smoke production and a high fire growth rate may initiate a throttle effect that seriously affects mine ventilation (Hansen 2020). Figure 2 shows the heat release rate of a loader in an underground mine (Hansen & Ingason 2013). The initial fire growth and heat release rates are very high and cause problems to the mine ventilation. A second peak in the heat release rate can be seen after approximately 50 minutes. This is due to the fuel igniting or being engulfed at later stages. Therefore, periods of peak heat release rates can be expected at later stages. The duration of the fire is considerable and must be considered when planning for the evacuation from refuge chambers. Figure 3 displays the heat release rate from a drilling rig experiment (Hansen & Ingason 2013). The drilling rig fire involved practically all the combustible fuel items in the early phases, which is seen in the single peak and the high heat release rate.

When developing design fire scenarios, changes in the velocity or direction of ventilation during the incident (starting or ramping up fans or if a ventilation duct burns up) should be considered. A change in the direction or magnitude of the ventilation flow will result in a different smoke spread and also in a different heat release rate (Hansen 2019).

Additional scenarios to be considered in planning:

- A fire is positioned at the intake of the main airway above ground and smoke spreads downwards into the mine. The fire could result in an extensive and rapid smoke spread that affects large areas and decrease time available for evacuation.
- A vehicle fire takes place close to either an intake fan or an intake shaft. The ventilation will initially aid the smoke spread and cause problems during evacuation.

Evacuation

Due to the long distances underground and the limited number of evacuation routes, evacuation plans will differ from those used for above ground. The differences lie in the use of refuge chambers, the use of vehicles to reach a safe place and intermediate assembly points (where personnel are counted and wait for instructions whether to remain in place, head to another safer place or leave the mine). Communicating to the personnel underground what evacuation routes is of upmost importance. The progress of the evacuation also needs to be communicated to rescue crews to ensure issues are quickly solved and rescue resources are used efficiently. Backup plans in case of communication failure should be established.

The use of positioning systems underground should be planned and coordinated. Also, planning for evacuation of injured people from a refuge chamber, of personnel through smoke or of a large number of personnel from a site should also be considered.

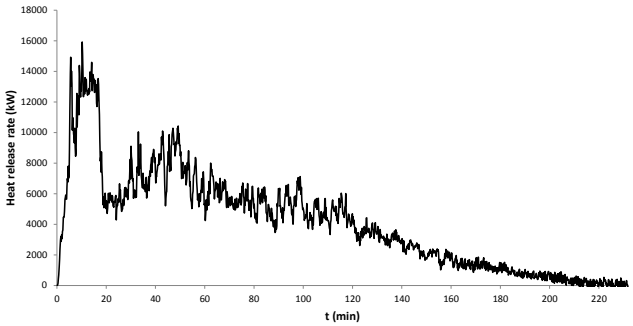

Figure 2: The heat release rate from the loader experiment (Hansen & Ingason 2013).

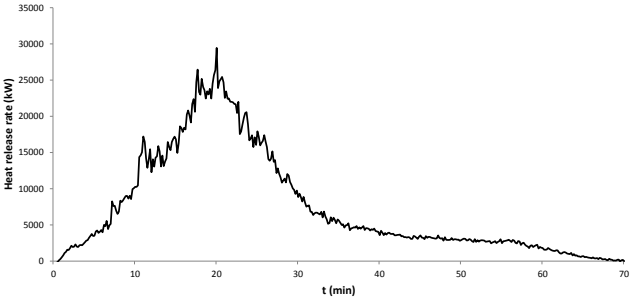

Figure 3: The heat release rate from the drilling rig experiment (Hansen & Ingason 2013).

Special considerations

Mines change as do their risks. According to Hansen (2010b), transient risks include:

- maintenance stops with hot works conducted and large amount of combustible material transported, and where the number of personnel underground increases considerably
- intermittent transports with explosives and flammable liquid in declines
- a temporary increase in the number of fire and rescue personnel, backup plan actions or countering cascading effects.

In some mine sections, smoke production may be extensive and is highly undesirable as it leads to smoke spread. This has a negative impact on the evacuation and mine ventilation as well as the fire and rescue operation. Examples where extensive smoke production occurs include conveyor drifts and workshops containing large amounts of tyres or flammable and combustible liquids (Hansen 2010a).

Abandoned parts of a mine may contain combustible material and fire protection systems may have been removed. A fire occurring in an abandoned section may go on for a long time before being detected and the fire size may be considerable. This can affect evacuation, mine ventilation and fire suppression activities.

Fire and rescue operations

In most circumstances, external firefighting resources might be used. Pre-planning could include the experience and qualifications of personnel and the need for additional training, specialised equipment and guides related to mine conditions as well as prior rehearsals for specific parts of operations.

An incident may require one or several staging points above ground and underground as well as several attack routes. The designated staging points serve as fresh air bases and turning places. When planning staging points, an evaluation is required of mine ventilation, communication, accessibility to route networks, turn-around places and other nearby risks.

Hansen (2019) indicated that design fire scenarios may cause risks and be challenging for fire and rescue operations. Figure 4 illustrates the heat release rate of a vehicle fire in a decline with longer and intermittent periods with high heat release rates occurring long after the start of the fire. The long periods of high heat release rates and the sudden increase of heat release rates adds to risks for the fire and rescue personnel.

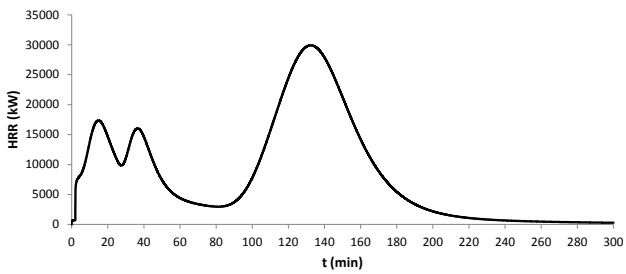

Figure 4: The heat release rate of a fire with intermittent periods with higher heat release rates (Hansen 2019).

Conclusions

To investigate pre-incident planning of fires in underground mines, data was applied from fire experiments, inventories and design fire studies. It is recommended that empirical models focusing on specific phenomena be used to complement other modelling tools. The use of empirical models may be cumbersome and using ventilation network-based mine fire simulation software is an alternative. Design fire scenarios and modelling results are a key tool when analysing fire behaviour and testing the plan and act as a checkpoint during the planning process. Mine ventilation systems should have instructions on how to manage the system and how to test it against design fire scenarios for mine sections and backup actions. By using analytical tools, iterative testing of plans and ongoing planning process, the high risks of fire in an underground mine can be mitigated.

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Perceptions of storm surges in north Queensland

Peer Reviewed

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Abstract

Storm surges have the potential to bring widespread damage to the north Australian coastline. The dangers from the wind aspect of cyclones are well understood, however, it is unclear if the same can be said about the potential dangers from accompanying storm surges. This study explored the differences between how cyclones and storm surges are perceived by people who are vulnerable to such events. It is important to consider these aspects given that storm surges have not occurred frequently in the past but may happen more often in the future. The sample consisted of 231 undergraduate students studying psychology subjects at James Cook University in Townsville in north Queensland. Participants were asked to record their experience with cyclones and storm surges, their understanding of official warnings used when these events are imminent and a self-assessment of their ability to plan and prepared for these events. Perceptions of severity, possible negative consequences, likelihood and preparedness for both events were also obtained. The results demonstrated that participants living in this region are not as familiar with the particulars of storms surges as they are with cyclones. This study suggests that further research is needed to understand how experience can both facilitate and impede perception of risk, so that risk communication can be best structured for people who do not perceive themselves as being vulnerable.

Introduction

Cyclones occur frequently in the northern parts of Australia with approximately 10 cyclones forming in the region every year and about 6 of those making landfall (Geoscience Australia 2020). Cyclones can significantly impact on the coastline bringing widespread destruction and causing economic loss to industry and infrastructure (Gurtner & Vachette 2017, Shultz *et al.* 2005). Residents living in these regions are generally knowledgeable about potential consequences from a cyclone, they have an awareness of what to do to plan for such events and an understanding of how to remain safe (Ramirez *et al.* 2013). However, despite residents appearing to have a good understanding of the dangers from the wind aspect of a cyclone, many may be less aware of the potential threats from water damage from storm surges.

Anderson-Berry and co-authors (2002) surveyed residents in 2 urban centres in northern Australia and only 22% of the 915 respondents correctly understood what a storm surge was. When participants were asked what they would do in the case of a storm surge, 75% of those respondents stated that they had no plan, or they did not answer the question. The research showed a disconnection between understanding the cause-and-effect relationship between a cyclone and a storm surge. These inaccurate perceptions about what a storm surge is and how one forms could be attributed to the infrequency of surge occurrence (Morrow *et al.* 2015). Storm surges have not occurred frequently in populous towns in northern Australia and, therefore, a large proportion of the region's population has not directly experienced such an event and possibly underestimate the dangers that a surge can bring.

Previous experience with an event is generally assumed to result in an individual being more likely to accurately perceive potential risks from similar extreme events (Wachinger *et al.* 2013). However, the type of experience can influence an individual's evaluation of possible future events. According to Wachinger and colleagues (2013), direct experience can increase perceptions of threat, especially if the consequences were severe. Indirect experience, such as family or friends being directly affected or hearing about an event via the media, can raise awareness of the consequences of extreme events but arguably may not have the effect of direct experience. Conversely, individuals who experienced an event but did not experience danger or damage may underestimate

the likelihood and consequences of future events (Keller *et al.* 2006). Perceptions of risk may lessen, and the individual may have a false sense of security regarding the occurrence and consequences of an event and hold misperceptions about their ability to cope (Keller *et al.* 2006).

The relationship between accurately perceiving a threatening situation and deciding to act in a protective manner has been widely researched (Bubeck *et al.* 2012). Several theoretical frameworks have examined the factors that predict whether someone is likely to follow recommended guidelines to remain safe (Ejeta *et al.* 2015). In particular, the Protection Motivation Theory highlights that it is not just the appraisal of threat that predicts how someone intends to behave but rather how they perceive their ability to mitigate or deal with the consequences of threat that elicits adaptive responding (Floyd *et al.* 2000). Such assessments of ability are referred to as 'perceived efficacy'. In the context of storm surges, the picture is somewhat complicated as it is unclear if surges are perceived as threatening or if the consequences from such events are recognised as potentially dangerous. While increasing perception of threat is an important factor in assisting individuals to understand potential danger from a storm surge, research suggests that this needs to be done in conjunction with communication about effective means to avoid dangerous outcomes (Bubeck *et al.* 2018).

In order to increase perceptions of threat and efficacy, research is needed to understand how storm surges are perceived in a population that is familiar with the particulars of cyclones but does not have a lot of experience with storm surges. This study explores the differences between how cyclones and storm surges are perceived and seeks to understand how the particulars of storm surges are comprehended in such a population. It is hypothesised that experience with a cyclone or a storm surge will be reflected in a higher level of understanding of the official warning systems used and greater knowledge about how to plan and prepare for that event and will also increase perceptions of the threat variables. Furthermore, it is hypothesised that storm surges will not be perceived as threatening compared to cyclones and the consequences from surges may not be recognised as potentially dangerous.

Method

Participants

Participants were recruited as a convenience sample from James Cook University who were studying first or second year psychology subjects. The data used for this study is part of a larger research project that assessed perceptions of other extreme events. Respondents were asked to report their age, gender and postcode of residential address. Given that this study focused on the perceptions about storm surges by individuals living in north Queensland, respondents who indicated that they were from an overseas campus were excluded (n=212). The final sample size consisted of 231 participants (68% female), with an average age of 23.6 years (SD=8.55).

Ethical approval was obtained through the James Cook University Human Research Ethics Committee (#H7911).

Measures

Experience was measured by asking participants if they had direct and/or indirect experience of a cyclone and storm surge. Direct experience was ascertained by asking the participants if they had been personally affected, if they had evacuated from their home or if they had lost items as a direct result of each type of event. Indirect experience was measured by asking participants if the town or city where they lived or if family and friends had been directly affected by a cyclone and/or storm surge. Survey questions covered:

- Own perceptions of understanding of official warnings - participants were asked if they knew about the official warning systems used when a cyclone is approaching or a storm surge is imminent (Yes/No).
- Assessment of ability to plan and prepare - participants were asked to indicate if they were familiar with recommended guidelines for planning and preparing for a cyclone and for a storm surge (Yes/No).
- Perceptions of severity, consequences, likelihood and preparedness - where 'severity' encompassed the entire timeline of the event and assessment of preparedness and 'consequences' dealt solely with the post-event effects. A 5-point Likert scale ranging from 1 (not at all) to 5 (extremely) was used to ascertain the perceptions of the following aspects of cyclones and storm surges:
  - potential severity
  - likelihood of one occurring in the next 5 years
  - magnitude of possible consequences
  - ability to be prepared for each event.

Procedure

The survey was made available to university students via Sona Systems website.[1] The survey was available for 12 months between September 2019 and September 2020. No cyclones or storm surges directly impacted on the region during this time. The survey took approximately 15 minutes to complete. Informed consent was obtained from all participants.

After answering the demographic questions, respondents were presented with a definition of a cyclone and of a storm surge, as:

- cyclone - a low-pressure system that forms over warm tropical waters and has gale-force winds near the centre. The gale-force winds can extend hundreds of kilometres from the cyclone centre. If the sustained winds around the centre reach 118 km/hr (gusts in excess of 165 km/hr) then the system is classified as severe (Bureau of Meteorology 2018a)
- storm surge - a raised dome of water about 60 to 80 km across and typically about 2 to 5 metres higher than the normal tide level. If the surge occurs at the same time as a high tide, then the area inundated can be quite extensive, particularly along low-lying coastlines (Bureau of Meteorology 2018b).

1. Sona Systems is an online research platform used by universities to recruit research participants.

Results

Table 1 shows that the majority of respondents reported having experience, understanding of warnings and had plans and preparations in place for cyclones. When considering storm surges, the corresponding proportions were all around one-third of the sample. The exception was indirect experience of storm surges, which was endorsed by around half the sample.

Table 2 shows how 'experience' was related to an understanding of warnings and a preparedness for each type of event. Chi-square tests of association showed that there was a significant association between direct experience of cyclones and understanding of warnings, χ^2 (1, n=231)=11.89, p=0.001, and direct experience and planning and preparing, χ^2(1, n=231)=16.45, p<0.001. Of respondents who stated they were aware of the warning systems used, the majority were also those who had experienced a cyclone. This pattern was repeated when considering those who reported having a plan and being prepared for a cyclone.

An association was also seen for storm surges between direct experience and understanding of warnings, χ^2 (1, n=231)=22.33, p<0.001 and direct experience and planning and preparing χ^2 (1, n=231)=34.20, p<0.001. However, the pattern was opposite to that observed for cyclones. Over half respondents indicated that they did not have direct experience of a storm surge and were not aware of warning systems for storm surges. A similar proportion reported not having indirect experience nor having a plan/being prepared for the advent of such an event.

A further Chi-square analysis was conducted to explore the relationship between indirect experience and understanding of official warning systems in place for cyclones and storm surges, as suggested by the literature (see Table 3). No significant association was seen in the case of cyclones, χ^2 (1, n=231)=1.56, p=0.0212, but one was found for storm surges, χ^2 (1, n=231)=24.25, p<0.001. Participants who had no indirect experience with storm surges also tended to report not being aware of the warning systems associated with such an event.

Pearson's product-moment correlations were computed to examine the relationships between age and perceptions of severity, likelihood, possible consequences and ability to plan and prepare for cyclones and for storm surges, and the relationships between the perception variables. Tables 4 and 5 show no significant relationships were detected between age and the

Table 1: Percentage of participants responding 'yes' in each category, for each extreme event.

Categories	Cyclones		Storm surges	
	N	%	N	%
Direct experience	181	78.4	71	30.7
Indirect experience	193	83.5	109	48.2
Understanding of warnings	187	81.0	79	34.2
Plan and prepare	204	88.3	77	33.3
All categories	136	58.9	30	13.0

Table 2: Crosstabulations for direct experience with cyclones and storm surges.

		Understanding of warnings cyclone	
		Yes	No
Direct experience cyclone	Yes	67.1%	11.3%
	No	13.9%	7.8%
		Planning and preparing for cyclone	
		Yes	No
Direct experience cyclone	Yes	72.7%	5.6%
	No	15.6%	6.1%
		Understanding of warnings storm surge	
		Yes	No
Direct experience storm surge	Yes	17.3%	13.4%
	No	16.9%	52.4%
		Planning and preparing for storm surge	
		Yes	No
Direct experience storm surge	Yes	18.6%	12.1%
	No	14.7%	54.5%

Table 3: Crosstabulations for indirect experience with cyclones and storm surges.

		Understanding of warnings cyclone	
		Yes	No
Indirect experience cyclone	Yes	68.8%	14.7%
	No	12.1%	4.3%
		Understanding of warnings storm surge	
		Yes	No
Indirect experience Storm Surge	Yes	23.8%	23.4%
	No	10.4%	42.4%

perception variables for either cyclones or storm surges (all $p>0.05$). For cyclones, significant positive associations were seen between all other variables (Table 4). The correlation coefficients for the perception variables for storm surges were only significant between the severity and consequences variables and the likelihood and preparedness variables (Table 5).

A point-biserial correlation was run to determine the relationship between gender and perceptions of the severity, likelihood, possible consequences and ability to plan and prepare for cyclones and storm surges. It appeared that females in the sample were more likely than males to report higher perceptions of the severity of cyclones ($r(pb)=0.151$, $p=0.023$) (Table 4). Females also tended to perceive their ability to plan and prepare for storm surges as significantly lower than males ($r(pb)= 0.178$, $p=0.007$) (Table 5). All other correlations between gender and the listed variables, for both cyclones and storm surges, were not significantly different to zero (all $ps>0.05$).

Paired sample t-tests were conducted to see if participant perceptions about the severity, likelihood, consequences and ability to plan and prepare, differed between cyclones and storm surges. The mean rating for each variable and for each event is shown in Table 6. Cyclones were perceived as significantly more severe, more likely to occur, result in more severe consequences and respondents rated themselves as better prepared, compared to storm surges.

Independent t-tests were run to examine if direct experience with each event impacted on how participants perceived the severity, likelihood, possible consequences and ability to plan and prepare for cyclones and storm surges. For both cyclones and storm surges, shown in Table 7 and Table 8, direct experience with the event did not affect how participants rated the severity or how they perceived potential consequences that could occur (all $p>0.05$). Respondents with direct cyclone experience rated the likelihood of a cyclone in the next 5 years as significantly higher than those with no direct experience. Those with direct experience also rated their ability to plan and prepare for a cyclone higher than those with no such experience. This pattern was seen in those with direct experience with a storm surge and respondents with direct experience rated the likelihood and their level of preparedness higher than those with no direct experience.

Discussion

The focus of this study was to examine how storm surges were perceived in a population that is vulnerable to such events. The study first sought to ascertain how familiar participants were with cyclones and with storm surges. Cyclones occur frequently in this region and the results supported that participants were more familiar with cyclones than they were with storm surges. It was not surprising that respondents recorded a greater level of experience with cyclones (78%) compared to storm surges (31%), higher levels of understanding of official warning systems used for cyclones (81%) compared to storm surges (34%) and greater understanding of how to plan and prepare for wind events (88%) rather than storm surges (33%). Despite the differences in the samples used in the study (defined subgroup) and the sample used in the Anderson-Berry and co-authors (2002) survey (systematic household survey), the results of the current study are in line with the earlier research.

Direct experience

This study explored the role of directly experiencing a cyclone or storm surge on understanding of warning systems and knowledge of what to do to plan and prepare for the event. As suggested by Wachinger and co-authors (2013), experiencing an event may directly increase an awareness of the dangers that may occur and the necessity to take protective action. The results supported the hypothesis that direct experience with either a cyclone or storm surge would be associated with having a better understanding of the official warning systems used and knowing how to plan and prepare for that event.

Despite this link, direct experience was not shown to effect how participants perceived the severity or potential consequences that could occur from a cyclone or from a storm surge. This appears to be understandable for storm surges, as these events have not occurred frequently and it could be expected that individuals would underestimate their perception of risk for these events. However, it was surprising that direct experience with a cyclone did not increase perception of the threat variables. It could be that the experience participants had was not serious enough to elicit a sense of danger about the magnitude of consequences that could occur. It might also be that participants underestimated the intensity of this category of cyclone. There is evidence for such an underestimation of wind speed and intensity in the literature. Scovell and co-authors (2020) asked residents of the region from which the current sample was recruited, to retrospectively estimate the speed of Severe Tropical Cyclone Yasi in their area. All respondents had experienced the fringe effects of the cyclone but none lived in the direct path of the cyclone. Scovell and co-authors (2020) reported that 70% of the sample overestimated

Table 4: Correlations of age, gender and perception variables for cyclones.

Variables	1.	2.	3.	4.	5.	6.
1. Age	-					
2. Gender	0.011	-				
3. Severity	0.060	0.151*				
4. Likelihood	0.018	0.068	0.344**	-		
5. Consequences	0.102	-0.018	0.497**	0.194**	-	
6. Prepared	0.115	0.064	0.228**	0.374**	0.181**	-

*p<0.05. **p<0.01.

Table 5: Correlations of age, gender and perception variables for storm surges.

Variables	1.	2.	3.	4.	5.	6.
1. Age	-					
2. Gender	0.011	-				
3. Severity	0.005	0.022	-			
4. Likelihood	0.021	-0.056	0.036	-		
5. Consequences	-0.037	0.018	0.588**	0.119	-	
6. Prepared	0.089	-0.178**	0.080	0.299**	0.086	-

*p<0.05. **p<0.01.

Table 6: Results from paired t-test comparing cyclones and storm surges.

Type	Cyclones		Storm Surges		*t*	*p*
	M	SD	M	SD		
Severity	3.42	0.880	2.97	0.944	6.675	0.000
Likelihood	4.24	0.852	3.06	1.080	14.193	0.000
Consequences	3.84	0.852	3.39	0.852	7.683	0.000
Preparedness	3.73	0.863	2.70	1.140	13.464	0.000

Table 7: Direct experience with a cyclone.

Type	Yes n=181		No n=50		*t*	*p*
	M	SD	M	SD		
Severity	3.43	0.883	3.36	0.875	0.504	0.615
Likelihood	4.33	0.774	3.96	1.049	2.726	0.007
Consequences	3.86	0.761	3.76	0.822	0.779	0.437
Preparedness	3.86	0.790	3.28	0.970	4.338	0.000

Table 8: Direct experience with a storm surge.

Type	Yes n=71		No n=160		*t*	*p*
	M	SD	M	SD		
Severity	3.01	0.933	2.95	0.950	0.475	0.635
Likelihood	3.65	0.927	2.81	1.043	5.849	0.000
Consequences	3.39	0.836	3.39	0.861	0.056	0.955
Preparedness	3.17	0.926	2.49	1.165	4.354	0.000

the wind speed in their area by at least one cyclone category level. Given that the locations sampled in that study (Scovell *et al.* 2020) and that participants did not experience any extensive damage to housing stock and other property from that cyclone, it was also not surprising that the respondents also underestimated the consequences of future cyclones.

Direct experience with a cyclone or with a storm surge in this study was positively associated with the intention to plan and prepare for an event. This suggests that participants had confidence to take action to avoid harm when faced with these events. However, given that experience did not increase perceptions of threat, it could be that participants had overconfidence in their ability to plan and prepare, as they underestimated the potential threat from the situation. Figure 1 shows the extent of inundation and evacuation zones in Townsville.

Indirect experience

Indirect experience has been suggested to increase knowledge about an event, through raising awareness through media outlets or because family or friends had been impacted (Wachinger *et al.* 2013). The study examined if indirect experience increased the likelihood of participants being aware of the official systems used to convey the risk from an approaching cyclone or storm surge. While a large percentage of the sample had indirect experience with a cyclone (84%) and a storm surge (49%), this variable was only shown to be associated with participants' understandings of warning systems in the context of storm surges. However, this was only reflected for those respondents who did not have indirect experience and were not aware of official warnings for storm surges. Indirect experience was therefore not shown to impact on this variable in a meaningful way. For cyclones, the overall awareness was already high, given that 78% of participants recorded having direct experience, and so indirect experience alone did not influence on how many participants indicated that they were aware of official risk communication.

While indirect experience has been shown to increase knowledge about an event (Wachinger *et al.* 2013), this was not supported in this study, raising questions about possible ambiguity on this variable. It could be that indirect experience was too broad a category, encompassing a wide range of experience or anecdotal recollections rather than specific events that could contribute to an increase in knowledge.

Age and gender demographics

The study did not find any significant relationship between the age and perceptions of the severity, likelihood, possible consequences and ability to plan and prepare for cyclones and for storm surges. While females perceived cyclones to be more severe than males and reported being less able to plan and prepare for a storm surge compared to males, these were very weak relationships. Therefore, it can be concluded that gender did not appear to have a meaningful impact on the perception variables in this sample.

Comparison between cyclones and storm surges

Finally, the study examined if there were differences between how participants perceived cyclones and storm surges. Cyclones were perceived as more severe, more likely to occur, result in more consequences and more able to be prepared for than storm surges. While this result was not surprising, given that more

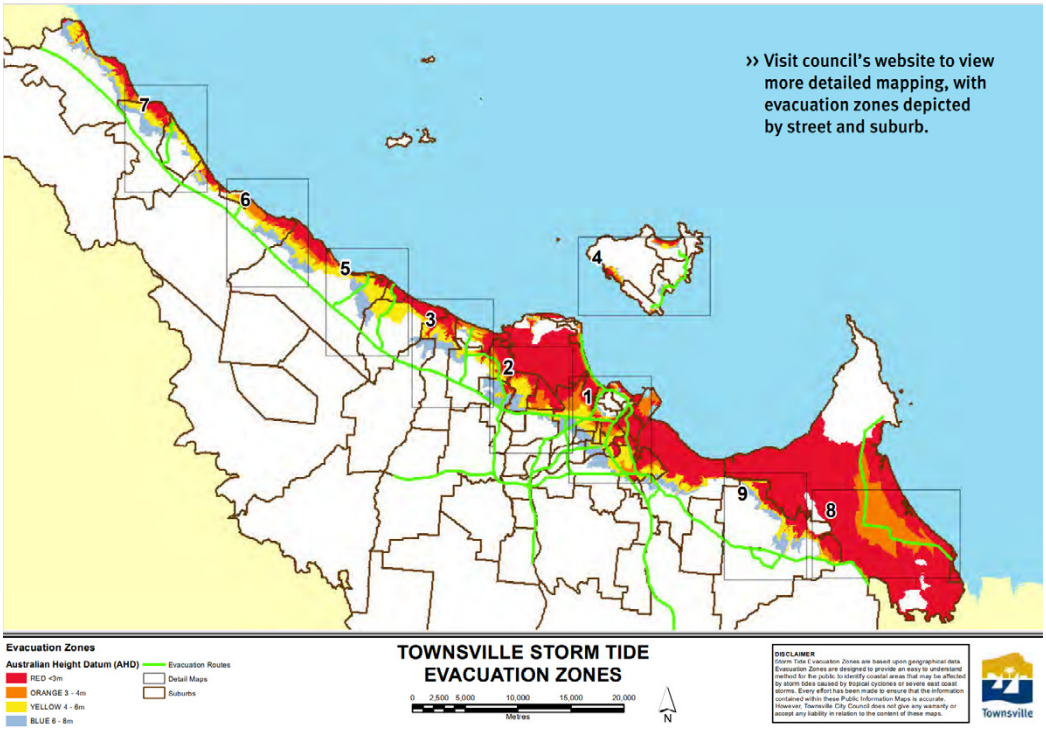

Figure 1: Map of Townsville, Queensland, showing storm surge inundation and evacuation zones.

Source: Townsville Storm Tide Evacuation Guide, at www.townsville.qld.gov.au/__data/assets/pdf_file/0021/6735/TCC_Evacuation-Guide.pdf.

participants had experienced a cyclone, it highlights that the threat from a storm surge appears to be underestimated. In order to increase awareness of how to remain safe during a storm surge, it is imperative to increase perceptions of the danger a storm surge can bring. Understanding how storm surges are perceived can inform further research to contribute to improving community awareness and preparedness behaviours.

Several limitations were identified in the study. First, the use of a student convenience sample may not be representative of the general population. The aim of this study was to ascertain how storm surges are perceived in relation to cyclones and to inform further research in a population at risk from these events but with differential experience of each. Therefore, this limitation should not affect the interpretation of the results within the context of an early tertiary educated, young adult sample. The results also provide evidence for the likely usefulness of further investigations with a broader sample. Second, it is acknowledged that the descriptive approach to asking participants about their knowledge about cyclones and storm surges may be biased and not reflect accurate, objectively gathered information. This study sought to establish a baseline of perceptions, as it is important to understand what individuals think they know in order to assess the foundations for intentions and behaviour. Future research could explore how participant subjective interpretations reflect objective information.

Conclusion

The dangers from cyclonic winds are widely known in north Queensland. However, this study demonstrated that some residents living in this region may not be as familiar with the particulars of storm surges. While storm surges have not occurred frequently in this region and respondents predictably had limited experience with these events, the study highlighted that the multi-faceted nature of experience warrants further exploration. Future research should focus on how experience can both facilitate and impede risk perception, to further understand how to target risk communication, in particular for individuals who do not perceive themselves as vulnerable.

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Abstract

Every year, flash floods hit many cities in the Kingdom of Saudi Arabia (Saudi Arabia) leading to many injuries and deaths as well as a huge amount of damage to infrastructure. Risks of frequent flash floods have been linked to a lack of emergency planning. This paper presents a systematic review of emergency planning for flash floods response currently in place in Saudi Arabia. Collected information was analysed based on the suitability of content and data for emergency planning in flash floods response. Aspects of the dominant approach of emergency planning and the community-based approach are examined and considered against applications in Saudi Arabia. A case study is used about flash floods in Jeddah in 2009 and 2011 to consider these approaches. This may be the first systematic review of emergency planning for flash floods response in Saudi Arabia and shortcomings listed may lead to improvements in policy, planning and training, particularly given the scientific consensus of an increase in the frequency and magnitude of flash floods in Saudi Arabia.

A systematic review of the emergency planning for flash floods response in the Kingdom of Saudi Arabia

Peer Reviewed

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Introduction

The Emergency Events Database (UNDRR 2020) shows that a total of 7,348 natural disasters have occurred in the past 2 decades. Table 1 shows that between 2000 and 2019 around 1.23 million people died due to a natural hazard disaster, averaging 60,000 deaths annually, with other impacts on more than 4 billion people. In economic terms, such disasters globally caused a loss of around US$2.97 trillion (UNDRR 2020). Compared to the preceding 2 decades, the number and effects of natural hazards disasters have significantly increased. Between 1980 and 1999 there were 4,212 reported disasters across the globe, with loss of life of around 1.19 million people and impacts on more than 3 billion individuals, plus US$1.63 trillion lost in economic terms (UNDRR 2020). Remarkably, between 2000 and 2019, flash flooding made up 44% of recorded disasters and affected 1.6 billion people globally, which was more than for any other kind of disaster and averages 163 occurrences each year (UNDRR 2020).

Table 1: Effects of disasters: 1980–99 compared to 2000–19.

Category	1980–99	2000–19
Reported disasters	4,212	7,348
Total l costs of deaths	US$1.19 million	US$1.23 million
Total costs of people affected	US$3.25 billion	US$4.03 billion
Economic losses	US$1.63 trillion	$2.97 trillion

Source: UNDRR (2020)

Studies including those of Alexander (2002), Shaluf (2008), Kusumasari, Alam and Siddiqui (2010) and Mikulsen and Diduck (2016), describe a 4-phase approach to managing emergencies namely: mitigation, preparedness, response and recovery, as shown in Figure 1. Each of these emergency management phases has a role in safeguarding lives as well as property. Although there is significance to actions

taken in all of these phases, preparedness activities that include emergency planning are considered the most significant. The literature on managing emergencies continues to develop and the central role of planning for effective preparedness and response activities has increased in this field. With this in mind, this paper presents a systematic review of the approaches to emergency planning with a case study for flash floods response planning in the Saudi Arabia.

Motivations

Although the climate in Saudi Arabia is characterised as dry overall, flash floods are increasingly occurring and affecting most Saudi cities (Mohamed 2017; Chen, Yeh & Chen 2018). These flash floods have resulted in injuries and deaths as well as general damage to residences, vehicles and other property (Youssef *et al.* 2016, Abdalla 2018) as shown in Figure 2. Both socially and economically, such events severely affect the country.

The planning for flash floods response varies significantly from country to country. In Saudi Arabia, the General Directorate of Civil Defence (GDCD) holds overall responsibility for managing and planning for emergencies as well as for protecting lives and properties (GDCD 2020a, GDCD 2020b). This is characterised as 'working from the top down'. However, while GDCD has shown intent for identifying flash floods risks, its policies, legislation and regulation development related to emergency planning for flash floods response has been a prolonged process (Abosuliman, Kumar & Alam 2013). According to Alamri (2010), the GDCD has struggled to be proactive when planning for risks related to flash floods and may be less prepared for possible future flash floods as risk-reduction approaches are mainly reactive rather than proactive (Ledraa & Al-Ghamdi 2020).

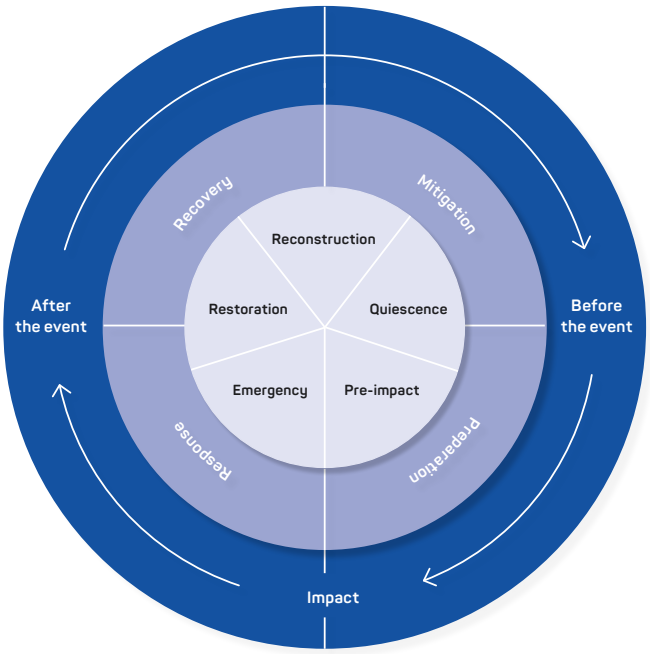

Figure 1: The emergency management cycle.

Source: Alexander (2002)

Saudi Arabia has been subject to criticism from individuals and local and international societies related to its policies, procedures and plans used in planning for flash floods. It is clear that there is a need for effective emergency and disaster response planning on the part of the decision-makers and response agencies. This systematic review of the literature aims to understand the trends in planning for emergency and disaster response that focuses on flash floods response in Saudi Arabia. Lessons are identified.

Methodology

Research approach

According to Khan and co-authors (2001), a systematic review is defined as:

> *A review of the literature on a clearly formulated question that uses systematic and explicit methods to identify, select and critically appraise relevant secondary data, and to extract and analyse data from the studies that are included in the review.* (p.12).

The literature review for this paper was performed on databases such as Google Scholar and Scopus, since each database has different functionality. The research used terms such as: 'disaster response', 'disaster preparedness', 'emergency planning', 'emergency management policies and plans', 'emergency training or capability' and 'flash floods in Saudi Arabia. The full papers (in English or Arabic languages) were used on yearly national emergency prevention and response, on flash floods, threats and mitigation of floods, emergency preparedness, emergency response, flood guidance and emergency policies/decrees. The papers were evaluated on the basis of their link with disasters and components of disaster management, especially preparedness and planning for response to flash flooding.

English and Arabic publications were selected that related to disaster preparedness and response planning research in Saudi Arabia between January 2000 and December 2020. Publications that included compound terms such as 'emergency policy and preparedness', 'disaster management reforms' or 'floods impacts' were analysed, regardless of the paper's form and content.

The full publication type for each paper was analysed on disaster preparedness and response planning. Any overlaps were noted, such as between preparedness and response policy and disaster management. In order to explore how prepared Saudi Arabia's government and response authorities are with regards to responding to flash flooding, emergency planning papers linked specifically to flash floods were reviewed, except those that did not match the full criteria.

An Excel spreadsheet was used to compile the data and to analyse themes of emergency planning for flash flood response and any challenges, particularly in relation to flash flooding in Saudi Arabia.

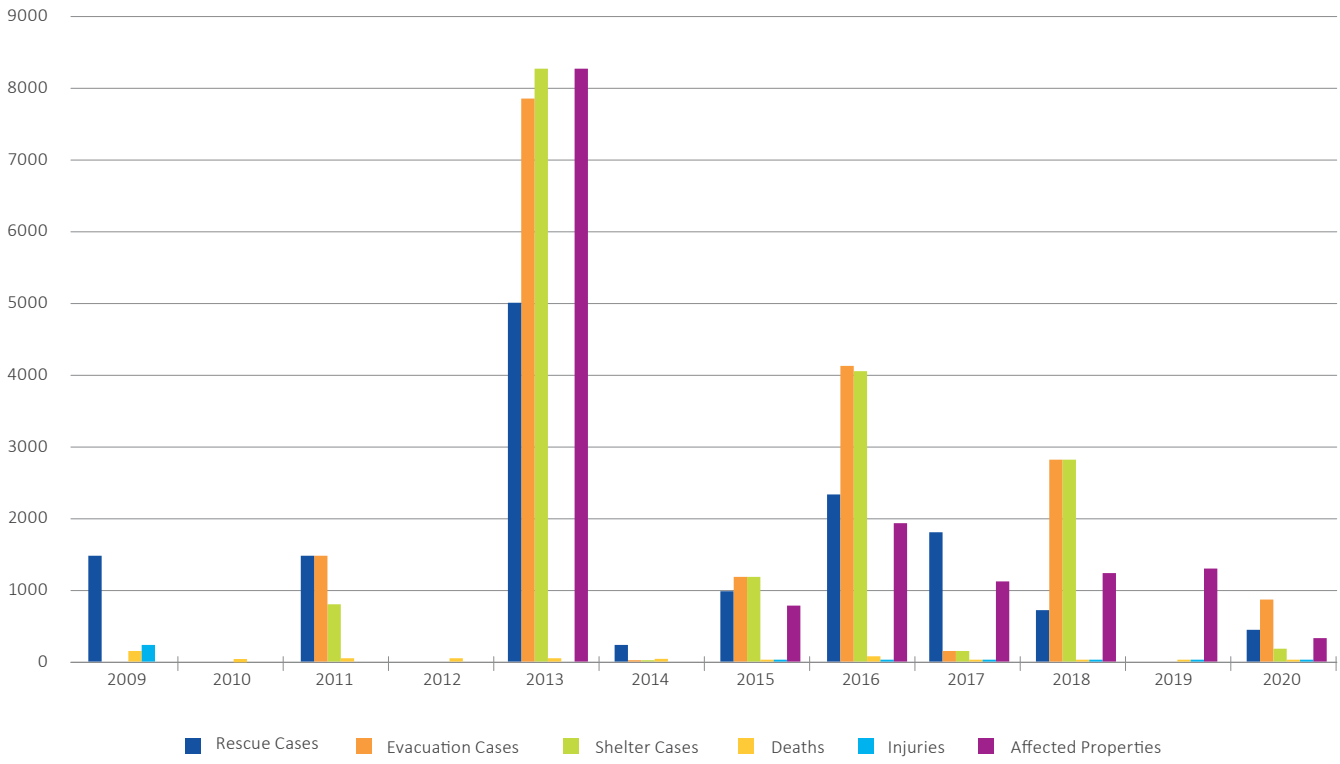

Figure 2: Frequency of flash floods in Saudi Arabia between 2009 and 2020.

Source: GDCD (2021)

Results

A total of 123 articles, papers and plans were obtained and reviewed. Of these, 18 complete papers met the inclusion criteria, including the GDCD website. These were analysed based on the suitability of content and data for emergency planning for flash flood response in Saudi Arabia (see Figure 3).

Discussion

Planning

Governments, experts and organisations are continually working on methods to prepare for and respond to hazards and threats to minimise the severe effects of these events on individuals, communities and infrastructure. Planning is an essential and vital part of the preparedness phase. The concept of planning varies according to the field in which it functions. Generally, scholars have held that it has been taking place since biblical times: the story of Noah's Ark is often cited as one instance where plans were developed in advance of a severe disaster. Additionally, Alexander (2002) states that emergency planning started to spread in government, business and culture in the 1990s and defines emergency planning as, 'A response to the requirement to enhance safety as well as progressing understanding of hazards' (p.10).

The wide range of disasters that has led to extensive harm and lives lost attests to the importance and value of planning. Zhao and co-authors (2017) indicate that before an event occurs, emergency planning can effectively minimise the harm; in other words, emergency planning is key for effective emergency management. The approaches to emergency planning include how planning should be performed and who should be doing it. In general, 2 viewpoints have been established over the last 2 decades: the 'dominant' and the 'community-based' approach.

The dominant approach

Looking into history, planning was a unidirectional, information-driven process implemented 'top-down' by practising specialists of emergency planning (McGuirk 2001). This approach is known as the dominant approach and concentrates on hazards as the main factor in an emergency and positions it as central to response planning. Based on this interpretation, the dominant approach tends to concentrate on strategies for infrastructure such as flood dams and technological solutions to control the hazard. A dominant 'top-down' strategy may also recommend, for example, moving individuals to safer areas to avoid the flood threat.

The historical record of the dominant approach can be seen, for example, in the use of constructed flood controls such as dams in ancient urban civilisations (Jones 2000, Fleming *et al.* 2001). Additionally, the Indian Ocean tsunami in 2004, was monitored

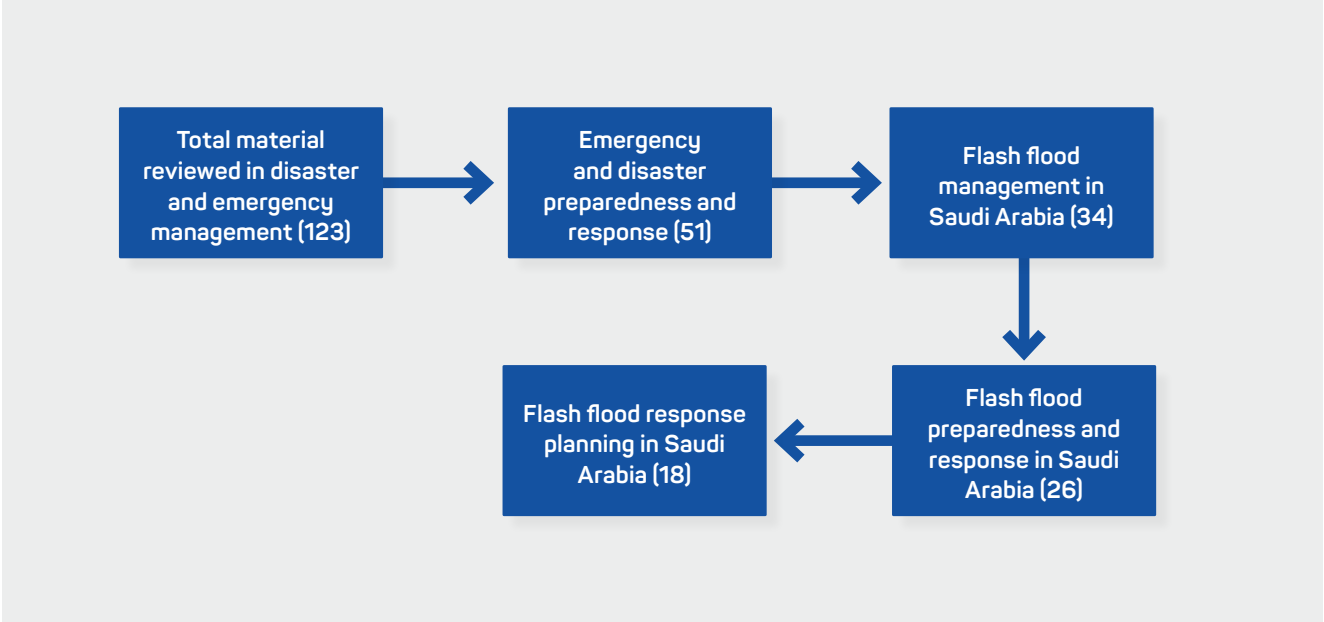

Figure 3: Literature review search results for emergency planning for disaster response.

by a highly technical early warning system. The severity of that event resulted in a request from the British government for a Natural Hazard Working Group meeting to be held to advise on the monitoring of tsunamis, floods, cyclones and other natural disasters (King *et al.* 2005).

The dominant approach, however, is marked by many flaws. Several studies have criticised the organisational top down approach in emergency planning, especially in the developing world (Jain 2000, Magrabi 2012). These difficulties and shortcomings prompted planners to investigate other decision-making methods and to encourage community participation. A gradual transition from the dominant approach to the community-based approach is ongoing albeit slower than expected (Buckle, Marsh & Smail 2003).

The community-based approach

The community-based approach includes planning that is undertaken by a variety of people and typically values democratic and opinion values. There is a dependency on engagement and consultation and also on the representation and interaction of a variety of participants. The community-based approach emphasises inclusion and participation of partners in the planning stage as well as the cooperation and coordination between decision-makers and affected communities (Innes 2004, Koontz & Johnson 2004). The concept is also known as 'community-based' in non-government organisations and community-based organisations.

Giddens (2013) indicates that the theoretical framework for the community-based approach is based in Critical Theory by Jürgen Habermas. In the decision-making phase, planning includes and involves all stakeholders and planners to facilitate shared comprehension of the information based on real, truthful communication and discussion between planners and community members. In this way, the community-based planning approach is intrinsically collaborative, consultative and participative.

The main difference between this approach and the dominant approach is that it stresses susceptibility to a hazard instead of the hazard itself, with groups considered vulnerable being able to participate effectively as part of the problem-solving efforts. The community-based approach provides a 'bottom-up' procedure from the people at risk, showing the connection between disasters and humans and their physical, economic and social situations. Thus, Heijmans (2004) argues that successful emergency planning should be based on social, political and economic community factors.

Although the community-based approach is widely acknowledged by many community organisations, others underestimate the role of local communities. In India, the High Committee on Disaster Management argued that due to the low literacy levels and extensive poverty of their population, the community as an important entity is yet to take form (National Centre for Disaster Management 2001). However, there have been many attempts to shape and enhance local community-based organisations.

Jeddah flash floods: a case study

The statistical analysis of disasters showed that the most widespread threat in the past 2 decades has been flash floods (Alamri 2010, Youssef *et al.* 2016). This risk is largely due to the geography and topography of Saudi Arabia (Solecki, Leichenko & O'Brien 2011). To explore the effectiveness of emergency planning in Saudi Arabia, the Jeddah flash floods in 2009 and 2011 are examined as a case study. Figure 4 shows the location of Jeddah city.

Figure 4: Location of Jeddah City within Saudi Arabia.

On 25 November 2009, the city of Jeddah experienced substantial rainfall with 90mm of rain within 4 hours. This was twice the city's annual average (Azzam & Ali 2019). Flash flooding hit multiple areas across Jeddah at midday and poorer neighbourhoods to the south of the city were most affected (Abosuliman, Kumar & ALam 2014). Less than 2 years on, on 26 January 2011, the city suffered another severe heavy rain event of 111mm (Ameur 2016). Azeez and co-authors (2020) state that this heavy rain led to a flash flood, causing the Um al-Khair Dam to fail. As a result, many people, homes and other properties were destroyed or severely damaged. Figure 5 shows a collection of satellite images of the Um al-Khair Dam. Image (a) is the dam before the collapse, image (b) shows the dam during the failure, image (c) shows the second day of the flash flood and image (d) shows the dam several days after the flash flood.

The damage from both flood events was vast: 161 people lost their lives in the first occurrence and a further 11 died in 2011 (Ameur 2016, Youssef *et al.* 2016, Azzam & Ali 2019). Furthermore, 8,000 homes and over 7,000 vehicles were damaged (Abosuliman, Kumar & Alam 2014). The economic damages totalled approximately US$1 billion and the reimbursement for those affected was projected at a further US$2 billion (Ameur 2016). The floodwaters washed across 80% of the city, including highways, sidewalks and structures and covered around 400 to 600km^2 (Azzam & Ali 2019). The flash flood effects led to condemnation by numerous accountable Saudi government organisations including wastewater control, flood prevention and emergency response (Al-Saud 2010).

The primary objective of investigations into the Jeddah flash floods was to determine how response was planned. Firstly, there was a lack of data for forecasting, mitigation and emergency planning. The advanced warning system was ineffective and an incomplete Emergency Relief Plan also contributed to planning failures. A further and fundamental reason for inefficiency was the strictly centralised aspect of the emergency management system. Even though response and relief activities have been evident in rebuilding and rehabilitation and there has been a greater focus on the response and recovery phases, it does not mean that such phases were successfully applied. In fact, difficulties were likely to arise in each of the phases. Additionally, the lack of a master flood management plan was an important reason for a poor response. Finally, there were no qualified teams or special emergency response training at either the city or national levels.

This case summary indicates that the contributing failures could include:

- inefficiency in advanced emergency planning
- a top-down, centralised system for emergency planning rather than a bottom-up approach
- stakeholders are not involved in disaster response planning
- poor contact, collaboration and cooperation between response organisations, local communities and stakeholders
- inefficient or non-existent training in responding to floods
- a lack of preparation, experience and knowledge about major risk areas
- no central database system or a way to monitor and control the information management system.

Conclusions

This paper presented a systematic review of emergency planning for flash floods response in Saudi Arabia. This included a discussion of the dominant and the community-based approaches to emergency planning. The recognised advantages in using a community-based approach for emergency planning still experiences limitations on what could be accomplished through identification and analysis of risks as well as potential solutions at the community level. For example, when identifying and analysing potential hazards, communities may not place adequate focus on hazards and risk they have not yet encountered. These could include dormant volcanoes or threats associated with a changing climate.

Conversely, the remedial steps required using the dominant approach could be hampered by the substantial economic costs required to implement such steps. For example, flood risks found in upstream communities would affect downstream communities and they should also be considered. The resources needed to address these factors could generate further risks. Thus, it might be that a mixture of dominant and community-based approaches is an effective method for emergency planning for flash floods response.

There are challenges facing current emergency planning for flash floods response in Saudi Arabia particularly related to a lack of policies, an ambiguity of legislation and plans, poor coordination between stakeholders, a lack of involvement from all stakeholders, a lack of databases for emergency planning and poor training for personnel. Encouragingly, compared to neighbouring countries, emergency planning in Saudi Arabia has

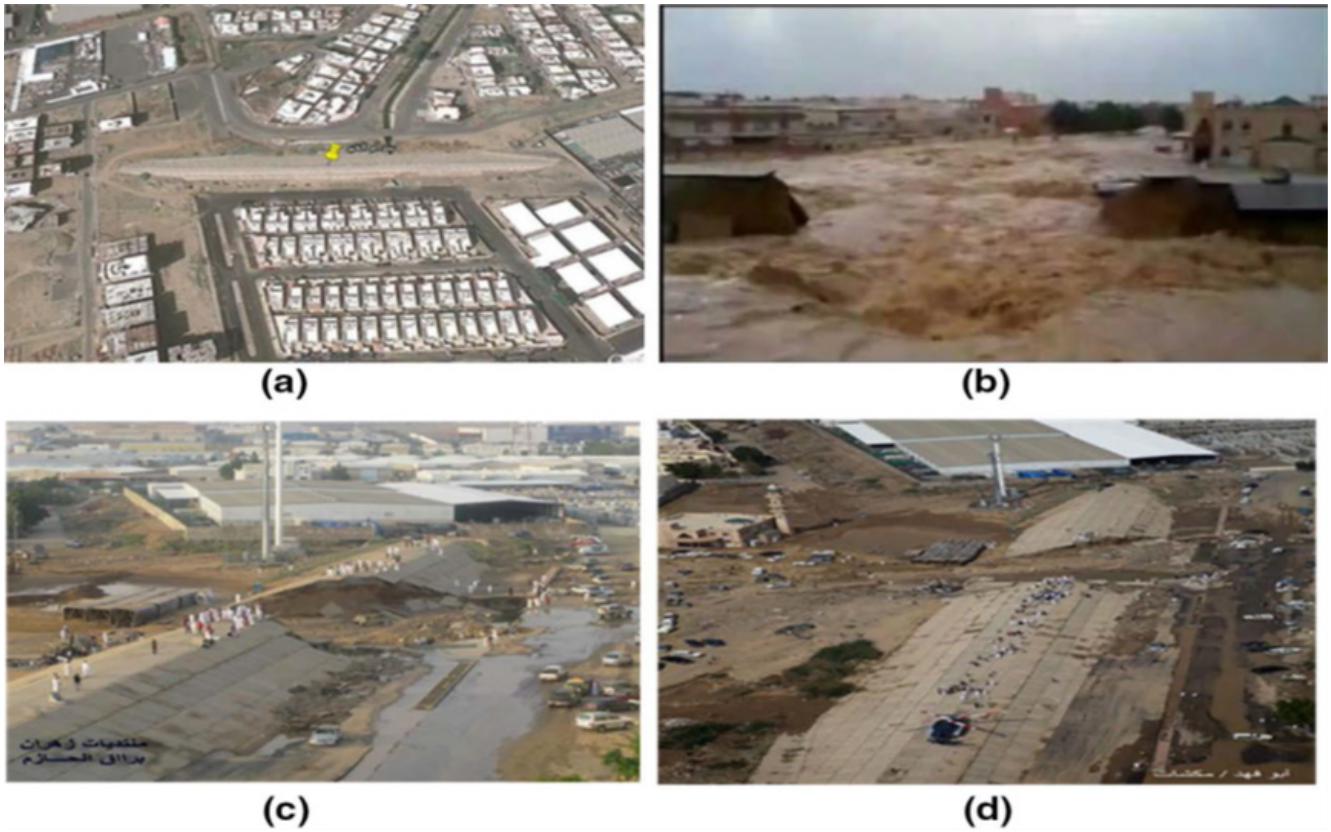

Figure 5: Satellite images of the Um al-Khair Dam before (a), during (b) and after the collapse (c) and (d).

Source: Azeez *et al.* 2020

greatly improved over the past 2 decades. However, the focus remains on handling disasters reactively, rather than on planning for possible future hazards and being proactive and taking a risk-reduction approach. Emergency planning requires a proactive attitude and a mixture of the dominant and community-based planning approaches, especially with regards to flash flood preparedness, early warning systems, response planning and hazard risk identification and treatment.

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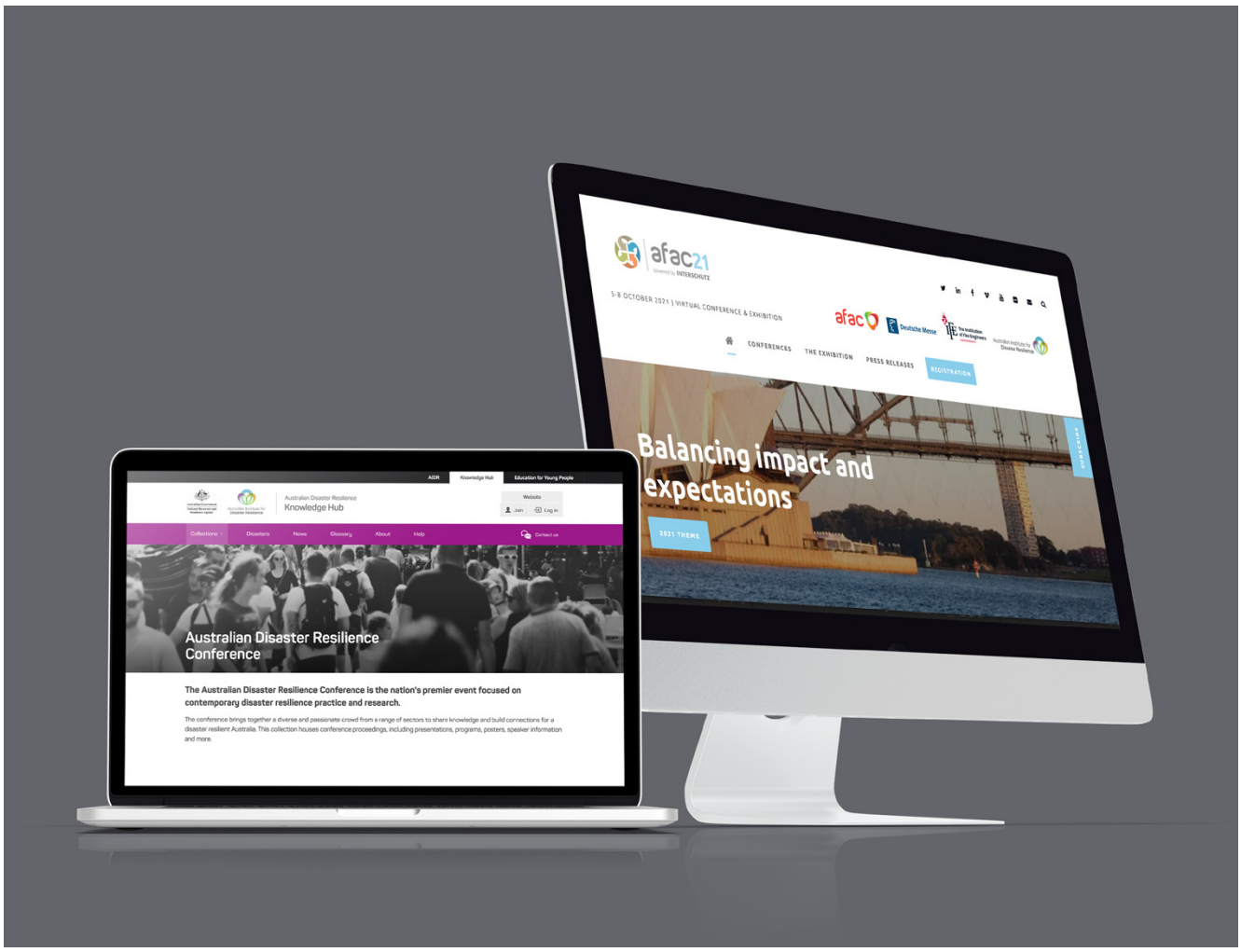

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