How ready is ready? Measuring physical preparedness for severe storms

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Abstract

This paper investigates use of inventories, or checklists of activities, as an emergency management tool to motivate preparedness action in individuals. It develops the inventory concept to provide the foundation for a more targeted approach to storm preparation communication and community engagement. It also examines the potential efficacy of alternatives to paper-based checklists, such as web or smartphone applications. Academic and grey literature was reviewed to collect activities for a storm inventory for emergency agencies to measure individual preparedness and individuals to measure their preparation progress. The resulting master list was refined for application and tested for useability in a pilot study of semi-structured interviews in a storm-susceptible community in Queensland, Australia. Also, clustering items by type of preparedness activity reveal where strengths and weaknesses exist in individual preparedness. For instance, preparation for leaving and safety planning were shown to be the areas of weakest activity in the pilot sample, while preparation of the house for a storm was the strongest area. In addition, behaviour change literature shows potential for effective use of an inventory-based smartphone application in motivating preparation activity. Data collected by a storm preparedness smartphone application could show where a communication or engagement program for targeted communities should be focused. It is supported by health literature that identifies preferences of individuals to make progress on complex tasks in stages, the value of lists to achievement of goals and demonstrated increase in uptake of activities prompted by smartphone applications over web or paper-based diaries.

Keywords: Storm, Cyclone, Hurricane, Inventory, Hazard adjustments, Preparedness, Checklist

Introduction

Motivating individuals and households to prepare for natural hazards has become an increasingly important strategy in emergency management since the mid-1990s (Ablah et al. **2009**; Allen **2006**; Boon **2014**; Childs et al. **2006**; Cretikos et al. **2008**; Gillespie and Streeter **1987**; Goudie **2007**; Goudie and King **1999**; Handmer and O'Neill **2016**; Howe et al. **2018**; Kapucu **2008**; Kohn et al. **2012**; MacDougall et al. **2014**; McCaffrey **2015**; Molino and Huybrechs **2004**; National Governors' Association ~~Center~~ Centre for Policy Research **1979**; Paton **2003**; Paton and Johnston **2001**; Rhodes **2011**; Tippett et al. **2015**; Trigg et al. **2015b**). This strategy is driven by evidence that lack of hazard preparedness has led to many otherwise preventable deaths, injuries and damage caused by natural hazards. Deaths resulting from devastating disasters such as the ~~2019-20~~ 2019–20 Australian bushfires, the Black Saturday bushfires (Teague et al. **2010**), the tsunami that followed the Tohoku earthquake in Japan in 2011 (Esteban et al. **2013**), Hurricane Katrina (Townsend **2006**), the Nepal earthquake (Sharma **2015**) and the Christchurch earthquake (Paton et al. **2015**) have increased the urgency of disaster preparation. Preparation, along with mitigation, are central concepts within the Sendai Framework (United Nations Office for Disaster Risk Reduction **2015**), an international agreement facilitated by the United Nations that ~~recognizes~~ recognises the State as the primary actor in disaster prevention and management, and also that responsibility is shared with other levels of government, the private sector, communities and individuals (United Nations Office for Disaster Risk Reduction **2015**).

Activities by individuals and communities that reduce risk and vulnerability to natural hazards are also known

as hazard adjustments (Burton et al. **1978**; Kates **1976**; Lindell and Perry **2000**). Lists of hazard adjustment activities (Burton et al. **1978**; Chaney et al. **2013**) have been adopted for use in the community by emergency agencies and are often referred to as a 'checklist' (called an inventory, preparatory scale, preparedness scale or index in the literature). The checklist or inventory tool has two clear purposes: ~~i~~(1) a comprehensive inventory to measure preparedness levels for either academic studies or pre-campaign research by agencies (such as those used by Kanakis and McShane **2016**; Kleier et al. **2018**; McLennan **2014**; Trigg et al. **2015a**); and ~~ii~~(2) a simplified checklist to motivate and inform preparedness behaviours by individuals and/or households by facilitating a self-assessment process (for instance, Department of Civil Defence **2018**; Federal Emergency Management Agency **2017**; NSW Rural Fire Service n.d.-b). This study will focus on developing a uniform instrument for self-assessment purposes by developing a storm preparedness inventory that agencies can use to tailor checklists for their local communities. It will also consider how a checklist could be used by agencies as both a research tool and a preparation motivator for individuals, families and communities.

Inventories, used in checklist form, are thought to be effective as motivators for preparedness by householders because in other fields they have been found to guide ~~behavior~~ behaviour (Keller **2010**), motivate action (~~Connor~~ Conner et al. **2011**; Dholakia **2010**) and allow people to try new practices in stages (Rogers **2010**). One of the factors contributing to high commitment to goals is belief by the individual that progress can be made on the task that leads to the goal (Locke **1996**).

Some researchers investigating preparedness have grouped inventory items according to their potential effect or purpose. For instance, earthquake preparation activities have been separated into mitigation and survival (Lindell ~~&~~ and Perry **2000**; ~~Spitall~~ Seidel et al. **2008**), and similarly for tornado preparation (Chaney et al. **2013**). McLennan and Elliott (**2011**) refined this approach in relation to bushfires (wildfires), and proposed five groups of preparation activities based on the aim of those ~~activities – bushfire~~ activities—bushfire safety planning, preparation for leaving, preparation for active house defence, preparation to reduce danger to the house ~~,~~ and preparation to reduce the vulnerability of the house. These groupings point to the possibility that agencies might measure, as Spittal et al. (2008) did, individual levels of preparation within a group of activities, and identify specific areas of weakness and strength in preparedness. This assessment process might then contribute to making hazard community education and engagement programs more focused on those groups of activities, based on McLennan and Elliot's (**2011**) clusters, that indicate lack of preparation by an individual, household or community in a specific area of preparation.

Only one full inventory was found for storm preparedness under the definition of storm used in this study and articulated below. This was developed and tested by Moon (**2010**) and further used by Kleier et al. (**2018**) to measure influences on preparedness for a hurricane. Moon's (**2010**) inventory was based on a list of activities developed to measure earthquake preparedness by Paton ~~, Smith, Johnston, Johnston and Ronan~~ et al. (**2003**), which they described as key performance indicators for assessing resilience and preparedness (Paton et al. **2003**, p. 28). Moon's (**2010**) instrument, which was also used in association with other phenomenon of interest, such as motivations and vulnerabilities that might affect preparedness activity, showed relatively high internal consistency scores with Cronbach's alpha scores ranging from .731 to .881 (n = ~~153~~ 153) (Moon **2010**, p. 73). Kleier et al. (**2018**) reported a Cronbach's alpha score of their preparedness scale of .90 (n = ~~147~~ 147). Some studies have included a small number (nine or fewer) preparedness questions to measure preparedness in conjunction with measurement of some other phenomena in studies of tornado (Chaney et al. **2013**) and hurricane/cyclone (Sattler et al. 2002~~;~~). Other in-depth consideration of inventories has been focused on earthquakes (Mulilis et al. **1990**; Spittal et al. **2006**). However, although internal consistency was tested in the storm scales reviewed here, the relevance to and effect on individuals of the inclusion of each activity seems to have been assumed. Secondly, checklists used by agencies and academic researchers vary in length and the type and number of activities, so very little uniformity can be achieved for comparisons in the case that data ~~is~~ are collected. Thirdly, there appears to have been no research to test the effect of the inventory instruments used, with studies focused on preparedness levels of individuals rather than the motivating effect of the checklist itself. And finally, no research was found that tested the hazard impact reduction efficacy of the individual or clusters of hazard adjustment activities that are generally included in checklists offered by agencies.

While this study does not address all of these identified gaps, it has does aim to address four. Firstly, it intends to develop a master storm preparedness inventory from the literature, and then demonstrate the way users (researchers and agencies) can tailor the instrument to their situational needs, and yet still provide a

tool that would allow comparison of data across hazard types and jurisdictions. Secondly, it initiates a discussion on the effect of inventory instruments and suggests a method of collecting data that might provide insights into the effect of a checklist instrument on overall preparedness activity by individuals. Thirdly, it aims to demonstrate how such a checklist can be used to identify specific strengths and weaknesses rather simply present binary 'prepared or not' insights, thereby allowing agencies to tailor messaging and engagement approaches to the preparedness weaknesses exposed in a community. This aim could be the first step in solving the dilemma of whether preparedness checklist activities have any effect on the safety of preparers. Fourthly, it aims to report on the range of potential methods of application for a checklist that could support motivation of individual preparedness, and collection of data for review of engagement programs and determination of the relevance and efficacy of each activity included in a checklist.

Preparedness in the context of this study is understood to be (Australian Institute of Disaster Resilience 2017):

> The knowledge and capacities developed by governments, response and recovery organisations, communities and individuals to effectively anticipate, respond to and recover from the impacts of likely, imminent or current disasters.

The focus of this study arose from confirmation that storms and hurricanes are becoming more intense and causing more rainfall with climate change (Walsh et ~~.~~al. **2019**). As well, only two studies have been found that consider storm preparedness and storm inventories, compared with many studies for earthquake, wildfire and flood. Research in Australia indicates that more storm experience predicts better preparation (King et al. **2006**; Kleier et al. **2018**; Sattler et al. 2000~~;~~), which is a problem now that the tropical belt that generates and hosts cyclones in Australia seems to be widening (Seidel et al. **2008**), exposing inexperienced populations to severe storms. In addition, from 1987 to 2016, storms in Australia took 89 lives, injured 360 people, caused 15,500 people to become homeless and directly affected over four million people (Deloitte Access Economics **2017**) in a population of 23.~~4 million~~ 4 million (Australian Bureau of Statistics, **2016**). Queensland, Australia is the focus because the research was part of a wider study for the Queensland emergency ~~agency — only~~ agency—only the quantitative component of that study is reported here.

Throughout this paper, we use the definition of 'storm' provided by the Australian Institute of Disaster Resilience in its Glossary (n.d.):

> ~~"~~1. An atmospheric disturbance involving perturbations of the prevailing pressure and wind fields, on scales ranging from tornadoes (~~1 kilometre~~ 1 km across) to extratropical cyclones (~~2,000-3,000 kilometres~~ 2000–3000 km across). 2. Wind with a speed between 48 and 55 knots (Beaufort scale wind force 10).~~"~~

Table **1** provides an explanation of the different levels of severity of storms, and translation of the categorisations for international context. It allows readers from around the world to understand the terminology used in this paper:

Table 1 Storm categories (developed from Australian Bureau of Meteorology **2018**~~,~~; National Hurricane ~~Center~~ Centre **2019**~~,~~; World Meteorological ~~Organization~~ Organisation n.d.) ~~—2-3 4-5~~

Australian name	Australian category	USA	US Saffir-Simpson category scale	NW Pacific	Arabian Sea/Bay of Bengal	SW Indian Ocean	South Pacific (East of 160E)
Tropical low	~~–~~	Tropical depression	~~–~~	Tropical depression	Depression or severe depression	Tropical depression	Tropical depression
Tropical cyclone	1	Tropical storm	–	Tropical storm	Cyclonic storm	Moderate tropical storm	Tropical cyclone (gale)
Tropical cyclone	2	Severe tropical storm	–	Severe tropical storm	Severe cyclonic storm	Severe tropical storm	Tropical cyclone (storm)
Severe tropical cyclone	3	Hurricane	1	Typhoon	Very severe cyclonic storm	Tropical cyclone	Tropical cyclone (Hurricane)
Severe	4	Hurricane	2–3	Typhoon	Very severe	Intense	Tropical

tropical cyclone					cyclonic storm	tropical cyclone	cyclone (Hurricane)
Severe tropical cyclone	5	Hurricane	4–5	Typhoon	Super cyclonic storm	Very intense tropical cyclone	Tropical cyclone (Hurricane)

Background

Communities mostly remain unprepared for the impact of natural hazards, even in areas susceptible to hazards or after significant events or engagement efforts by agencies (Nicolopoulos and Hansen **2009**; Paton et al. **2006**). While people generally recognise their level of risk, and identify a good range of actions for getting ready, they tend not to act on their understanding. Hazard preparation research in Australia, where this study was located, is understandably dominated by bushfire studies, with a small number focused on storm, cyclone and flood hazards. This is despite Australia being susceptible to the full range of storms (and their consequences) described in Table **1** (Australian Institute for Disaster Resilience ~~,~~ **2019**). In ~~2018–19~~2018–2019, Australia experienced four tropical cyclones, as well as major storm events in Queensland, New South Wales, Victoria, South Australia and Western Australia (Australian Institute for Disaster Resilience ~~,~~ **2019**).

Bushfire studies have shown that preparation is characterised by generally low levels of preparation activity (Mackie et al. **2013**; McLennan et al. **2012**) and very little formal planning (McLennan et al. **2015b**). Many people don't prepare because they plan to leave (McLennan et al. **2015a**) but tend not to make preparations to leave. The storm literature shows that some communities are better prepared than others. In north and western Queensland, Australia (regions more likely to be exposed to storm, cyclone and flood events), residents were well prepared for generic natural hazards when asked about survival tools such as enough food and water for three days, enough medication, torch and batteries, first aid kit, adequate food for pets and a battery power radio (Office of the Government Statistician **2012**~~; Office of the Government Statistician~~ , **2013**).

However, it seems the further south in Australia a person lives, the lower their preparation for a storm will be, which is most likely a reflection of the northerners' experiences of cyclones and cyclone-generated extensive rain events, with experience being an influencing factor on preparation (Cretikos et al. **2008**; Kleier et al. ~~2017~~ **2018**; Mackie et al. **2013**). Overall though, Australians seem to be generally ill-prepared for all hazards, with their preparation levels calculated to be 3.84 out of a possible 10 (Kelly and Ronan **2018**) using a preparedness scale that was developed using an inventory-based questionnaire. This tendency for community experience to generate storm preparedness action is a problem now that the tropical belt appears to be widening (Seidel et al. **2008**)~~— which —~~which in Australia, means potentially affecting communities with little experience of wild storms.

Inventories and their use in natural hazard preparedness

To understand how the use of inventories could be a motivator for preparation activity, this paper will first consider barriers to, and the decision-making processes for, preparedness activity, before moving into consideration of the psychology of ~~behavior~~ behaviour triggers and motivation. It will look briefly at the use of inventories currently, and will consider potential uses in behaviour change efforts by agencies.

Triggers for protective action

Three sets of perceptions inform decision-making in response to some stimuli (Lindell ~~&~~ and Perry 2012). These are perceptions of risk, perceptions of the value and effect of getting ready, and perceptions of the social actors within the natural hazard scenario. Firstly, perception of risk relates to understanding of likelihood and severity of the hazard, weighed against the demands of the ~~day-to-day~~ day–day and lack of prioritisation of time. Staupe-Delgado and Kruke (**2017**) identify this as "the impasse of preparedness based on residual and acceptable risk", and it results in optimism bias (it won't happen here, it won't be as bad as they are saying) (Mackie et al. **2013**; Spittal et al. **2005**; Trumbo et al. **2011**) and a low ~~personalization~~ personalisation of risk that results in failure to get ready for the risk (McLennan et al. **2015b**; Paton et al. **2006**). Secondly, perception of value of hazard adjustment includes effectiveness, cost, knowledge required

to undertake the activity ~~,~~ and how the action can solve a number of problems at the same time (Lindell ~~&~~ and Perry 2012). Studies finding lack of confidence that preparation will change the outcome, or outcome expectancy (~~Kanakais et al.~~ Kanakis and McShane **2016**; Prior **2010**; McNeill et al. ~~2014~~ **2013**), support this. Thirdly, trust in social actors such as agencies (and individuals within agencies), social networks and information sources will affect the timing and level of preparation activity (Lindell ~~&~~ and Perry 2012).

The stimuli that can trigger action can occur as a result of risk identification, risk assessment, protective action search and protective action assessment (Lindell ~~&~~ and Perry 2012). For some people, the trigger is the start of the bushfire or storm season (Paton et al. 2008) and information delivered by agencies to announce this (Ryan ~~&~~ and King 2017) while for others, it is imminent arrival of bad weather (Paton et al. 2008), the arrival of the threat itself (Paton et al. 2008), ~~or~~ or other people getting ready (McIvor and Paton **2007**). These decisions are not made in isolation and are a result of a number of influences (McIvor et al. **2009**). Realisation of risk can prompt a search for information among those who feel responsible for preparing for a hazard (Kanakis ~~et al.~~ and McShane **2016**; Kleier et al. **2018**) and the reverse for people who transfer preparedness responsibility to others (Mishra et al. **2009**).

Knowledge drawn from the research on the influence of these perceptions on natural hazard preparedness ~~behavior~~ behaviour should influence the way a checklist is presented and incorporated into community engagement that is aimed at motivating people and their communities to get ready. While information plays a support role in the decision to prepare and does not consistently prompt preparedness without the range of background perception factors, it is an important factor in level of preparedness once individuals decide to take action (Basolo et al. **2009**; Frandsen et al. **2011**; McCaffrey **2015**; Rohrmann **2000**). The inventory, or the checklist developed from it, is an important part of the information that can guide preparation activity, but given the range of influences on preparedness, and the motivations and triggers for activity, it is important to retain the checklist as a part of a community engagement program rather than a standalone tool. This has implications for the way the checklist tool is presented, the timing of its promotion, ease of access and use, and its approach to solving the barriers discussed in this section.

Inventories as information tools

Inventories or checklists are recognised in motivational research, particularly in distance learning, as a central tool that guides behaviour and can also be used as a measurement instrument (Keller **2010**). The lists are comprised of individual goals that present a mastery and ability challenge and can contribute to feelings of positive self-efficacy (Pintrich **1999**). While research on the efficacy of checklists as a behaviour trigger is limited, research in the fields of health ~~behavioral~~ behavioural change and goal setting show that surveys developed from a checklist can trigger change. This phenomenon, known as the question-behaviour effect, attempts to describe the influence on behaviour of asking questions (Conner et al. **2011**; Wilding et al. **2016**). It has been observed in health and psychology research and is used in health programs to prompt desired behaviour (Conner et al. **2011**; Dholakia **2010**). While it has not been tested in a hazard preparation setting, it seems to be the underlying premise of checklists offered by agencies in their preparation resources provided for communities. Checklists are used as a ~~behavior~~ behaviour guide once motivation to achieve a higher goal has been triggered (Conner et al. **2011**; Murphy and Rodríguez-Manzanares **2009**; Tuckman **2007**) and are accepted in education research as components of motivational scaffolding (Murphy ~~&~~ ~~Rodriquez~~and Rodríguez-Manzanares **2009**; Tuckman **2007**). In health prevention research, checklists have been found to be effective because people prefer to try new practices in stages (Rogers **2010**), and programs are more effective if action steps are staged over time (Steckler et al. **1992**). This is similar to findings of Sturtevant and McCaffrey (**2006**) relating to getting ready for wildfire.

Inventories are extensively used by emergency agencies to motivate and guide people to get ready for a natural hazard (such as Department of Civil Defence **2018**; Federal Emergency Management Agency 2004; New South Wales Rural Fire Service, n.d.; NSW State Emergency Service, n.d.; Queensland Reconstruction Authority **2017**; Queensland Rural Fire Service **2015**; Victoria State Emergency Service, n.d.). A range of preparedness actions can form checklists of activities, some of which can be applied across hazards (see work undertaken on earthquake and tornado scales of preparation by Mulilis and colleagues, for example, Mulilis et al. **1990**, **2000**; Mulilis ~~et al. **1990**; Mulilis~~ and Duval **1997**). Others are specific to a type of hazard (such as Dunlop et al. **2014** for bushfire; and Moon **2010** for hurricane). The methods and reasons for selecting each item in these scales are unclear because research on the effect of each or even combinations of multiple activities on safety, damage prevention and/or survival could not be found. Generally, checklist development

seems to be based on field experience of agencies in terms of damage and injury mitigation, and the actions that agencies consider will best prevent these two aspects of a natural hazard.

Evidence also exists to suggest that the use of checklists poses potential problems, such as at-risk householders checking-off a large number of the activities on agency-supplied checklists and emerging with an unrealistic expectation of how prepared they are (Prior **2010**). This in turn may prevent them from doing more or result in them rationalising that they had done enough to be safe. However, the checklist remains valuable because of the staging effect in new practice referred to by Rogers (**2010**). This could be effective for natural hazard ~~preparation - staging~~ preparation—staging activity allows people to progress at a comfortable pace and allows them to measure their progress (Sturtevant ~~&~~ and McCaffrey **2006**). Checklists could provide a starting point for a new cognitive process or innovation (Steckler et al. **1992**), which would be particularly useful for people new to getting ready for a natural hazard.

The potential applications for storm preparation checklists

Checklists in emergency management are usually delivered and applied in printed form, either directly or downloaded from an agency webpage (for example, FEMA **2017**; RFS NSW n.d.-b). Despite interactivity improving the quality and efficiency of decision-making in consumer behaviour (Häubl ~~&~~ and Trifts 2000) and learning outcomes (Wei et al. **2015**), web and smartphone checklists with interactive components are not used widely. Only one smartphone app was discovered focused on hazard preparation (GoCanvas n.d. in the ~~United States~~USA) and interactive web sites for bushfire (such as NSW Rural Fire Service, n.d.-a; Department of Fire and Emergency Services, n.d.) and storm (Bureau of Meteorology, n.d.) were found, but no published research on their use or outcomes of their implementation.

Smartphone applications have been used in health behaviour change programs relating to alcohol, asthma, breastfeeding, cancer, depression, diabetes, general health and fitness, headaches, heart disease, HIV, hypertension, iron deficiency/anaemia, low vision, mindfulness, obesity, pain, physical activity, smoking, weight management and women's health (McKay et al. **2018**) and fruit and vegetable consumption (Alkhaldi et al. **2016**). Research into the effectiveness of apps as ~~behavior~~ behaviour change tools has found that studies are generally too small to ~~generalize~~ generalise (Payne et al. **2015**), at risk of bias (Zhao et al. **2016**) and that interventions and evaluations were poorly assessed and reported (McKay et al. **2018**; Zhao et al. **2016**). However, most were founded on ~~behavior~~ behaviour change theory and many reported statistically significant effects (Zhao et al. **2016**). Three systematic reviews in this field considered mobile phone apps to be feasible agents of behaviour change (McKay et al. **2018**; Payne et al. **2015**; Zhao et al. **2016**). Zhao et al. (**2016**) reported that 19 studies in a systematic literature review reported 65% or greater retention for use, while a review by Payne et al. (**2015**) saw a range of ~~29% to 100%~~ 29–100% across 24 studies. In one study, the app-based intervention recorded almost 50% more adherence to the program than web-based or paper diary interventions (Carter et al. **2013**).

Zhao et al. (**2016**) found that in motivational apps, those that were most effective were based on contemporary behavioural science theories. Other features of successful apps included user-friendly design (Zhao et al. **2016**), usefulness of the information (Zhao et al. **2016**), app usability and the limited time users needed to be on the app (Carter et al. **2013**; Zhao et al. **2016**), comfort using the app in public (Carter et al. **2013**), ability to see progress over time (Carter et al. **2013**) and ~~personalization~~ personalisation (Michie et al. **2017**), often in the form of texts generated by the app (Zhao et al. **2016**). Barriers to use included pressure by the app to do activities, and complexity of some tasks, seen in calorie counting apps (Carter et al. **2013**). Apps rated highly by users were not necessarily effective in producing the desired ~~behavior~~ behaviour change (Zhao et al. **2016**).

Smartphone ownership in Australia is among the highest in the world, with 91% of the population owning a smartphone (Deloitte 2019). This provides emergency agencies with one of the most effective channels of reaching and motivating people to get ready for storm season. From an organisational point of view, digital intervention provides the potential to collect data of a type and amount that can be used to inform planning of interventions, with rapid feedback possible (Michie et al. **2017**) that might inform program adjustments. Digital applications, whether web- or smartphone-based, allow tailored, logic-based paths through the preparation landscape that would accommodate a range of choices presented in the storm preparation process.

Study design

Development of a storm preparedness master-list inventory

Recommended storm preparation activities were drawn from academic and grey literature, and then the list of activities were categorised based on the five McLennan and Elliott clusters (**2011**). The academic literature was secured using the SpringerLink, Ebscohost, Elsevier and Google Scholar databases and then bibliographies of secured articles combed for possible articles. The grey literature was secured by searching the websites of the 14 Australian emergency agencies, the Federal Government's disaster knowledge hub, the Australian Institute for Disaster Resilience Knowledge Hub, and the Australian Bushfire and Natural Hazards Co-operative Research Centre. The federal/national emergency management agencies for the ~~United States~~USA, New Zealand and the United Kingdom were also searched. Any hazard preparation activity was included. The results of this distillation are presented in Table **2**. Three key grey literature sources were the key to ensuring the instrument was relevant to Australian, and particularly Queensland, conditions (NSW State Emergency Service n.d.; Queensland Reconstruction Authority **2017**; Victoria State Emergency Service n.d.). As we developed the list, we discovered that many of the activities that were initially allocated to safety planning were actually related to post-impact survival rather than safety before and during the hazard. This post-impact focus was not a characteristic of bushfire preparation checklists, but existed in checklists for storm, tornado, flood, tsunami, earthquake and cyclone/hurricane/typhoon (see literature identified in Table **2**). This led us to add to McLennan and Elliott's (**2011**) clusters a further cluster that we called Post-impact/recovery preparation.

Table 2 Storm preparedness actions sourced from literature

Cluster (McLennan et al. ~~2015~~ **2015a**, **b**)	Storm preparation activities	Source
Safety planning	Develop a written household emergency plan	Department of Civil Defence (**2018**), Moon (**2010**), Mulilis (1999~~*~~)[a], Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d., Boylan et al. (2013), McLennan (**2014**)
	Develop an unwritten emergency plan	Boylan et al. (2013), McLennan (**2014**)
	Rehearse/share/talk about emergency/evacuation plan	Faupel et al. (1992), Chaney et al. (**2013**), Victoria State Emergency Service n.d., NSW State Emergency Service n.d.
	Have a (portable) first aid kit, including thermometer	Cretikos et al. (**2008**), Department of Civil Defence (**2018**), Moon (**2010**), Sattler et al. (2002), Faupel et al. (1992), Mulilis (1999), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d.
	Have working radio with battery	Cretikos et al. (**2008**), Department of Civil Defence (**2018**), Moon (**2010**), Faupel et al. (1992), Wong-Parodi et al. (2018), Mulilis (1999), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d.
	Ability to charge mobile phone	Cretikos et al. (**2008**), Queensland Reconstruction Authority (**2017**~~,~~)
	Spare batteries	Cretikos et al. (**2008**), Department of Civil Defence (**2018**), Sattler et al. (2002), Faupel et al. (1992), Mulilis (1999), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d.
	Learn about warnings you might receive	Victoria State Emergency Service n.d.
	Emergency contact lists	Cretikos et al. (**2008**)
	Monitor weather regularly/search for more information on the hurricane/cyclone/storm	FEMA (2004), Mulilis (1999), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d.
	Get cash from the bank	Moon (**2010**), Wong-Parodi et al. (2018)
	Make arrangements to stay connected to	Mulilis (1999)

	media/internet/others during the event	
	Prepare an emergency kit (including safety clothing and equipment)	King et al. (**2006**), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d., NSW State Emergency Service n.d.
	Fire extinguisher	Moon **2010**, Hung (2017)
	Identify or consider building a safe room	FEMA 2004, Faupel et al. 1992, Chaney et al. **2013**, Queensland Reconstruction Authority **2017**, NSW State Emergency Service n.d.
	Make contact with an agency/attended a meeting/seminar/workshop on storm preparation/search website	Faupel et al. (1992), NSW State Emergency Service n.d.
	Have access to emergency reference materials such as first aid, what to do after impact	Moon **2010**, Mulilis (1999)
	Access to a landline telephone	Wong-Parodi et al. (2018)
	NOAA weather radio and extra batteries (U.S.)	Moon (**2010**), Chaney et al. (**2013**)
	Have torch/candles/matches in waterproof containers	Cretikos et al. (**2008**), Department of Civil Defence (**2018**), Moon (**2010**), Sattler et al. (2002), Faupel et al. (1992), Wong-Parodi et al. (2018), Mulilis (1999), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d., NSW State Emergency Service n.d.
Preparation for leaving	Arrange to stay/have contact with family or friends out of town	Moon (**2010**)
	Have an evacuation/shelter plan	Moon (**2010**), Chaney et al. (**2013**), Wong-Parodi et al. (2018), Meyer et al. (**2014**), Hung (2017)
	Have an evacuation route plotted	Moon (**2010**), Faupel et al. (2002), Hung (2017)
	Plan for where family will meet if separated and have to leave	Moon (**2010**), Faupel et al. (1992)
	Have an evacuation plan for pets	Taylor et al. (2015); National Advisory Committee for Animals in Emergencies (2013)
	Have an evacuation plan for livestock	Taylor et al. (2015); National Advisory Committee for Animals in Emergencies (2013)
	Have local maps	Moon (**2010**)
	Pack medication and glasses	Moon (**2010**)
	Pack personal hygiene items	Moon (**2010**), Queensland Reconstruction Authority (**2017**)
	Pack paper and pens	Moon (**2010**)
	Fill car with fuel	King et al. (**2006**), Sattler et al. (2002), Faupel et al. (1992), Wong-Parodi et al. (2018), Hung (2017)
	Shop for supplies (food, water)	King et al. (**2006**), Meyer et al. (**2014**)
	Pack mobile phone, chargers and power source	Cretikos et al. (**2008**), Moon (**2010**), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d.(Victoria State Emergency Service n.d.)
	Pet supplies (including cage, bedding and food if leaving)	Department of Civil Defence (**2018**)
	Pack important documents (including insurance and bank docs) or hard drive in	Moon (**2010**), Wong-Parodi et al. (2018), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d., NSW State Emergency Service

	waterproof casing	n.d.
	Clothes for three days packed including rainwear, sturdy shoes or boots	Department of Civil Defence (**2018**), Moon (**2010**), Hung (2017), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d., NSW State Emergency Service n.d.
	Sleeping bag/bedding for each person	Department of Civil Defence (**2018**), Moon (**2010**), Hung (2017)
Preparation for reducing danger to the house	Bring loose furniture and other outdoor items indoors, tie down larger items	Cretikos et al. (**2008**~~, FEMA2004.~~), FEMA (2004), King et al. (**2006**), Faupel et al. (1992), Hung (2017), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d.
	Take down sails and other temporary structures	King et al. (**2006**)
	Turn off utilities just before expected impact	FEMA (2004), Mulilis (1999), Hung (2017), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d.
	Clear grass, branches and rotting or sick trees from around the house, ensuring the yard is tidy	Cretikos et al. (**2008**), FEMA (2004), King et al. (**2006**), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d.
	Unplug all appliances to protect against storm surges	FEMA (2004), Queensland Reconstruction Authority (**2017**),
	Access/stockpile sandbags	Wong-Parodi et al. (2018)
	Fasten furniture (~~eg~~ e.g. bookcases, hot water heater, hangings) to walls	Mulilis (1999)
	Clearing drains and gutters	Cretikos et al. (**2008**), FEMA (2004), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d., NSW State Emergency Service n.d.
Preparation for reducing house vulnerability	Keep house maintenance up to date/make repairs	King et al. (**2006**), Queensland Reconstruction Authority (**2017**), NSW State Emergency Service n.d.
	Ensure insurance policy covers wind/storm and storm-caused flooding	Mulilis (1999), Hung (2017), Queensland Reconstruction Authority (**2017**), Victoria State Emergency Service n.d.
	Tape windows	King et al. (**2006**), Queensland Reconstruction Authority (**2017**~~,~~)
	Install permanent shutters/have timber on hand to put over the windows	FEMA (2004), Sattler et al. (2002), Meyer et al. (**2014**), Hung (2017)
	Install cyclone straps to improve strength of the house/ensure storm resistant buildings	FEMA (2004), Mulilis (1999), Hung (2017)
Post-impact/recovery preparation	Store three days (non-perishable) food including for small children	Cretikos et al. (**2008**), Department of Civil Defence (**2018**), Moon (**2010**), Sattler et al. (2002), Faupel et al. (1992), Meyer et al. (**2014**), Mulilis (1999), Hung (2017), NSW State Emergency Service n.d.
	Have three days' supply of medications	Hung (2017), Victoria State Emergency Service n.d., NSW State Emergency Service n.d.
	Store (three days/adequate) drinking water	Cretikos et al. (**2008**), Department of Civil Defence (**2018**), Moon (**2010**), King et al. (**2006**), Sattler et al. (2002), Faupel et al. (1992), Mulilis (1999), Hung (2017), Victoria State Emergency Service n.d., NSW State Emergency Service n.d.
	Ensure gas BBQ/portable stove workable/gassed	Cretikos et al. (**2008**), Department of Civil Defence (**2018**), Hung (2017), Queensland Reconstruction Authority (**2017**~~,~~)
	Whistle/flag to signal for help	Moon (**2010**), Hung (2017)

	Dust mask	Department of Civil Defence (2018), Moon (2010)
	Have wipes, plastic bags and toilet paper	Department of Civil Defence (2018)
	Wood, wood stove	Wong-Parodi et al. (2018)
	Have a generator with ~~three days'~~ 3 days' fuel/secondary power source	Wong-Parodi et al. (2018), Meyer et al. (2014), Hung (2017)
	Get information on evacuation shelters/options	Moon (2010), Chaney et al. (2013)
	Fill bath and other large containers with water for cooking and washing	FEMA (2004), Department of Civil Defence (2018), Queensland Reconstruction Authority (2017),
	Have on hand water purifiers such as special jug or chlorine/hydrogen peroxide with a medicine dropper	Moon (2010)
	Ensure supply of spare fuel	Queensland Reconstruction Authority (2017)

~~*~~[a]Mulilis et al. (2000) presents an interchangeable tornado and earthquake preparation scale ~~(Mulilis et al. 2000)~~

The allocation of activities to a cluster was conducted separately by each author. The two sets of allocations were compared, with two disagreements out of the 62 activities. These were resolved by discussion between the authors, resulting in Table 2.

In total, 62 items were collected from the literature relating to storm preparedness. This immediately presented a problem for use in the field; to include all of the items in the checklist could result in non-completion similar to that experienced in academic and market research when an instrument contains too many items (Deutskens et al. 2004; Dillman 1991; Dillman et al. 1993; Guo et al. 2016). For instance, Heberlein and Baumgarter (1978) discovered that each additional question reduces response rate by 0.5% and each additional page by 5% overall and Fan and Yan ~~and Fan~~ (2010) determined that the optimum length was around ~~13 minutes~~13 min.

One of the factors contributing to the non-completion of a Household Bushfire Self-Assessment Tool reported by Rhodes et al. (2011) may have been the number of questions asked as people worked their way through the tool. While Rhodes and colleagues did not report the number of questions incorporated into the tool, a similar tool used by their commissioning organisation, NSW Rural Fire Service, in 2018 used more than 40 items, expanding into secondary questions when provided with certain answers (NSW Rural Fire Service n.d.-a). The ideal number of items for a survey (or checklist) seems to depend on the discipline (science, social science, marketing), the mode of delivery (online, face-to-face, pen and paper), salience of the topic and the situation in which the respondents are recruited (for instance, on the street or via mailbox/inbox invitation) (Yammarino et al. 1991; Fan and Yan 2010).

Given the issue of time poverty that was a theme in the literature review, and evidence that the shorter the time investment in a survey, the better the chances of completion, the team decided to use the 62-item list as a master and develop from it a smaller instrument that would allow a ~~10–15 minute~~ 10–15 min time limit for an individual to work through a checklist.

The authors used the 62-item master inventory in a two-stage process that allowed the master inventory to be pared down to a region-specific tool. The first stage removed items related to activities that:

- Did not fit the inland Queensland context that applied to the study area (i.e. unlikely to experience a cyclone, unlikely to experience a storm during the winter season);
- Were specific to a country other than Australia (such as possession of a U.S. NOAA radio)
- Were not relevant in the context of Australian/Queensland legislation;
- Could only be undertaken upon the imminent arrival of the threat where the situation influenced the action to be taken and could be considered response rather than preparation (such as turning off utilities).

This resulted in 20 activities being removed from the list, leaving 42 items. The remaining list featured some tasks that were similar to others and could be amalgamated. For instance, several items were related to emergency kit ingredients, so these were removed in favour of a more general question about an emergency kit. This further reduced the number of activities to 29. The activities related to insurance, warnings and contact lists were removed because questions on these topics were included elsewhere in the interview instrument but could not be included in the checklist analysis because answers were provided in a different format, many of them open-ended. The final checklist after this process contained 26 activities, shown in Table **3**. The response options to each question were 'Yes', 'No' and 'Not applicable'.

Table 3 Checklist clusters and final wording of the instrument items that asks what people do reliably for each storm season

Cluster	Activity
Safety planning (SP)	Do you prepare a written storm emergency plan?~~*~~**[b]
	Do you prepare a storm emergency plan in your head?~~*~~**[b]
	Do you discuss the storm emergency plan with your family/household?
	Do you practice the storm emergency plan?
	Do you review how to switch off water, gas and power?
	Do you ensure you have a battery-operated radio?
	Do you monitor weather regularly/search for more information on the hurricane/cyclone/storm
	Do you prepare an emergency kit (including safety clothing and equipment) for self/family?
	Do you ensure you have battery backup/charging for your mobile phone?
	Do you identify the safest room in the house in which to shelter?
	Do you contact the State Emergency Service for advice or search the website?
Preparation for leaving (PL)	Do you arrange a safe evacuation place for family?
	Do you arrange a safe evacuation place for pets?
	Do you arrange a safe evacuation place for large animals/livestock?
	Do you plot evacuation routes?
	Do you pack supplies for pets/livestock ready to go?
	Do you pack valuables and an overnight bag ready to go?
Preparation for reducing danger to the house (PH)~~*~~[a]	Do you bring furniture and other loose items inside on bad days?
	Do you clear leaves and grass from around the house?
	Do you cut back trees near the house?
	Do you clear gutters?
Preparation for reducing house vulnerability (PV)~~*~~[a]	Do you check your roof to make sure it is in good condition?
	Do you install or check protective covers for windows?
Post-impact/recovery preparation (PI)	Do you make sure you have enough food for ~~three days~~3 days?
	Do you make sure you have enough water for ~~three days~~3 days?
	Do you ~~organize~~ organise a secondary power source?

~~*~~[a]Note that the two clusters related to house preparation (PH and PV) were merged for analysis in this specific study because the two clusters included only a few items in this checklist. However, in the master-list and subsequent uses of the master-list, these two clusters should remain distinct if there are five or more activities

~~*~~*[b]These activities have been separated because they have appeared as separate items in other inventories (for example, McLennan et al. ~~2015~~ **2015a**, **b**). There appears to be an assumption that a written plan is more robust and therefore more effective than a plan that exists in a householder's ~~head – this~~ head—this is an area for further research

The 26 checklist items consisted of a range of activities that could be considered basic to advanced, based on

their ease of implementation and resources required. Within the clusters, there were 11 Safety planning (SP) activities, 6 Preparation for leaving (PL), 4 Preparation to reduce danger to house (PH), 2 Preparation for reducing house vulnerability (PV) ~~,~~and 3 Post-impact/recovery preparation (PI) activities. Because there were only two activities to measure in the PV cluster, the decision was made to merge the PH and PV clusters because of their similarities, and to ensure a meaningful measure was secured. The new measure was labelled PH after the dominant cluster (Table **6**). It is worth noting that two similar ~~activities — having~~ activities—having a written plan or a mental ~~plan — were~~ plan—were kept separate because the literature showed that these stages of one activity might be related to differing levels of overall preparation and different actions in a bushfire, with a written bushfire plan and 'firm' plan, and a mental plan subject to inconsistencies and ambiguity (Eriksen et al. **2016**; Whittaker et al. **2013**)

Semi-structured interviews that tested the use of this checklist were completed in August and October 2017 from two locations near Toowoomba, Queensland, which is two hours west of Brisbane on a mountain range inland from the coast. The locations were identified by the local emergency agency as high storm risk, due to their position on the Great Dividing Range escarpment, and due to the limited access points for a number of streets in each community. In one of the locations (Highfields), there were three distinct geographic groups of homes and two groups in the second location (Hodgson Vale), with a total of 160 homes across both locations (Table **4**).

Table 4 Summary of sampling for semi-structured interviews

	Population (households)	Households approached	Completed ~~Interviews~~interviews
Highfields A	39	23	8
Highfields B	13	4~~*~~[a]	5
Highfields C	32	16	5
Hodgson Vale A	23	12	6
Hodgson Vale B	53	26	9
Total	160	80	33

~~*~~[a]Two people from one of these households were interviewed

To ~~randomize~~ randomise interviewee participation, the total number of households within each of the five geographic groups was divided by a target quota to determine the sequence of households to be approached. For instance, the area Highfields B had 13 houses, and three interviews were required by the commissioning emergency agency from this street. Thirteen divided by three gives 4.3, so every fourth house was approached in that street, starting with the first house physically located on that road and continuing along that side of the street. If the first pass of the street failed to produce the desired number of interviews, the count continued from the last house approached around the street again. Once the interview quota for that street was reached, no more houses were approached. Properties with dogs and those where householders were not at home were left a note in the mailbox asking potential respondents to contact the research team. Three days elapsed before these properties were re-approached. If an interview was not secured, the household was replaced by an approach to the next home in the street that fit the criteria. Table **4** summarises the results for each street or cluster of streets. Two of the people who agreed to be interviewed experienced unexpected circumstances which led to cancellation of the interview before researchers arrived. These people were counted as a 'no' in the final count. Eighty households were approached with 33 completed interviews, resulting in a response rate of 41.0%.

The interview instrument

An interview instrument comprised of both closed and open-ended questions was created based on questions drawn from the literature review and advice from emergency agency staff, and included the storm checklist of activities shown in Table **3**. Three pre-interviews were conducted to test the instrument and several small changes were made to the wording of questions for clarity. This study reports only the results of the checklist questions and one question relating to perception of storm preparedness. All analysis was performed using SPSS, the Statistical Package for the Social Sciences version 24 to allow the researchers to test the process. Participants were ~~anonymized~~ anonymised during the data entry process, whereby each participant was allocated a record number within the SPSS file, with no identifying data entered into a record.

The interviews were conducted in May and June, which was too early for natural hazard season preparation

to have started for most households, so questions were asked in the context of preparation habits rather than behaviour for the specific season. The respondents were asked "Do you…" rather than "Have you…"

Data analysis methods

Category frequencies were calculated for three descriptive household variables (Table 5). There were no missing data for these variables. For each of the 26-individual checklist items describing storm preparation activities, the frequencies of 'yes' responses were calculated (Table 6). Summary statistics including the mean, standard deviation, minimum and maximum number of activities within each cluster that households had engaged with were also calculated (Table 7). To further explore household preparedness within each of the four clusters, the proportion of 'yes' responses within each cluster of activities was calculated for each household. Pearson's correlation coefficient (r) among the four clusters was then calculated (Table 8).

Table 5 Frequencies of features of the sample (N =~~33~~ 33)

Storm ~~Insurance~~insurance	Home	Home and contents	Contents	Not sure	
Ownership	3	22	3	5	
	~~Ownership~~	Renting	Own		
Experience of storm damage	3	30			~~Experience of storm damage~~
	Yes	No			
	-	25	8		

Table 6 Frequencies of storm preparedness activities within 4 clusters: ~~Preparation~~ preparation to reduce damage to house and premises (PH), ~~Safety~~ safety planning (SP), ~~Preparation~~ preparation for leaving (PL) ~~,~~ and ~~Post~~ post-impact (PI) activities

Preparation (~~Households~~households =~~33~~ 33):	Yes	
Safety preparation (SP) (On the approach to each storm season…)		-
Do you identify the safest room in the house in which to shelter?	21	
Do you review how to switch off water, gas and power?	30	
Do you prepare a storm emergency plan in your head?	19	
Do you prepare a written storm or emergency plan?	0	
Do you discuss the storm emergency plan with your family/household?	13	
Do you prepare an emergency kit (including safety clothing and equipment) for self/family?	8	
Do you contact the State Emergency Service for advice, or search the website?	10	
Do you monitor weather regularly/search for more information on the cyclone or storm?	32	
Do you ensure you have a battery-operated radio?	22	
Do you ensure you have battery backup/charging for your mobile phone?	21	
Do you practice the storm emergency plan?	2	
Preparation of house (PH) (On the approach to each storm season…)		-
Do you clear leaves and grass from around the house?	33	
Do you clear gutters?	32	
Do you cut back trees near the house?	31	
Do you check your roof to make sure it is in good condition?	33	
Do you bring furniture and other loose items inside on bad days?	19	
Do you install or check protective covers for windows?	2	
Preparation for leaving (PL)		-
Do you arrange a safe evacuation place for family?	13	
Do you arrange a safe evacuation place for pets?	9	
Do you arrange a safe evacuation place for large animals/livestock?	1	
Do you plot evacuation routes?	20	
Do you pack supplies for pets/livestock ready to go?	3	
Do you pack valuables and overnight bag ready to go?	6	
Preparation for post-impact (PI)		-

Do you make sure you have enough water for ~~three days~~3 days?	31
Do you make sure you have enough food for ~~three days~~3 days?	32
Do you organise a secondary power source?	9

Table 7 Summary statistics for the four clusters of storm preparedness (SP, PL, PH and PI)

	SP	PL	PH	PI	All
Number of Activities	11	6	6	3	26
Mean	5.4	1.6	4.5	2.2	13.7~~Std. Deviation~~
SD	1.8	1.2	0.7	0.6	2.5
Minimum	2	0	3	1	8
Maximum	10	4	6	3	19

Table 8 Correlations among the proportion activities within each cluster performed by households (* ~~p<0~~$p <$ 0.05)

Cluster	Safety planning (PS)	Preparation of house (PH)	Preparation for leaving (PL)
Preparation of house (PH)	0.21		
Preparation for leaving (PL)	0.44*	0.19	
Preparation for post-impact (PI)	~~0~~– 0.19~~0~~	– 0.06	~~0~~– 0.51*

Results

Descriptive statistics and analysis

The analysis undertaken as part of this instrument test demonstrates one method to draw findings from inventory-driven data. This section will report the results from the checklist component of the study that was conducted with this small sample to illustrate the useability of the inventory data and the cluster approach. ~~Results~~ The results to qualitative questions on other topics will not be reported here.

Twenty-one of 33 interviewees were over ~~55 years~~ 55 years old, 11 were retired and 32 knew their neighbours. Nearly all (30) were home owners and 25 had previously experienced storm damage (Table **5**).

Cleaning of leaves and grass from around the house, clearing gutters, cutting back trees and checking the condition of the roof were all highly adopted activities with nearly all of the 33 households indicating that they perform these activities (Table **6**). Only 19 households indicated that they bring furniture and other loose items inside as part of their storm preparation activities (Table **6**). None of the households had a written storm emergency plan and only 19 had a plan in their head. While only 10 indicated that they had contacted emergency services or used an agency website for advice, 32 indicated that they monitored weather forecasts for dangerous weather conditions. Almost all households indicated that they had enough food (32) and water (31) for three days. However, only 6 indicated that they had prepared for a storm by packing valuables and an overnight bag to be ready to go if necessary. We also investigated relationships between the clusters of ~~activity – we~~ activity—we were interested to find out if the different categories of activity could be correlated with activity in other clusters. A demonstration of how the results might be presented in application of the checklist is presented in Table **7** showing measurement of preparedness within each cluster.

Of the 11 preparedness activities within the SP cluster the maximum number that a household identified as having engaged with was 10, while the minimum was 2 activities (Table **7**). Across the 33 households, the average number of SP activities was M =~~5~~ 5.4 (~~SD~~SD =~~1~~ 1.8). Within the PL cluster, households indicated that they engaged with between zero and four activities, with a mean of M =~~1~~ 1.6 (~~SD~~SD =~~1~~ 1.2) activities out of the six possible activities included within this cluster. The PH cluster was one of the clusters most comprehensively undertaken by participants with an average of M =~~4~~ 4.5 (~~SD~~SD =~~0~~ 0.7) activities ranging from 3 to the full 6 activities investigated. Households engaged with between 1 and 3 of the 3 activities in the PI cluster, with an average of M =~~2~~ 2.2 (~~SD~~SD =~~0~~ 0.6) activities undertaken by households. Overall, householders were unprepared, having undertaken between 8 and 19 of the 26 activities, with a mean of M =~~13~~ 13.7 (~~SD~~SD +~~2~~ 2.5) of the activities completed as part of their preparation plans.

As there were unequal numbers of activities within each cluster, the proportion of activities for each household was calculated and then the correlation between clusters was calculated (Table **8**) to explore if households that were more likely to engage with activities of one cluster were also more likely to engage with activities of another cluster.

A significant positive correlation (~~r~~ r = ~~0~~ 0.44, ~~p<0~~ $p < 0.05$) was found between the safety preparation (SP) and the preparation for leaving (PL) clusters. This suggests a moderately strong linear relationship, indicating that within households' similar proportions of SP and PL activities were implemented. In contrast, a significant negative correlation (~~r~~ r = ~~0~~ − 0.51, ~~p<0~~ $p < 0.05$) occurred between the preparation for leaving (PL) and the preparation for post-impact clusters (PI), suggesting that households that engaged strongly with activities in one cluster did the opposite with activities in the other cluster.

Potential applications

Regarding the possible applications for individuals to access and use the checklist, the literature review showed that a web- or smartphone-based application could achieve positive results based on similar approaches in health interventions. Many health interventions that used smartphone applications reported statistically significant effects (Zhao et al. **2016**) and that smartphone apps were a feasible agent of behaviour change (McKay et al. **2018**; Payne et al. **2015**; Zhao et al. **2016**), with one study recording 50% more adherence to the program offered via smartphone than web- or paper-based diary interventions (Carter et al. **2013**).

Discussion

This study aimed to develop and pilot ~~-~~ test a process of using a master storm preparedness inventory to develop a checklist that would allow agencies and individuals measure individual, and therefore community, preparedness for storm. Secondly, it made efforts to provide insights into the motivation role of checklists and to embed this knowledge into development and application of a storm checklist. Thirdly, it aimed to advance the binary concept of an overall preparedness checklist into one that could pinpoint specific areas of weakness across six aspects of preparedness; a diagnostic tool that would allow agencies to target their community engagement and education on specific aspects of getting ready. These will be discussed here. The fourth aim, to investigate the applications for a checklist approach, will be discussed further into this section.

The use of activity clusters, developed from the originally aims proposed by McLennan ~~, Paton and Beatson~~ et al. (**2015a**), facilitated a structured approach to exploring the levels of preparation for storms among a small sample of households (N = ~~33~~ 33) in a storm prone region near Toowoomba, Queensland. By classifying activities (checklist items) into four clusters (safety planning, preparing to leave, preparing the house and preparing for after the storm impact), it was possible to consider cluster level engagement and relationships among clusters, in addition to levels of engagement with individual storm preparedness activities included in the checklist.

The pilot testing of the checklist instrument reported here indicates that on average households engaged with only 53% of the storm preparedness activities (an average of 13.7 activities out of the total 26 items on the checklist), despite storms in Australia causing. Although not high, this level of overall preparedness does indicate a willingness to engage with preparation activities, however, agencies would require more information on where the weaknesses lay in order to boost the overall preparedness ~~score — the~~ score—the checklist developed here can facilitate this understanding.

As the number of items within each cluster was unequal, it can be misleading to consider the mean engagement per cluster when comparing across clusters. The cluster averages indicate that the PH (M = ~~4~~ 4.5) and PI (M = ~~2~~ 2.2) clusters had the highest proportion of engagement relative to number of activities within those clusters, with 75% and 73% average engagement, respectively. In the PH and PI clusters, at least one household performed all activities (6 and 3 activities, respectively). This level of engagement indicates that households within this sample demonstrate reasonably sound levels of preparedness in relation to preparing their house for storms and in the post-impact preparation.

In contrast, although the SP cluster had the highest overall mean of 5.4, as a proportion of the total number

of activities (11) within the SP cluster the average engagement with SP activities was only 49%. The PL cluster had the lowest average engagement of 27% based on a mean of 1.6 activities out of the 6 items listed within the cluster. The PL cluster was also the only cluster for which at least one household indicated that they had not engaged with any of the checklist preparedness activities. Another interesting feature from the test data were correlations among clusters. In this pilot sample, these indicated that households who implemented a high proportion of safety preparation activities were also more likely to adopt activities related to preparation for leaving. However, people who engaged in higher levels of preparation for leaving tended to have low levels of preparation for the post-impact phase of the hazard. These analyses illustrate the usefulness of the cluster approach to identify strengths and weaknesses in the preparations of communities, and to provide insights into what would make people more likely to prepare in certain areas.

These strengths and weaknesses of household engagement within the checklist clusters can be explored further to inform the focus of education and further areas in need of research. For instance, in preparation for leaving (PL), all of the activities scored low on the reported completed scale except plotting an evacuation route (60.6%) and arranging a safe evacuation place for the family (39.4%). However, during the interviews respondents consistently seemed to give these questions very little thought and may have been reporting their normal exit route from their house to the nearest major town without accounting for fallen trees or power lines, or flooded roads. The interviewers heard often that the participant would "just go to Mum's place", regardless of whether the route was open. Two particularly weak links in preparation for leaving was the lack of evacuation options for large animals (3.0%) and low reporting of packing supplies for animals and pets ready to go (9.1%). Having animals is an obstacle to evacuation across hazards (Trigg et al. ~~**2017**~~; ~~Trigg et al. **2015b**~~ **2015b**, **2017**) and could have been a reason for deaths in the Victorian Black Saturday bushfires in 2009 (Teague et al. **2010**). Very few people in our pilot of the instrument had an evacuation place organised for their smaller animals or their pets (27.3%).

These levels of insight provided by the use of clusters within the inventory approach allows agencies to develop communication strategies that can lift levels of preparedness where they are most needed in communities by targeting specific behaviours. Translated into practice, this might mean a move from general messages about having a plan and enacting your plan (in other words, do all the activities on the checklist), to specific messages about planning evacuation routes and what to take, putting together an emergency kit from the guide found on the agency website, talking to family about it, and making sure that pets are factored ~~in to~~ into any preparation for evacuation.

The checklist also provides a valuable tool for measurement of success of community engagement activity within target communities. The checklist provides two levels of ~~measurement – an~~ measurement—an overall scale, and the ability to drill down into areas of preparedness activity. This will be important as agencies make efforts to systematise their evaluation of community engagement and education efforts, which is traditionally an area of weakness in emergency agency activity (Gilbert **2007**; Molino and Huybrechs **2004**; Rhodes et al. **2011**).

The process of developing the checklist highlighted the importance of tailoring the inventory to the specific features of the community. For instance, consideration of the master list showed many questions would not be relevant to Queenslanders. Examples of this were the question relating to ensuring enough wood for heating, when storm season in Queensland is in summer. However, a question on this activity would be important for areas where storms are a winter occurrence. What this checklist did not measure, because of the nature of the larger instrument it resided in for this particular study, was the level of insurance cover, whether people had investigated or knew where to get information, and whether they had an emergency contact list compiled. These were questions asked separately in a level of detail that could not be converted to suit the techniques of analysis used in this study. However, they were part of the master-list. The authors recommend that in future utilisation of the checklist, while insurance cover be classified as preparedness for reducing house vulnerability (PV), the questions on knowing where to get up-to-date information and emergency contact lists be included in safety planning (SP).

The fourth aim of the study was to investigate the feasibility of using an inventory approach to preparedness in a non-paper-based application. Behaviour change literature from the field of health shows promising results when participants use a smartphone app against a web-based or paper-driven program. Motivation and retention in health programs using apps seem to be positive in this field, even though few studies used randomised control trials or worked with large enough samples to make generalisations.

One of the limitations of this study was that only preliminary testing of the developed scale was undertaken with a small sample of homogenous householders. Further testing of the scale, including for reliability, is necessary (Spittal et al. **2006**). An additional limitation was omission of the activities outlined earlier from this version of the checklist, three because of the nature of the wider project and their inclusion in the instrument outside the checklist and one inadvertently left out of the instrument. Each of these four measures could be an important inclusion in larger studies using the checklist. The development of the checklist approach based on data secured almost ~~three years~~ 3 years ago could also be a ~~limitation – however~~limitation—however, little has changed in terms of agency materials since then. Agency materials have mostly not changed in the intervening period.

A further limitation is that the calculations that provide the score for preparedness within each cluster complicate the application of the checklist for use by the individual without help from agency staff. Development and testing of a smartphone application that undertakes these calculations and produces a preparedness score for each cluster would solve this problem. Such an app could take advantage of the psychology of task lists and goal setting, and its portable nature might overcome barriers to ~~day to day~~ day–day utilisation of the checklist by individuals.

A critical gap in preparedness research has emerged in undertaking this study. The efficacy of individual preparedness actions, and therefore their rationale for being included in any inventory or checklist, has not been researched or established. To undertake such research requires investigation of the perceptions of individuals on the effect of individual actions, but, more critically, testing of effect on physical safety and decision-making ability during a hazard, using both intervention and control groups. Further research could measure perceptions of preparedness more specifically within each of the clusters, extending the utility of the cluster concept, rather than rely on a single, overall perception of preparedness value as we have done here. For instance, it would be helpful to record a person's perception of how well prepared they were to leave the property, stay safe during the incident or protect the house, instead of an overall preparedness level that includes all these things. Comparisons could then be made between the perception and the reality within each cluster. This would give added insights for communication strategy relating to attitudes to preparedness.

Overall, this short, easily tailored and simple checklist (around 30 items) potentially lends itself to motivating preparedness by taking advantage of a process approach to achieving goals and by breaking the preparedness process down into achievable stages for the individual (Locke **1996**; Steckler et al. **1992**; Sturtevant and McCaffrey **2006**). The cluster scales also have potential to be used in conjunction with a measure of an individual's perception of their readiness for a storm, demonstrating to individuals inconsistencies between their belief and the reality. It also facilitates an evidence-based approach to preparedness education and engagement by agencies that could be easily tapped into using smartphone technology.

Ethics approval and implementation

This project was undertaken with ethics approval, number H17REA150, from the University of Southern Queensland Human Research Ethics Committee. This committee is guided by the University's Research Code of Conduct Policy (2007), the Australian Code for the Responsible Conduct of Research (2007), and the National Statement on Ethical Conduct in Human Research (2007).

ArticleNote

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Compliance with ethical standards

Conflict of interest

The authors declare that no conflict of interest occurred in the undertaking of this research.

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