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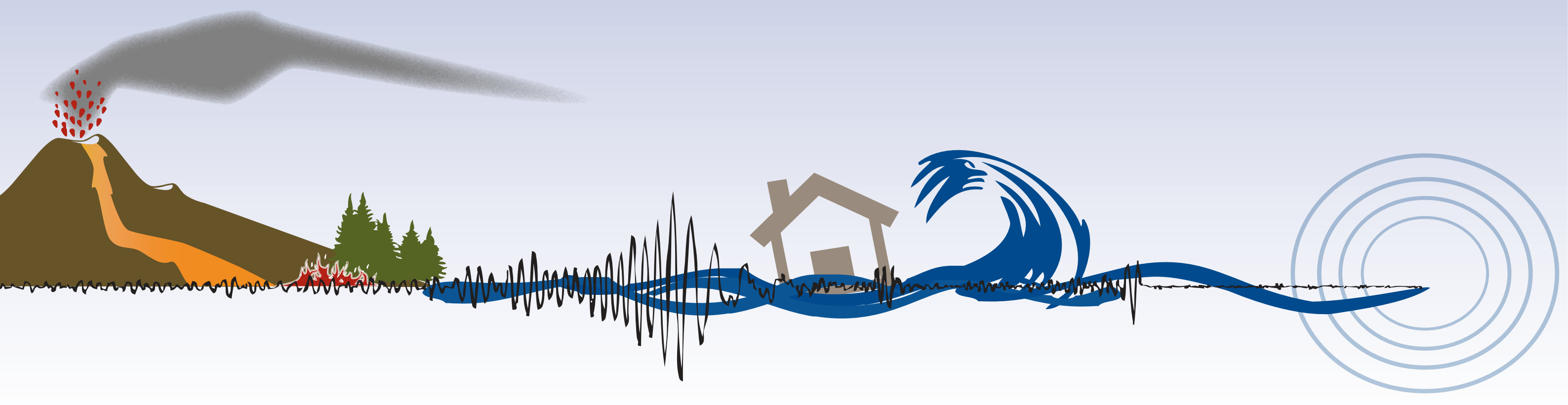

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Pathways to Earthquake Resilience: Learning from past events

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Abstract

To be more prepared for future hazard events, learnings from past events must be identified, shared, and applied. This task does not belong solely to either practice or academia but requires a collaborative approach. In line with this goal, this special issue presents a combination of empirical research papers, research updates, and practice updates which contribute to knowledge of the impacts and outcomes of the M7.8 14th November 2016 Kaikōura earthquake in Aotearoa New Zealand, focusing particularly on lessons for the capital city of Wellington. The main focuses are how the event affected the thoughts and behaviours of Wellington residents; how organizations can improve their operation during disruptive events; and using collaborative, multi-sector approaches to identify how resilience can be understood and demonstrated. The title "Pathways to Earthquake Resilience" reflects the nature of the papers included in this special issue, bringing focus to the ways in which various sectors and disciplines can contribute to increasing resilience to earthquakes by implementing the lessons learned from past events.

Keywords: *Earthquake, resilience, research, practice, New Zealand*

Between 1998 and 2017, disasters globally killed 1.3 million people and negatively impacted another 4.4 billion; financial losses during this period amounted to US$2.9 trillion, not including the estimated 63% of unreported disaster impacts (Wallemacq & House, 2018). Earthquakes represented 8% of these global disasters but caused 23% of the reported economic loss and more fatalities than all other disasters combined (Wallemacq & House, 2018). The impact of earthquakes globally is increasing, with estimated annual financial losses increasing ten-fold and the number of people affected each year nearly tripling since the mid-1980s (United Nations Office for Disaster Risk Reduction; UNDRR, 2017).

To be better prepared to withstand, respond to, and recover from these events, it is crucial to learn from past ones. To learn a lesson, ways to improve in future must both be identified and implemented. Following the earthquakes in the Canterbury region of Aotearoa New Zealand (NZ) in 2010 and 2011, significant academic and policy learning has occurred, particularly around structural engineering, psycho-social well-being, indigenous disaster management, and organisational resilience. Knowledge of other earthquake risks, including in urban centres like the capital city of Wellington, are well established and a great deal of effort is going into building a more resilient city, including:

- The Wellington Regional Emergency Management Office's (WREMO) Group Plan (Wellington Regional Emergency Management Office, 2019);
- Updates to building legislation which target earthquake-prone buildings in Wellington (Smith, 2015);
- Wellington City Council's (2017) resilience strategy which is part of the international 100 Resilient Cities project (Berkowitz & Kramer, 2018); and
- Activities undertaken by the International Centre of Excellence in Community Resilience as part of the Integrated Research on Disaster Risk (IRDR) initiative (Doyle, Becker, Neely, Johnston, & Pepperell, 2015).

While Wellington has been affected by several strong earthquakes in living memory, such as the 2013 Cook Strait sequence, the impacts of the M7.8 2016 Kaikōura earthquake far exceeded previous experience. The shaking caused significant damage to buildings in the central business district and triggered a tsunami warning. These impacts are still being felt and have led to a renewed urgency to strengthen the city's resilience for a future event.

The Kaikōura Earthquake

At 12.02 am on the 14th of November 2016, a complex series of fault ruptures occurred in the northern South Island of Aotearoa NZ, which led to intense, widely felt shaking (Blake, Johnston, Leonard, McLaren, & Becker, 2018). Two people were killed and nearly 600 injured and the earthquake generated an estimated NZ$1 billion in damage (Stevenson et al., 2017). The extreme and unusual shaking damaged several buildings in Wellington to the point of requiring demolition, despite the distance of approximately 220 kilometres between the city and the epicentre of the earthquake (Devlin, 2017). A tsunami warning led to many Wellington residents attempting to evacuate to high ground (Blake et al., 2018).

Wellington has a known seismic risk from a number of earthquake sources with the potential to generate severely damaging ground motions and tsunami hazards. Social science research focused on residents' preparedness suggests that the majority of the city is underprepared, even after extreme events like the Canterbury earthquake sequence (Colmar Brunton, 2018; Khan, Crozier, & Kennedy, 2012). Two of the papers within this special issue (McClure, Ferrick, Henrich, & Johnston, 2019; Vinnell, Milfont, & McClure, 2019) report how the Kaikōura event affected preparedness. With 80% of all NZ's future earthquake fatalities anticipated to occur in Wellington (Smith, 2015), increasing the resilience of the city is a vital task. Without the experience of a major earthquake disaster in recent years, it is important that Wellington identifies lessons from the Kaikōura earthquake.

The Kaikōura earthquake is considered one of the most complex geophysical earthquake sequences ever studied (Amos, 2017). Much work has been done to understand the science behind the complex rupture sequence (e.g., Hamling et al., 2017) as well as documenting and understanding the physical impacts. Social science research is also critical to improving our understanding of how people reacted to the event and how affected communities might identify and address their own strengths and weaknesses in preparing for future disruptive events. Much of this understanding about how individuals and groups responded may be transferable to other contexts as research efforts try to draw out tangible recommendations for other communities and cities at risk, nationally and internationally. This special issue presents a range of these insights from academic, practice, and collaborative perspectives, which are important not only for Wellington to improve its resilience but to assist other communities globally to identify their own pathways to resilience. The next section provides a short description of each of the papers in this special issue.

McClure et al. (2019) examined risk perceptions and preparation behaviour before and after the Kaikōura earthquake. In a similar project, Vinnell et al. (2019) examined whether the event affected both peoples' support for earthquake-strengthening legislation (mentioned above; Smith, 2015) and whether that support can be increased with targeted normative information. Kay, Brown et al. (2019) present lessons from businesses that experienced the 2010/2011 Canterbury earthquake sequence which can help those in Wellington, as well as other cities, to be better prepared for future events. Members of the same team, along with other colleagues, developed resilience indicators for Wellington (Kay, Stevenson et al., 2019) and modelled potential physical and societal impacts of a Wellington Fault earthquake (Brown, McDonald et al., 2019). Fleisher (2019) reports on his experiences as the Primary Local Controller for Wellington during the response to the Kaikōura earthquake. Brown, Campbell et al. (2019) describe the process and outcomes of a workshop in Wellington focused on establishing a shared understanding of community and cultural resilience across academia, practice, and government. Finally, Brown, Rovins, Orchiston, Feldmann-Jensen, and Johnston (2019) summarize a project assessing the disaster resilience of Wellington hotels which identified both strengths and areas for improvement.

Focus One: Social Impacts of the Kaikōura Earthquake

In this special issue, the findings from two surveys of Wellington residents are presented which demonstrate the impact of the Kaikōura earthquake on the way people think and act regarding earthquake risk in Wellington. McClure et al. (2019) found that participants perceived higher earthquake risk in Kaikōura after the November 2016 event than they had before; however, both Wellington and the rest of New Zealand were still perceived as being at higher risk of an earthquake than

Kaikōura. People in Wellington were more likely to prepare, particularly undertaking actions to help them survive after an earthquake (e.g., storing food and water), if they both perceived a higher risk to Wellington than other parts of NZ and believed that others like them were preparing.

McClure et al. (2019) used a common method from social science disaster research of retrospective self-report, asking participants after an event to recall their beliefs and behaviour from before that event. As future earthquakes cannot be predicted, being able to compare data collected before and after an event requires a partly-fortuitous alignment of research and nature. Vinnell et al. (2019) present findings of a *natural experiment* (Leatherdale, 2019). This type of methodology is used and valued internationally to understand the impacts of disasters, including recently the effects of the 2011 Great East Japan Earthquake (Oishi, Kohlbacher, & Choi, 2018). While relatively rare given the unpredictability of disaster events, these methods offer data which are better able to provide evidence of causal processes.

Vinnell et al. (2019) implemented the first part of their study in July 2016 (prior to the Kaikōura earthquake) and repeated the survey one month after the Kaikōura event. This study demonstrated that concern about and preparation for earthquakes did increase following the event. However, support for legislation to strengthen earthquake-prone buildings decreased after the earthquake; the authors suggest that the public saw less value in work to bring older buildings closer to the standard required for new buildings when it was relatively modern buildings that failed. Together, the work by McClure et al. (2019) and Vinnell et al. (2019) suggests that a post-event window exists during which there is an opportunity to leverage increased discussion and perception of earthquake risk into preparation. Doing so will improve the ability of individuals to survive, respond to, and recover from future potentially disastrous events.

Focus Two: Lessons for Organizations

Wellington represents a significant proportion of NZ's economic output as the region of the country with the highest gross domestic product (GDP) per capita ($71,622; Statistics New Zealand, 2019). Business continuity is therefore a critical factor in ensuring the city can recover quickly after a major event. Given the estimated cost of NZ$29 billion to repair the city after an earthquake similar to the Christchurch, 2011, event (Devlin, 2017), it is essential we work to improve business resilience and recovery.

Kay, Brown et al. (2019) present a research update describing the work of Resilient Organisations from the beginning of the extensive Canterbury earthquake sequence in 2010. Wellington's geography means that it will take weeks for some areas to receive all necessary outside support, compared to several days as was the case in Canterbury, leading to a different recovery trajectory (George, 2017). However, Kay, Brown et al. present recommendations that can help Wellington businesses and organizations prepare for and continue through the aftermath of a local earthquake, such as improving adaptive capacity by planning before an event and leveraging relationships. The ability of businesses to continue operating after a disaster is not unique to NZ; similar efforts to identify ways to increase resilience among organizations at both large and small-scales have been made in countries including Japan (Baba, Watanabe, Nagaishi, & Matsumoto, 2014) and the US (Marshall & Schrank, 2014).

One such group which can benefit from these lessons is the Wellington hotel sector; in the year ending February 2018, tourism contributed over NZ$2.5 billion to the city's economy (WellingtonNZ, 2018). Using a mixed methods approach of surveys, interviews, and secondary data, Brown, Rovins et al. (2019) describe the challenges and strengths for the hotel sector in Wellington that emerged during their response to the Kaikōura earthquake. Hotels tended to have strong social networks, financial preparation, and compliant buildings, but weaker external networks and a focus on planning for a narrow range of hazards. This work has recently informed an exploration of the disaster resilience of hotels across Europe (Ivkov et al., 2019). Such work contributes to research which has examined the resilience of the tourism sector generally, both in NZ (Orchiston & Higham, 2016; Orchiston, Prayag, & Brown, 2016) and internationally, including the US (Johnston et al., 2007) and Thailand (Biggs, Hall, & Stoeckl, 2011).

Focus Three: Current and Future Resilience

The Kaikōura earthquake drew out the strengths and weaknesses of emergency management groups in Wellington, without overwhelming those organizations.

This event therefore provided a rare opportunity to evaluate current resilience and to identify areas for improvement. Fleisher (2019) identifies how response efforts in Wellington were prioritized immediately following the earthquake; in particular restoring infrastructure (e.g., roads and electricity), managing the cordoning of areas of the central business district, and assessing approximately 80 damaged buildings. Despite the NZ$2-3 billion estimated cost in insurance losses and repair work, which is still ongoing, Wellington's key lifeline utilities were not seriously impacted. However, these infrastructures are highly vulnerable to a larger event in future and Fleisher recommends improving the resilience of systems such as electricity supplies. Learnings from an event which caused damage and disruption in Wellington but did not overwhelm systems are invaluable for improving the resilience of those systems.

Fleisher (2019) identifies important strengths and weaknesses in Wellington's response to the Kaikōura earthquake. For example, the infrastructure overall fared well. However, no faults proximal to Wellington were triggered in the Kaikōura earthquake so it is not necessarily clear what impacts a local rupture would have. To explore this, Brown, McDonald et al. (2019) use the knowledge found by research like Fleisher's as one part of a process to develop a model of impacts to infrastructure, the economy, and communities in Wellington in the event of a large earthquake on a local fault. Modelling is a primary and important tool to improve resilience; systems are best strengthened against shocks when the impacts of those shocks are understood.

In line with the work of Kay, Brown et al. (2019) and Brown, Rovins et al. (2019) examining the resilience of businesses and organizations, which are critical to the resilience of Wellington as a functioning city, Brown, McDonald et al. (2019) examine impacts on businesses as part of a larger system, forecasting future impacts to identify areas of infrastructure where resilience can and should be improved. This paper also goes further to include impacts on individuals and communities, considering outcomes including population displacement and behavioural adaptation. This inclusion of human elements in an economic model recognizes that resilience refers to more than physical infrastructure and economic systems.

Resilience as a concept applies at different scales, from societal to community to individual, and covers many different aspects of the composition and function of a city (e.g., Mamula-Seadon & McLean, 2015). To improve resilience, it is important to define the concept in regard to the specific context and goal of the efforts being made to build resilience (Hobfoll, Stevens, & Zalta, 2015). This is not a new argument, especially when considering research within a type of resilience, such as community resilience (Huggins, Peace, Hill, Johnston, & Muñiz, 2015; Kay, Stevenson et al., 2019). Within a specific type of resilience there are still challenges to reaching a shared understanding, including between researchers and practitioners (Huggins et al., 2015). Adding to these difficulties, resilience is examined and discussed at the level of individuals, communities, or societies, and as physical, social, or psychological in nature, among other distinctions (Kelman, 2018).

To address the challenges that arise when different groups work to different definitions of resilience, Brown, Campbell et al. (2019) brought together a group of academics, government officials, and private organizations to reach a shared understanding of what these forms of resilience mean. For example, workshop participants challenged the common reference to resilience as bouncing back to the state in which a system (e.g., community) existed before an event. Instead, participants agreed that lessons from the event should be incorporated into efforts to guide the community towards a new equilibrium, appropriate for a changed context, rather than necessarily returning to its previous state. Shared understandings like this are important in developing a common goal after a disaster, so that everyone involved in the recovery process is sharing knowledge and progressing together.

To progress along the pathway to resilience we need metaphorical stepping-stones: objective measurements of important component factors. Kay, Stevenson et al. (2019) used a collaborative and innovative approach combining top-down and bottom-up processes to develop resilience indicators for the Wellington Region, covering categories including social capital, disaster risk reduction action, and leadership quality and capacity. These indicators make more tangible the specifics of the shared goal of increasing resilience for which groups in NZ are individually and collectively aiming. Such work will help NZ to meet its goals as part of the new National Disaster Resilience Strategy as well as global mandates including the Sendai Framework for Disaster Risk Reduction (UNDRR, 2015).

Conclusion

This special issue focuses on Wellington resilience in light of the 2016 Kaikōura earthquake, including how the event affected Wellington residents' thoughts and behaviours and the operation of organizations. The articles within also consider what future resilience means for Wellington and how improvements might be made using collaborative, multi-sectoral approaches. Looking across social and organizational impacts and current and future resilience, the articles in this special issue present "Pathways to Earthquake Resilience", highlighting lessons identified from past events and suggesting ways in which these lessons can be applied across sectors and disciplines to continue increasing resilience.

Finally, the editorial team wish to thank the authors who have contributed to this special issue, the peer reviewers who gave their time to ensure the quality of the articles, to all participants of the research presented, and to our readers. We trust that this issue contains useful and useable insights for the diverse audience of the *Australasian Journal of Disaster and Trauma Studies*.

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Risk judgments and social norms: Do they relate to preparedness after the Kaikōura earthquake?

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Abstract

Research has shown that preparation for natural hazard events reflects several factors including risk judgments and the cost of the actions. Research has also shown the effects of norms in other domains but very little research regarding natural hazards. This study examined risk judgments and preparedness norms following the recent Kaikōura earthquake. Wellington citizens judged the risk of earthquakes in Wellington, Kaikōura, and other parts of New Zealand ("elsewhere") before and after the 2016 Kaikōura earthquake. They also reported their preparation and perception of norms for different categories of actions. Judgments of the risk of a further earthquake occurring following the Kaikōura earthquake rose more for Kaikōura than for Wellington and elsewhere, but participants still judged an earthquake more likely in Wellington and elsewhere than in Kaikōura. Preparation was positively related to risk judgment and to the judgment that preparing was normative, particularly for survival actions. These findings suggest that normative information adds to the effect of risk perceptions about the probability of an earthquake to enhance preparation for these hazards. This finding can be applied in risk communications for earthquakes and other hazards by referencing norms for adaptive behaviours.

Keywords: *Earthquake, risk perception, norms, preparedness, optimism*

Levels of Preparedness for Hazards

Aotearoa New Zealand (NZ) is one of several locations globally that are vulnerable to earthquakes. This risk has been illustrated by recent damaging earthquakes in Canterbury (2010-2011), the Cook Strait (2013), and most recently, Kaikōura (2016). Despite the known earthquake hazard in these areas, many citizens in NZ as elsewhere are not well prepared (Johnston, Tarrant, Tipler, Coomer, Pedersen, & Garside, 2011; Lindell & Perry, 2000; Solberg, Rossetto, & Joffe, 2010). Furthermore, those who do prepare have typically performed more survival actions such as obtaining medicines than actions to mitigate damage such as removing brick chimneys (Charleson, Cook, & Bowering, 2003; Spittal, McClure, Siegert & Walkey, 2008). In Wellington for example, 73% of the population reported undertaking survival preparedness actions whereas only 24% reported actions to mitigate damage (Spittal et al., 2008). Although survival actions are invaluable in preparing for a major earthquake, damage mitigation is crucial for limiting structural damage to buildings as well as loss of life (Russell, Goltz & Bourque, 1995). It is therefore important to clarify what factors lead to more people making these preparations.

Psychological and Economic Factors and Preparation

Research has shown links between low levels of preparedness and several psychological and economic factors that are barriers to action. These include people's fatalism and lack of efficacy (the feeling that they can do nothing to prevent harm from an earthquake; McClure, Allen, & Walkey, 2001; Paton, 2003), their risk-taking tendency, and the cost of mitigating actions (Eiser, et al., 2012; Heller, Alexander, Gatz, Knight, & Rose, 2005; Lindell & Perry, 2000; Paton, 2018; Solberg et al., 2010). People living in rental accommodation cannot undertake most important mitigation actions such as strengthening a house or apartment. A lack of trust in authorities' hazard communications also inhibits preparation (Solberg et al., 2010).

Judgment of risk is an important prerequisite for people to prepare for a hazard (Slovic, 1987; Slovic & Weber, 2002). If people show unrealistic optimism, thinking that they are less at risk than others, then they prepare less for future events such as earthquakes (Burger & Palmer, 1992; Larsson & Enander, 1997; Sattler, Kaiser & Hittner, 2000; Weinstein, 1980). In contrast, experience of an earthquake increases risk judgments and leads to increases in preparation, unless the effects of the earthquake are minor, in which case people may become over-optimistic (Becker, Paton, Johnston, Ronan, & McClure, 2017; Lindell & Perry, 2000; Solberg et al., 2010).

A recent series of studies examined New Zealanders' risk perception in different locations following the 2010-11 Canterbury and 2013 Cook Strait earthquakes (McClure, Henrich, Johnston & Doyle, 2016; McClure, Johnston, Henrich, Milfont & Becker, 2015; McClure, Wills, Johnston & Recker, 2011). The studies assessed judgments of earthquake likelihood in these locations before and after the earthquakes. People rated the likelihood of an earthquake in Christchurch and other parts of New Zealand higher after the earthquakes than they recalled before, but they rated an earthquake in Wellington equally likely before and after the earthquakes and more likely than elsewhere in New Zealand. These findings suggest that people recognise that Wellington is a high-risk area for earthquakes.

Regarding preparedness, McClure et al. (2016) found that 60% of Wellington participants claimed they prepared prior to the 2013 Cook Strait earthquake whereas 74% said they had prepared since the earthquake. However, many people are unrealistically optimistic about their own and others' personal risk and so do not prepare (e.g. McClure et al., 2015; Spittal et al., 2008). Research shows that mere recognition of the risk of a disaster occurring often fails to translate into preparation (Paton, Smith & Johnston, 2000; Rustemli & Karanci, 1999; Weinstein, Lyon, Rothman, & Cuite, 2000b). As noted above, other factors play a role in reducing or increasing preparation, including fatalism and perceived efficacy, cost, home ownership, place attachment, and experience of prior events (Eiser et al., 2012; Paton, 2003; Paton, 2018 Solberg et al., 2010), Another key, although under-studied, factor is social norms, which are focused on here.

The Effects of Social Norms on Preparedness

Social norms comprise people's judgment of what behaviours are socially appropriate in a given situation (Cialdini, 2003; Fehr & Fischbacher, 2004). Research shows that these norms play a role in both desirable and undesirable actions (Cialdini, 2003). This research also shows the effects of two main sub-types of norms: injunctive and descriptive norms. A descriptive norm is the perception that a behaviour is performed by the majority of the relevant population. A well-known example is an experiment that increased the number of hotel guests re-using their towels by telling them that a majority (over 70%) of other guests did this (Goldstein, Griskevicius, & Cialdini, 2007). In contrast, an injunctive norm is the perception that a behaviour is approved of within a social group. For example, research showed that theft of petrified wood in a National Park in the United States decreased when researchers installed a sign asking visitors not to remove the wood and stating such acts were theft, expressing an injunctive norm of not stealing (Cialdini et al., 2006).

Lindell and Perry (2000) suggested that the communication of social norms through peer groups could enhance positive responses to natural hazards. However, there is little research on norms affecting earthquake preparedness (Solberg et al., 2010). The limited research that does exist on norms and natural hazards suggests that social norms do influence preparation. McIvor and Paton (2007) found that people who had social networks that support preparedness believed that preparation improves disaster outcomes, which is an important belief for combatting the barrier of fatalism mentioned above. Mileti and Darlington (1997) found that people discounted their risk from earthquakes until they were aware of the norm that others recognised the risk (See also Sorensen & Sorensen, 2007; Thompson, Garfin, & Silver, 2016). Becker, Paton, Johnston, and Ronan's (2012) qualitative research on the effect of social norms on hazard preparedness in three NZ towns suggests that preparedness was not seen as normative by many participants; people who did prepare were seen as abnormal or "over the top". However, this study was performed before the 2010-2011 Canterbury earthquakes and the most recent major earthquake disaster was the magnitude 7.8 Hawke's Bay earthquake in 1931. So, this study occurred during a period of earthquake quiescence, possibly explaining the norm of non-preparation. In contrast, in research on bushfire preparedness in at-risk areas of Australia, Morrison, Lawrence, and Oehmen (2014) found a strong relationship between preparedness and exposure to social norms supporting preparedness. This study performed in 2012-13 followed the Australian "Black Saturday" fires in 2009 and other damaging bushfires in 2011.

These findings suggest that social norms do indeed play a role in hazard preparedness. However, few studies have attempted to quantify or manipulate social norms to examine their relationship to people's earthquake preparedness or to distinguish the effects of the two main sub-types of norms: injunctive and descriptive. In one study focusing on this issue, Vinnell, Milfont, and McClure (2018) examined how citizens' judgments of legislation on earthquake-prone buildings (EPBs) related to descriptive and injunctive norms for earthquake preparation. The descriptive norm message read "Currently, Wellingtonians are strengthening an average of 72 earthquake-prone buildings a year to at least [the current legal minimum] standard, which means that at least 80% of these buildings will be strengthened within the 15-year time frame if this rate continues". The injunctive norm message read: "In a recent survey, 76% of Wellingtonians said they support this [building] legislation requiring the strengthening of earthquake-prone buildings". Vinnell et al. found that exposure to both the injunctive norm and a combined descriptive and injunctive norm increased support for the legislation. Hence this research suggests that injunctive norms, at least, can influence earthquake preparation.

The Present Research

This study examines judgments and preparation following the 2016 Kaikōura, NZ, earthquake. Previous research shows that the occurrence of a natural hazard can impact areas beyond where the hazard occurred (McClure et al., 2016; Mulilis, Duval & Lippa, 1990; Reve, 2011). In line with this literature, the current study examines how the occurrence of an earthquake affects people's attitudes and behaviours relating to earthquakes in different regions. This design allows for comparison with the previous studies with a similar design following the Canterbury and Cook Strait earthquakes (McClure et al., 2015; 2016).

With regard to risk judgments, this study simulated these previous studies on risk judgment in different locations but substituted Kaikōura for Canterbury and Cook Strait as the location of the recent earthquake. Participants judged the likelihood of an earthquake in three regions (Kaikōura, Wellington, and other parts of NZ), both before (recall) and after the 2016 Kaikōura earthquake. We expected that participants would rate an earthquake in Kaikōura more likely after the 2016 earthquake than they recalled before, but still lower than Wellington. As recalled probabilities are retrospective judgments subject to hindsight bias (Blank, Musch, & Pohl, 2007), we added two questions from McClure et al. (2016) asking whether the risk of earthquakes was more real, plausible, and important to them since the Kaikōura earthquake. We expected that participants would report preparing more after the Kaikōura earthquake than before.

The study also bridged the gap between the previous studies on risk judgments and preparedness (e.g. McClure et al., 2016) and research on the effects of norm messages (e.g., Vinnell et al., 2018). We examined social norms in the form of judgments of how much friends, family, co-workers, and neighbours support preparation (injunctive norm) and have prepared (descriptive norm). Rather than examining how norm information affects judgments as in Vinnell et al.'s (2018) study, this research examines people's perceptions of those norms following the 2016 Kaikōura earthquake.

We anticipated that people with higher norm scores (i.e., who perceive stronger norms in their social groups) would report more preparation than those with lower norm scores (i.e., who perceive weaker norms; Morrison et al. 2014). Specifically, we expected that those who report that their friends, family, co-workers, and neighbours see preparedness actions as important and have performed these actions would themselves have performed more of these actions.

Method

Design

The study employed a questionnaire where participants made judgments about the likelihood of earthquakes in three locations (Kaikōura, Wellington, and the rest of NZ) before (using recall) and after the Kaikōura earthquake and reported their preparation and norms judgments.

Participants

Participants were 241 residents of Wellington, NZ, of whom 165 (68%) were female, 49 (20%) were male, and one (1%) identified as "other", while the remaining 26 (11%) did not specify gender. The majority of participants (52%) were in the 21-30 age group. The questionnaire targeted those living in Wellington because of the known earthquake risk in the area and because the city sustained significant damage to its central business district in the 2016 Kaikōura earthquake.

Materials

The first eight questions of the questionnaire assessed risk perception, with six questions assessing how likely participants judged an earthquake in Kaikōura, in Wellington, and in another part of NZ both before (recall) and after the 2016 Kaikōura earthquake. These questions were adapted from McClure et al. (2016) and used seven-point Likert-type response scales ranging from 1 ("Not at all likely") to 7 ("Very likely"; see the Appendix for the full survey). The remaining two risk perception questions asked if the risk of an earthquake had become more real and plausible since the Kaikōura earthquake ("yes"/"no") and whether the combined occurrence of the Canterbury (2010-2011), Cook Strait (2013). and Kaikōura (2016) earthquakes made the risk of an earthquake more important for them and their region. This final question also used a seven-point Likert-type response scale ranging from 1 ("Not at all") to 7 ("Very much").

The questions regarding preparation asked participants whether they had made any preparations for an earthquake before or after the Kaikōura earthquake for four types of preparation options: basic survival actions such as stocking up on food, contents damage mitigation such as attaching shelves to wall, structural damage mitigation such as chimney removal, and logistics planning such as planning a meeting place. Participants could tick all options they had performed ("yes"/"no").

The next questions assessed participants' views regarding EPBs. A fatalism question asked participants to rate whether they believe strengthening EPBs reduces the risk of damage and loss in a major earthquake using a seven-point Likert-type response scale ranging from 1 ("Not at all") to 7 ("Very much"). Two questions asked for estimates of how many of the 5500 buildings in Wellington subject to EPB legislation were earthquake-prone and how many of these buildings are taken off the EPB list annually due to being strengthened, demolished, or re-assessed.

Five questions relating to social norms asked about participants' perceptions of their peers' attitudes and behaviours towards earthquake preparedness. Four questions were prefixed with "For the next four questions please rate how strongly you agree or disagree with the statements" and used a seven-point Likert scale from "Strongly disagree" to "Strongly agree". The questions read:

1) "Most of my friends, family, co-workers and neighbours have taken some survival actions (e.g. acquiring emergency supplies such as food, water and a radio) to prepare for the aftermath of a large earthquake in the future." [Descriptive norm];
2) "Most of my friends, family, co-workers and neighbours have taken some mitigation actions (e.g. removing their chimneys or getting an earthquake check of their home) to limit the damage their home might incur in the event of a large future earthquake." [Descriptive norm];
3) "Most of my friends, family, co-workers and neighbours think that it is important to prepare for potential future earthquakes." [Injunctive norm]; and
4) "Most of my friends, family, co-workers and neighbours would view me favourably if I prepared for a potential future earthquake." [Injunctive norm].

A fifth norms question asked what percentage of the Wellington population participants thought had taken steps to prepare for an earthquake. Participants were asked to give a specific percentage; range options were not provided.

Lastly, questions asked if participants incurred damage in the Kaikōura earthquake and if they had any additional comments about earthquakes or the Kaikōura earthquake (due to space limitations, these are not reported here; see Ferrick, 2017). Demographic questions assessed gender, age, number of dependent children in their home, and suburb.

Procedure

Participants were recruited through the Facebook social media platform and the survey was hosted on Qualtrics. Participation was voluntary and anonymous, and participants could withdraw at any time. The survey questions have low risk ethics approval from Massey University (ID 4000017003). A link to the questionnaire was posted on Facebook. Participants clicked the link if they were Wellington residents and then followed the prompts. The questionnaire could be accessed from any Internet-enabled device. After completion, the participants were thanked and debriefed and could enter a prize draw for a $60 supermarket voucher. Identifying information for this draw was provided through a separate link to maintain anonymity. The study was run in January 2017, nine weeks after the magnitude 7.8 Kaikōura earthquake on November 14th, 2016 and generated 241 responses.

Results

Judgments of Earthquake Likelihood

Figure 1 shows the mean ratings for likelihood of an earthquake in each of the three locations before (recall) and after the Kaikōura earthquake. We performed a 3 (Location: Wellington, Kaikōura, other part of NZ) x 2 (Time: Before, After) repeated measures analysis of variance (ANOVA) on the earthquake likelihood ratings, with both independent variables being within-subjects. This test compares a number of mean scores to identify whether there is a significant difference between them as a whole. Post-hoc tests then identify between which scores there are significant differences, if any. This analysis showed a main effect of time, where participants judged an earthquake more likely after the Kaikōura earthquake (M = 5.65, SD =1.06) than before (M = 4.88, SD = 1.16), $F(1, 240) = 119.30$, $p <.001$, $\eta^2 = .33$. There was also a main effect for location, F (1, 240) = 102.16, p<.001, η^2 = .30; follow-up ANOVAs showed that participants rated an earthquake more likely in Wellington (M = 5.55, SD =1.13) than in Kaikōura (M = 4.61, SD = 1.20), $F(1, 240) = 135.69$ $p < .001$, η^2 = .36, and more likely in other parts of New Zealand (M = 5.64, SD = 1.27) than in Kaikōura, $F(1, 240) = 135.72$, $p < .001$, $\eta^2 = .36$.

The analysis also showed a two-way interaction between location and time. Follow-up ANOVAs showed that in their recall of before the earthquake, participants rated an earthquake more likely for Wellington and other parts of New Zealand than in Kaikōura, F (1, 240) = 37.77, $p <.001$, $\eta^2 = .14$, and showed that this difference decreased after the earthquake. Following the earthquake, the increase in ratings of likelihood was significantly larger for Kaikōura (M = 1.24, SD = 1.58) than for Wellington (M = 0.63, SD = 1.37), $t(240) = 5.82$, $p < 0.001$ and other parts of New Zealand (M = 0.44, SD = 1.20), $t(240) = 7.84$, $p <.001$, although the likelihood of an earthquake was still seen as lower for Kaikōura than for the other two locations. Of the 241 participants, 187 (77.6%) answered that they thought that the risk of an earthquake was more real and plausible since the Kaikōura earthquake. The risk of an earthquake had become important to participants since the combined occurrence of the Canterbury, Cook Strait, and Kaikōura

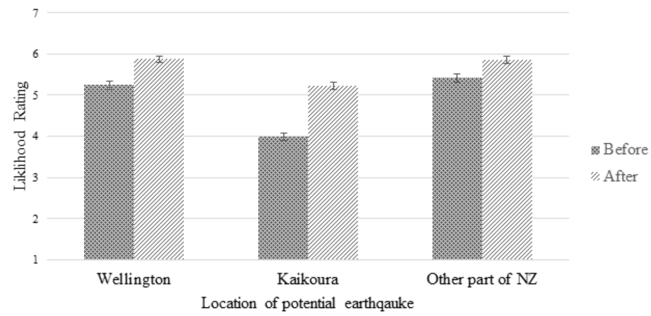

Figure 1. Mean ratings of the likelihood of an earthquake in different locations before and after the Kaikōura earthquake.

earthquakes with the mean rating near the top of the scale (M = 5.81, SD = 1.47).

Preparedness Actions

Overall, 133 participants (55.2%) recalled some preparations prior to the Kaikōura earthquake and 132 participants (54.8%) reported preparation actions since the Kaikōura earthquake, mostly survival and logistics actions, as shown in Figure 2. A frequency analysis using a chi-square test showed there was no difference in overall preparation before and after the Kaikōura earthquake, χ^2 (241) = 0.92, *ns*.

To compare the risk (earthquake likelihood) judgments of participants who did and did not prepare *before* the Kaikōura earthquake, we performed a 2 (Preparation: Yes or No) by 3 (Location; Wellington, Kaikōura, other part of New Zealand) by 2 (Time; Before, After) mixed design ANOVA where Preparation was a between-subjects factor and Location and Time were repeated measures completed by all participants. This analysis showed a two-way interaction between preparation before the Kaikōura earthquake and time, $F(1, 240)$ = 7.44, $p = 0.01$, $\eta^2 = .03$, where recalled risk before the earthquake was lower for those who had prepared (M = 4.45, SD =1.55) than those who had not (M = 5.23, SD =1.55), $F(1, 240) = 30.39$, $p <.001$, $\eta^2 = .19$, whereas

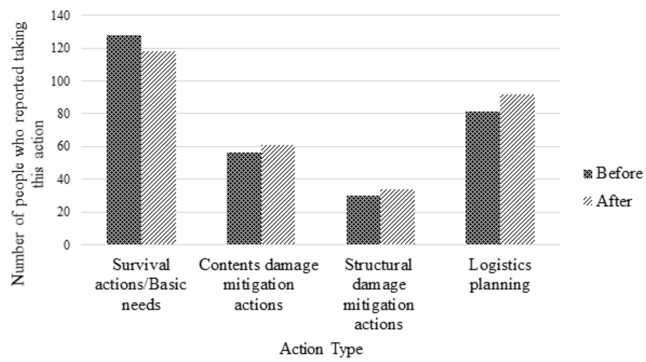

Figure 2. Numbers of participants who had undertaken each type of preparedness action before and after the Kaikōura earthquake.

perceived risk after the earthquake did not differ between those who had prepared (*M* = 5.43, *SD* =1.39) and those who had not (*M* = 5.84, *SD* =1.55), $F(1, 240) = 1.64$, $p = .20$, $\eta^2 = .01$. A three-way interaction between location, risk judgments, and preparation before the earthquake showed that the increase in perceived risk for Kaikōura after the earthquake was only for participants who had prepared before the event, $F(1, 240) = 13.76$, $p < .001$, $\eta^2 = .05$.

The same analysis with preparation *since* the Kaikōura earthquake showed a similar interaction between preparation and time, $F(1, 240) = 14.98$, $p < .001$, $\eta^2 = .06$ where recalled risk before the earthquake did not differ between those who prepared since the event (*M* = 4.99, *SD* =1.71) and those who did not (*M* = 4.79, *SD* =1.55), whereas the perceived risk after the earthquake was lower for those who prepared since the event (*M* = 5.47, *SD* =1.39) than for those who did not (*M* = 5.81, *SD* =1.55).

Social Norms

We tested correlations between each of the norm variables to check for relationships between norms for different types of preparations (survival and mitigation) and different types of norms (descriptive and injunctive). Table 1 shows the correlations between the four social norms questions and estimates of others' preparation. These correlations were mostly positive and significant and ranged from small to moderate. The correlations between the descriptive and injunctive norms questions suggest that these are related in people's minds, particularly for the importance of preparing and survival actions. Participants estimated that 51% of the Wellington population had made some preparations.

Table 1.
Correlation matrix for questions measuring perceptions of social norms.

	1	2	3	4	5
1. Estimate percent of prepared Wellington citizens	-				
2. Social norms (descriptive) - Survival	.21**	-			
3. Social norms (descriptive) - Mitigation	.07	.34**	-		
4. Social norms (injunctive) - Importance	.15*	.64**	.31**	-	
5. Social norms (injunctive) - Favourability	.06	.38**	.21**	.45**	-

Note. **p*<.05 (two-tailed); ***p*<.01 (two-tailed)

This variable significantly correlated with two of the four norms questions: the survival and importance norms.

To test our predictions of how social norms related to preparedness actions, we created an overall norm score by calculating the mean of participants' scores on the four norms questions. A mixed design ANOVA testing differences in means for the overall norm score between those who had prepared and those who had not found that those who reported preparing *before* the earthquake were significantly higher on the combined norms (*M* = 4.80, *SD* = 0.92) than those who did not (*M* = 4.39, *SD* = 1.11), $F(1, 216) = 6.72$, $p = .01$, $\eta^2 = .03$. The same effect was seen for reported preparation *after* the earthquake: had prepared (*M* = 4.91, *SD* = 0.94); had not prepared (*M* = 4.25 *SD* = 1.03), $F(1, 216) = 22.45$, $p<.001$, $\eta^2 = .09$ The interaction between before and after (i.e., effect of time) was not significant, $F(1, 216) = 3.36$, $p = .068$, $\eta^2 = .01$.

We then ran a logistic regression to test whether the individual social norms items predicted preparedness prior to the earthquake. The peers' survival actions norms question was the sole significant predictor of preparation, both before, *B*(*SE* = .14) = .25, OR = .76, [95% CI = .61, .99] , $p < .05$, and after *B*(*SE* = .13) = .45, OR = .64, 95% [CI = .49, .83], $p < .001$ the earthquake.

Fatalism and Estimates of Earthquake-Prone Buildings

Overall, participants demonstrated weak fatalism biases with a high average perception that strengthening earthquake-prone buildings reduces harm and loss from an earthquake (*M* = 5.47, *SD* = 1.55). One-way ANOVAs found no relationship between fatalism and preparedness before the earthquake, $F(1, 225) = 0.75$, $p = .39$ or after the earthquake, $F(1, 225) = 2.27$, $p = .13$, possibly reflecting a ceiling effect due to the high overall ratings. Participants greatly overestimated the number of the 5500 eligible buildings in Wellington that are rated earthquake prone (*M* = 2621; the correct number at this date was 654); however, they also overestimated the number of buildings removed annually from the EPBs list (*M* = 219); the correct number is about 50 (McCrae, McClure, Henrich, Leah, & Charleson, 2017). As noted by a reviewer of this paper, the proportion of buildings removed from this list relative to the number of buildings they judge to be prone (8%), is close to the correct proportion (7.6%).

Discussion

Risk Judgments for Different Locations

As predicted, participants' rating of the likelihood of a future earthquake was higher after the Kaikōura 2016 earthquake than their recall of the risk before. This finding is consistent with previous findings (Greening & Dollinger, 1992; Kung & Chen, 2012; McClure et al., 2016; McClure et al., 2015; McClure et al., 2011). The results also highlight that location plays a role, in that the change in likelihood was greatest for Kaikōura compared to Wellington, and smallest for other locations. This difference reflects the impacts of the recent earthquake in Kaikōura.

However, the Kaikōura likelihood ratings were still lower than the two other locations. This finding is interesting given how soon after the Kaikōura earthquake the data were obtained. The higher risk rating for Wellington may reflect the fact that Wellington has a well-known earthquake risk, with one expert estimate of a magnitude 7.5 earthquake occurring in Wellington on average once every 500 years with a potential death toll of 1,600 people (Cousins, 2013; see also Gulliver, 2015; Langridge, Leonard, van Dissen, & Wright, 2012). Risk judgments for the other parts of New Zealand may also be higher than for Kaikōura because people may have thought of locations such as Christchurch which recently experienced two major damaging earthquakes (Doyle, Johnston, McClure, & Paton, 2011; Greening & Dollinger, 1992; Kung & Chen, 2012). These judgments show that estimates of earthquake risk are based on several factors, not only the location of the most recent seismic event(s). These estimates also show that a rise in perceptions of earthquake risk is not restricted to the region where a recent earthquake has occurred. Efforts to get people to prepare can capitalize on this heightened perception of the risk following an event, regardless of the location of either the earthquake itself or the particular targeted population.

Preparedness Behaviours

Contrary to predictions, participants reported no more preparation following the Kaikōura earthquake than prior. A possible reason for this finding is that participants had recently experienced the 2010-11 Canterbury or 2013 Cook Strait earthquakes which occurred only 5 and 3 years respectively before the 2016 Kaikōura earthquake. Participants may have prepared after these prior earthquakes and did not feel the need to prepare again following the Kaikōura earthquake (McClure et al., 2016; Russell et al., 1995; Weinstein, Lyon, Rothman, & Cuite, 2000a). Past research found that reviewing logistics increased after the second of the Cook Strait earthquakes (Doyle et al., 2018). This increase may not continue after a third event (in this case, the Kaikōura earthquake) and many preparations such as attaching a hot water cylinder need doing only once. Participants in this study reported more survival actions than mitigation actions, in line with previous findings (Heller et al., 2005; Spittal et al., 2008). However, it is likely that some citizens who planned mitigation actions following the Kaikōura earthquake had insufficient time to do this by the time of this study (Miceli, Sotgiu, & Settanni, 2008). To deal with this issue, future similar research could measure intentions, with questions such as "Are you actively planning to take [mitigation] actions?", possibly with a time frame and priority rating scale.

Although preparation was no higher after the Kaikōura earthquake than before, it did relate to recall judgments of the risk of an earthquake. Recall of this risk before the Kaikōura earthquake was higher for those who had prepared than for those who had not, whereas these risk judgments after the earthquake were the same for the two groups (cf. Paton, 2003). This finding suggests that those who prepare prior to an earthquake are more likely to recognise the potential risk, consistent with previous research (McClure et al., 2016; Miceli et al., 2008). Perceived risk is not sufficient on its own for people to prepare and, as noted above, there are many other barriers to action; however, recognising the risk serves as a prerequisite to voluntary actions.

Preparation and Social Norms

In line with our predictions, those participants who had prepared typically had higher scores for the combined norms variable. That is, citizens who perceived their peers to be more prepared were themselves more likely to be prepared than those who perceived this norm as weaker. This finding applies to preparation before and after the Kaikōura earthquake and extends previous research on the relation of norms to actions to mitigate hazards (Morrison et al., 2014; Vinnell et al., 2018).

When the norms questions were examined individually, however, the only individual question that was significantly associated with preparation was the descriptive norm item stating that most of their peers have taken survival actions to prepare for an earthquake. This finding may reflect the fact that survival actions are more frequent than mitigation actions, which many of their peers may not have undertaken. Interestingly, participants' perceptions of how their peers judge the importance of preparation and how they would approve of the respondent preparing (both injunctive norms) did not predict preparation. These findings suggest that descriptive norms relate to preparation more than injunctive norms do, whereas Vinnell et al., (2018) found the opposite. There is clearly a need for research to clarify which types of norm affect hazard preparation and when. It may be that people report doing what other people do in a type of conformity effect (descriptive norm) but when given norm messages as in Vinnell et al., they are susceptible to messages expressing people's evaluations and approval of those actions (injunctive norms). Regardless of whether this is the case, the valuable finding here and in Vinnell et al. is that norms do have a relationship to earthquake preparation, giving another string to the bow of interventions.

Participants' estimates of how many Wellington citizens had prepared for an earthquake correlate with perceptions of their peers' survival actions (descriptive norm) and beliefs about the importance of preparing (injunctive norm). Again, this may be because people think that survival actions are the most easily performed so they infer that most people have taken this type of action. A related interesting finding is participants' estimate of the number of EPBs, which assesses a perceived norm of compliance with building standards. We made no predictions on this item, as it is a new measure. Of the 5500 eligible buildings in Wellington, participants greatly overestimated how many were earthquake-prone (2600), four times the actual number (650). This finding suggests people imagine a norm of not rectifying these buildings and may reinforce fatalism about ever making the city resilient. However, participants also greatly overestimated the number of buildings removed from this earthquake-prone list annually. This judgment shows that their estimates of the proportion of buildings being rectified is close the actual proportion (8%), even if their idea of the absolute numbers on both measures is greatly inflated.

Limitations and Future Directions

One limitation of the current research is that the respondents were relatively young and the majority were female, so the conclusions may not generalize to the wider population. Older participants are more likely to be homeowners and potentially have carried out more mitigation actions than people who are renting. A participant's friends, as evoked in the norms questions, are likely to be in a similar situation as that participant. However, the sample was not limited to students or any other group, so the results are more generalizable than some comparable studies which draw their sample from one specific population (e.g., students). Another possible limitation is the proximity in time between the Kaikōura earthquake and the survey, which allowed little time for mitigation actions to be completed. As mentioned above, future research with this design could add a question on whether people intend to carry out such actions. A further possible limitation is that the recall risk judgments are subject to hindsight bias, as recalled probabilities may be biased by subsequent events (Blank et al., 2007). However, the earthquake likelihood data on these recall measures are close to pre-Canterbury earthquake data in Wellington and Christchurch (comparative data for Kaikōura are not available; Becker, 2010) which suggests that hindsight did not greatly affect recall judgments. In addition, the questions on the greater reality of the risk since the earthquake are less subject to this potential hindsight bias. Researchers should be aware that the way questions are framed influences the judgments the questions are intended to elicit (McClure & Hilton, 1998; Schwartz, 1999).

Conclusion

In addition to supporting previous findings on risk judgments following earthquakes, this research shows that people who prepare more for earthquakes tend to believe that such preparation is the norm more so than people who do not prepare. This finding particularly applies with survival actions and descriptive norms. These findings suggest that norms provide an additional tool to apply to the difficult task of getting people to prepare more for natural hazards and could be used in risk messaging campaigns to this end. As illustrated in Vinnell et al.'s (2018) study, one way this can be achieved is by presenting messages where a majority (i.e., the norm) have performed an action (descriptive norm) or approve of that action (injunctive norm).

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Appendix

Questionnaire

Q1 Before the November 2016 Kaikoura earthquake, how likely did you think it was there would be a big earthquake in or near Wellington?

Q2 Since this earthquake, how likely do you rate a future big earthquake near Wellington?

Q3 Before this earthquake, how likely did you think it was that there would be a big earthquake on the west coast of the South Island (e.g. Kaikoura)?

Q4 Since this earthquake, how likely do you rate a future big earthquake on the west coast of the South Island (e.g. Kaikoura)?

Q5 Before this earthquake, how likely did you think it was that there would be a serious earthquake in another part of New Zealand?

Q6 Since this earthquake, how likely do you rate a future big earthquake in another part of New Zealand?

Q7 Has the risk of an earthquake become more real and plausible to you since this earthquake?

Q8 Has the combined occurrence of the earthquakes in Canterbury in 2010-2011, Cook Strait (2013) and Kaikoura (2016) increased your feeling that this is an important risk for you or your region?

Q9 Before the Kaikoura earthquake, had you made any preparations specifically for an earthquake?

If 'Yes', Q10 Please list these preparations below: [tick those that apply [see method]

Q11 Since this earthquake, have you made any preparations specifically for an earthquake?

If Yes, Q12 Please list these preparations below: [tick those that apply [see method]

Q13 Do you think that strengthening earthquake-prone buildings reduces the harm and loss that results from a really big earthquake?

Q14 There are 5,500 public buildings subject to the legislation on earthquake prone buildings in Wellington. These buildings have all been inspected to see if they are earthquake-prone. How many of the 5500 would you guess are earthquake prone?

Q15 How many of these earthquake prone buildings would you guess are taken off the earthquake-prone list each year due to being strengthened, demolished, or re-assessed?

Q16 What percentage of people in Wellington do you think have taken steps to prepare for earthquakes?

Q17 Most of my friends, family, co-workers and neighbours have taken some survival action/s (e.g. acquiring emergency supplies such as food, water and a radio) to prepare for the aftermath of a large earthquake in the future:

Q18 Most of my friends, family, co-workers and neighbours have taken some mitigation action/s (e.g. removing their chimneys or getting an earthquake check of their home) to limit the damage their home might incur in the event of a large future earthquake:

Q19 Most of my friends, family, co-workers and neighbours think that it is important to prepare for potential future earthquakes:

Q20 Most of my friends, family, co-workers and neighbours would view me favourably if I prepared for a potential future earthquake:

Q21 The above four questions asked about your friends, family, co-workers and neighbours; please rank these groups according to how important they are to you. Rank the most important group as number 1, and the least important group as number 4.

Q22 Did you incur damage in the earthquake?

Q23 Any other comments you would like to make (about earthquakes or the Kaikoura earthquake). (Optional)

Q24-27. Gender, Age, No. of dependent children in your household, Suburb

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The impact of the Kaikōura earthquake on risk-related behaviour, perceptions, and social norm messages

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Abstract

The unpredictability of earthquakes poses a significant challenge to examining and understanding the effects of these events on risk-related perceptions and behaviour. Natural experiments, a type of quasi-experimental method, allow for close approximations of treatment-control designs when data collection and earthquake events coincide. This study reports one such natural experiment, testing the effect of the November 2016 Kaikōura earthquake on risk perception, perceived norms, and preparation among residents of Wellington, Aotearoa New Zealand. Additionally, this research tested whether previously demonstrated effects of social norm messaging on support for recent legislation for strengthening earthquake-prone buildings was weaker following the event. As expected, earthquake preparation and concern were higher after the earthquake. Social norm effects were weaker after the earthquake but did not disappear entirely; these effects therefore appear to be relatively robust even to significant events, supporting the use of social norms in earthquake-related messaging.

Keywords: *Earthquake, New Zealand, natural experiment, earthquake preparation, social norms*

Social norms have been used to change behaviour in a wide range of domains, namely pro-environmentalism (Farrow, Grolleau, & Ibanez, 2017) and health (Dempsey, McAlaney, & Bewick, 2018). Recent research has demonstrated that social norms are an important concept to disaster preparation (Becker, Paton, Johnston, & Ronan, 2014; Vinnell, Milfont, & McClure, 2018). However, the role of social norms in disaster-related behaviours has not yet been explored thoroughly (Solberg, Rossetto, & Joffe, 2010). Specifically, research is needed to establish the impact of disaster experience on the effectiveness of risk-related social norm messaging (e.g., Vinnell et al., 2018), as well as on perceptions of social norms. In addition to addressing this issue, a secondary purpose of the current research is to test previously-demonstrated effects of disaster experience on risk-related concern and behaviour (e.g., Becker et al., 2014; McClure, Johnston, Henrich, Milfont, & Becker, 2015; McClure, Willis, Johnston, & Recker, 2011) using a more rigorous methodology. These previous effects as well as issues with common methodologies and benefits of the design of the current study are explained later in the introduction.

Context

On the 14th of November 2016, a magnitude 7.8 earthquake struck in the North Canterbury area of Aotearoa New Zealand (NZ), leading to two fatalities, nearly 600 reported injuries, and an estimated economic loss of between NZ$4 to $5 billion (Winter, 2017). In Wellington, approximately 300 kilometres from the epicentre, the quake triggered a tsunami warning (Blake, Johnston, Leonard, McLaren, & Becker, 2018) and severely damaged several high-profile buildings (Devlin, 2017). This earthquake allowed for a study on the effects of direct experience on risk-related judgments, perceptions, and behaviours of residents in Wellington. Of interest are the impacts of the earthquake on both perceptions of social norms for earthquake preparation and the effectiveness of social norm messaging. The current study examined social norm messages used to increase support for national legislation that requires the strengthening of earthquake-prone buildings. Briefly, this legislation targets public and private non-residential buildings and multi-level apartment buildings which were built before 1976 when earthquake codes were upgraded. Approximately 5,300 buildings in Wellington fit into this category. In 2016, 700 of those 5,300 did not meet at least 34% of the new building standard (NBS), meaning they were not likely to withstand shaking one third of the intensity of shaking which new buildings are constructed to withstand, and hence were deemed earthquake-prone.

Social Norms

Social norms act as decisional shortcuts, operating on both the motivation to behave consistently with others (because a common behaviour is seen as likely to be beneficial) and to be approved of by others (because acting contrary to what others approve risks social punishment; Cialdini, 2007). These shortcuts tend to operate more strongly in new or ambiguous situations (Goldstein, Griskevicius, & Cialdini, 2007) where there is a lack of past knowledge or other guides in the environment and when the individual does not already have strong beliefs about the behaviour (Morris, Hong, Chiu, & Liu, 2015). This study examines the two main types of norms: descriptive, which refers to the prevalence of the behaviour, and injunctive, which refers to the level of approval or disapproval of the behaviour (Cialdini, Reno, & Kallgren, 1990). Vinnell and colleagues found that an injunctive norm stating that 76% of other Wellington residents approved of the earthquake strengthening legislation described above increased participants' support for the legislation. Further, a descriptive norm conveying the rate at which buildings were being strengthened (72 per year on average) increased judgments that the strengthening work was achievable within the time frame allowed by the NZ Government.

Vinnell et al. (2018) presented *actual* social norms about earthquake preparation, which convey objective information about the prevalence and approval of particular behaviours. It is therefore pertinent to test whether the social norm effects found by Vinnell et al. (2018) are robust to earthquake events, such as the 2016 Kaikōura earthquake, which should make the legislation more relevant to participants. This increase in relevance should decrease the situational ambiguity and lead to stronger opinions about the strengthening legislation, thereby weakening the effect of social norm messaging. As well as testing the impact of a disaster event on the effectiveness of actual social norm information, the present study examined the effect of the Kaikōura earthquake on perceived interpersonal norms: the extent to which participants think those close to them (friends and family) have prepared for an earthquake and approve of them preparing (Lapinksi & Rimal, 2005).

Risk-related Perceptions and Behaviours

Past research demonstrates a brief increase in preparedness (e.g., McRae, McClure, Henrich, Leah, & Charleson, 2017; Russell, Goltz, & Bourque, 1995) and concern (McClure et al., 2015) following earthquakes, with some evidence showing that this increase decays completely in less than three months (McRae et al., 2017; Oishi, Kohlbacher, & Choi, 2018). However, a review of evidence suggests that experience needs to pass a threshold of impact on an individual to motivate concern and preparedness, but that too extreme an experience can lead to decreases in these outcomes (Solberg et al., 2010). The other main purpose of this study, therefore, is to test the effect of the Kaikōura earthquake on risk-related perceptions and behaviours. This includes preparation at the household level, concern about earthquakes, and concern about earthquake-prone buildings.

Methodology

One main challenge in this research domain is that it is neither possible nor ethical to simulate a disaster caused by a natural hazard event such as an earthquake (Oishi et al., 2018). Past research has typically used retrospective self-reports (e.g., McClure et al., 2011) requiring participants to recall their risk judgments and disaster preparation from before an event. While these cross-sectional studies provide useful data, people's reports of previous knowledge and behaviour can be affected by interposing events (e.g., Smith, Leffingwell, & Ptacek, 1999). Given the unpredictability of disasters and the implausibility of true experimental manipulation, quasi-experimental research provides a useful methodology to explore causal relationships.

Quasi-Experimental Research Designs

A quasi-experimental research design is one which approximates an experiment in that participants are assigned to conditions, but not truly at random (Cozby & Bates, 2012). Instead, some aspect of the environment in which participants are studied acts as the assigner. For example, field observation studies often use a number of different locations so that researchers can infer an effect of location on the observed behaviour. Quasi-experimental designs therefore allow testing causal factors which cannot, for logistical or ethical reasons, be manipulated by researchers.

A natural experiment design, by extension, is typically one where the aspect of the environment approximating the manipulation randomly occurs, such as a natural hazard event (Leatherdale, 2019; Oishi et al., 2018), as opposed to being deliberately selected by the researcher. The natural occurrence either splits participants quasi-randomly into between-subjects “treatment” and “control” groups (Oishi et al., 2018) where data has been collected prior to the event (Leatherdale, 2019) or allows for a pretest-posttest design where the same participants are observed before and after the event. These designs have strengths over more controlled studies, such as randomized control trials, in that they test real-world effects and can examine influences which would be impractical or unethical to manipulate. Because of these strengths, calls for such methods are increasing both in the research community and within governments (Leatherdale, 2019). The current study reports survey data collected approximately three months before (Vinnell et al., 2018) and one month after the November 2016 Kaikōura earthquake, in line with one of the recommended methods for natural experiments (White & Sabarwal, 2008). As this study compares two discrete groups surveyed at different time points rather than pre-tests and post-tests using the same sample, we will use the terms control group for those surveyed before the earthquake and treatment group for those surveyed after the earthquake (Cozby & Bates, 2012).

The Present Study

The present study made five main predictions. Based on the suggestions of previous researchers (e.g., Goldstein et al., 2007; Morris et al., 2015) we expected effects of social norm messaging on judgments of earthquake strengthening legislation to be weaker in the treatment group than in the control group, as these participants will have more first-hand earthquake experience to inform their judgments. We did not expect the norm effects to disappear entirely, given that high knowledge of the earthquake legislation not only failed to suppress the norm effects entirely in previous research, but even strengthened one of these effects (Vinnell, 2016). Further, we expected that the perceived norms of general preparedness, both descriptive and injunctive, would be stronger in the treatment group compared to the control group.

We expected that preparation for earthquakes would be higher in the treatment group compared to the control (e.g., McRae et al., 2017). Based on past findings (e.g., McClure et al., 2015), we also expected that concern about earthquakes and earthquake-prone buildings would be higher, and risk tolerance lower, in the treatment group (i.e., following the Kaikōura event) than the control group (i.e., before the Kaikōura event). Finally, we expected overall support for the building legislation to be higher in the treatment group than the control group, given the visible impacts of earthquake damage to buildings in Wellington.

Method

Design

As described above, this study used a natural experiment design. Participants who took part in the survey before the earthquake formed the control group and participants who took part after the earthquake formed the treatment group. This study also used a between-subjects experimental design as within both the treatment and control groups participants were randomly assigned to a social norm condition in the online survey. All conditions presented a message briefly explaining the legislation, but each had a different, additional piece of information as detailed in Table 1: descriptive norm, injunctive norm, combined norm, risk information, or control with no extra information. The treatment group included all five conditions; the control group did not include the control condition.

Participants

Participants were recruited through public Facebook groups targeting Wellington audiences. Details of the control group and the treatment group are presented separately. Because the sample in the study conducted before the earthquake was larger than the sample in the treatment group, a random subsample from the first survey sample was selected to represent the control group. This random subsample was used for between-group comparisons to ensure the two groups were matched for sample size, as samples equal in size are preferred for mean comparison tests (Grace-Martin, n.d.). Because this was a subset of an existing dataset, exclusions based on age, location, and the manipulation checks had already been made and are therefore not reported here.

Treatment group. Six-hundred and twenty-two participants commenced the survey which ran after the

Kaikōura earthquake. The data from 126 participants were excluded as they did not complete a majority of the survey questions. A further eight participants were excluded for being under the required age of 18. Of the remaining 488 participants, 144 failed one or both of the manipulation check questions and were also removed from the dataset. This left a sample of 344 participants. The majority (272) identified as female, 66 as male, and four as transgender; the remaining two participants did not answer the gender question. Ages ranged from 18 to 65 with a mean of 26.83 (*SD* = 8.55). Time lived in Wellington ranged from less than a week to 56 years, with a mean of 13.02 years (*SD* = 12.19). Participants numbered 65 in the descriptive condition, 69 in the injunctive condition, 75 in the combined condition, 67 in the risk condition, and 68 in the control condition.

Control group. As the first survey did not include a control condition, a sample equal to the totals from the four other conditions in the second survey was randomly selected. Of this sample of 276 participants, the majority (219) identified as female, 46 as male, and one as non-binary. The remaining ten participants chose not to report their gender. Participants were slightly younger in the control group than in the treatment group, with ages ranging from 18 to 60 and a mean of 24.96 (*SD* = 7.97). Participants had lived in Wellington for between less than a week and 50 years, with a mean length of residence of 11.96 years (*SD* = 11.55). These apparent differences in mean age and time lived in Wellington are tested for statistical significance, reported below. Participants numbered 63 in the descriptive condition, 65 in the injunctive condition, 73 in the combined condition, and 75 in the risk condition.

Table 1.
Information included in the pre-survey message for the different experimental conditions.

Condition	Information
Descriptive norm	Currently, Wellingtonians are strengthening an average of 72 earthquake-prone buildings a year to at least this standard, which means that at least 80% of these buildings will be strengthened within the 15 year time frame if this rate continues
Injunctive norm	In a recent survey, 76% of Wellingtonians said they support this legislation requiring the strengthening of earthquake-prone buildings
Combined norm	Both the descriptive and injunctive norm sentences
Risk-prone	The chance of these buildings collapsing or sustaining serious damage in an earthquake is about 10 to 20 times that of a new building at the same location
Control	No additional information

Materials

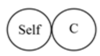
This study adapted the material used in Vinnell et al. (2018). The background information presented to all participants introduced the earthquake legislation, identified the type of buildings to which it applied, and the number of earthquake-prone buildings in Wellington (at the time, 641). Each condition also included one of the messages presented in Table 1, which represents the experimental manipulation. Consistent with the preference in past literature for factual rather than fabricated norm information, the injunctive norm conveys the actual rate of approval of the legislation found in Vinnell, McClure, and Milfont (2017) and the descriptive norm conveys the actual rate of building strengthening calculated by comparing the number of buildings on the Wellington City Council (WCC; 2015) list of earthquake-prone buildings at one time to the updated list four months later. The information about the risk of prone buildings is from a WCC (n.d.) brochure about earthquake-prone buildings.

All participants answered two manipulation questions tailored to the particular social norm condition. All manipulation questions had two response options and were not designed to be challenging to anyone who had properly read the message. An example question is: "How many buildings a year on average are being strengthened in Wellington?" which was presented to participants in both the descriptive and combined norm conditions. The two answer options were "0 – 100" and "100+". As mentioned above, 29.5% of eligible participants gave incorrect answers to one or both of these questions. The number of participants excluded did not significantly differ between conditions (p = .49).

The manipulation checks were followed by six questions about the legislation, all using seven-point Likert-type scales. Table 2 presents a full list of the questions.

These questions assessed prior knowledge of the legislation, support for the legislation, feasibility of the strengthening work, appropriateness of the standard required, justification of the expense, and appropriateness of the standard required for "modern buildings" (i.e., those built after 1976). This final question was added for the treatment group as several of the high-profile cases of damaged buildings in the Kaikōura earthquake were modern buildings (Stevenson et al., 2017).

Table 2.
Questions included in the survey conducted after the earthquake.

Number	Question	'1' Anchor	'4' Anchor	'7' Anchor
4	Before reading the above information, how much did you already know about this legislation?	Nothing	Some	A lot
5	Overall, how much do you support this legislation?	Not at all	Partly	Completely
6	How possible do you think it is to strengthen all 641 of these earthquake-prone buildings in Wellington?	Impossible	Unsure	Very possible
7	Do you think 34% of the current building code is an appropriate standard compared to legislation on other risks (e.g. Vehicle Warrant of Fitness)?	Not firm enough	About right	Too firm
8	Do you think the expense of this strengthening work is justified, given the risk of earthquakes compared to other risks (e.g. traffic accidents)?	Fully justified	About right	Excessive
9	Do you think the standard for 'modern buildings' (that is, those built after 1976 and not covered in this new legislation) are appropriate?	Not firm enough	About right	Too firm
10	How concerned are you about the danger of earthquakes where you live?	Not at all	Moderately	Extremely
11	How concerned are you about the issue of earthquake-prone buildings in Wellington?	Not at all	Moderately	Extremely
12	How effective do you think strengthening buildings will be in reducing damage and injury in a large earthquake?	Not at all	Moderately	Extremely
13	How much experience do you have of earthquakes?	None	Some	A lot
14	How much preparation had you made for the event of a large earthquake (e.g. secured fixtures such as TVs and bookshelves) before the recent Kaikōura earthquake?	None	Some	A lot
15	How much earthquake preparation have you already made since the recent Kaikōura quake?	None	Some	A lot
16	How much preparation do you intend to make in the next few weeks or months?	None	Some	A lot
17	To what extent do you think personal preparation is important for surviving earthquakes?t	Not at all	Moderately	Extremely
18	How much preparation have your family/friends made for a large earthquake?	None	Some	A lot
19	How often do your family/friends tell you that you should prepare for a large earthquake?	Never	Sometimes	A lot
20	Circle the pair which best describes your connection with the community where you live (S = Self, C = community)			

Note. Question 1 asked where participants lived. Questions 2 and 3 were manipulation checks.

Participants then answered 10 general questions regarding concern about earthquakes, concern about earthquake-prone buildings, efficacy of strengthening, experience of earthquakes, preparation before and (in the treatment group) after the Kaikōura earthquake, intentions to prepare, importancte of preparation, perceived interpersonal descriptive norm, and perceived interpersonal injunctive norm (see Table 2). Participants also completed the Inclusion of Community in Self scale (ICS; Mashek, Cannaday, & Tangney, 2007) to measure the strength of their identification with their community and demographic questions assessing age, gender, and time lived in Wellington to ensure that the post-quake sample closely matched the pre-quake sample.

Procedure

The survey for the treatment group ran in December 2016. Participants could complete the Qualtrics-hosted survey on any Internet-enabled device. The first page of the survey briefly introduced the study and provided a link to a more detailed information page. After the demographic questions, participants received a debrief about the purpose and experimental nature of the study. Finally, participants could follow a link to a separate web page to provide their contact details to go into the draw for an $80 supermarket gift card. This study received ethical approval from the School of Psychology Human Ethics Committee under delegated authority of the Victoria University of Wellington Human Ethics Committee (approved: 23rd March, 2016; Reference number: 0000020938).

Results

Descriptive Statistics

Participants in the different social norm conditions did not statistically differ on any of the variables unrelated to the legislation ($p > .09$ for all): knowledge of the legislation, experience of earthquakes, earthquake preparation before or after the Kaikōura quake, age, time lived in Wellington, or gender distribution, in both the treatment and control groups. The two samples did not differ on gender distribution or time lived in Wellington ($p > .27$ for both), but the control group had a significantly higher mean age, $t(535) = 2.85$, $p < .01$, $d = 0.25$. This is a small effect (Cohen, 1992) and controlling for age did not change the pattern of results; therefore, the simpler analyses without this control are presented.

Table 3.
Mean scores for participant and dependent variables for both groups, with standard deviations presented below in parentheses.

	Control group	Treatment group
Knowledge of legislation	2.29 (1.49)	2.90 (1.61)
Concern about earthquakes	4.57 (1.45)	4.98 (1.44)
Concern about earthquake prone buildings	4.71 (1.30)	5.21 (1.40)
Efficacy of strengthening	5.41 (1.18)	5.13 (1.37)
Earthquake experience	4.64 (1.53)	4.81 (1.43)
Earthquake preparation	3.14 (1.55)	3.83 (1.79)
Interpersonal descriptive norm	3.45 (1.53)	4.31 (1.57)
Interpersonal injunctive norm	2.55 (1.45)	3.65 (1.83)
Community identification	3.26 (1.36)	3.03 (1.27)
Support for legislation	5.84 (1.22)	5.50 (1.54)
Feasibility of strengthening	4.74 (1.32)	4.72 (1.62)
Comparative risk tolerance	2.86 (1.12)	2.50 (1.19)

Note. The two questions regarding the appropriateness of the standard and the expense of the legislation (questions 7 and 8 in Table 1, respectively) were combined to create the variable 'Comparative risk tolerance', as both required participants to compare the risk of earthquakes to other risks. Lower scores on this scale represent lower tolerance for earthquake risk

Between-Group Comparisons

Table 3 presents the means and standard deviations of the participant variables, comparing scores between the control group (i.e., those surveyed before the earthquake) and the treatment group (i.e., those surveyed after the earthquake).

Mean differences between control and treatment groups. This section reports the results of independent samples *t*-tests comparing the means of dependent variables where the responses could be affected by experience of the Kaikōura earthquake but not by the norm manipulation. Interestingly, reports of earthquake experience did not significantly differ between participants who answered this question before and after the Kaikōura quake ($p = .21$). Other evidence shows that this earthquake, which caused shaking for nearly two minutes, was widely felt in the sampled region; in a study of two Wellington suburbs, only 3% of participants reported the earthquake shaking as mild or not felt, with the remaining 97% describing the shaking as moderate (27%), strong (51%), or severe (19%; Blake et al., 2018). Although the quake struck around midnight, 78% of participants in the study by Blake et al. (2018) reported being woken by the shaking. Further, 69% of this study sample subsequently evacuated at some point in the hours after the earthquake during which an official tsunami warning was issued. It seems unlikely therefore that this earthquake was not objectively experienced, but that other factors meant that it did not increase subjective ratings of total earthquake experience. It is possible that this lack of change is due to a shift in comparative baseline; participants were aware that this study surveyed only people from Wellington so although estimates of the average amount of experience might have shifted, each participant's personal level of experience comparative to that estimated average would have remained fairly stable. Most participants would also likely have experienced the 2013 Cook Strait earthquake, which might have raised their perceived levels of experience to a point where a single event has negligible impact.

However, consistent with predictions, knowledge of the earthquake legislation was higher for participants surveyed after the Kaikōura earthquake, $t(550) = 4.89$, $p < .01$, $d = 0.42$, as was concern about both earthquakes in general, $t(544) = 3.02$, $p < .01$, $d = 0.26$, and earthquake-prone buildings, $t(544) = 4.25$, $p < .01$, $d = 0.36$, compared to the control group. As expected, reports of both perceived descriptive norms, $t(540) = 6.36$, $p < .01$, $d = 0.55$, and injunctive norms, $t(523.24) = 7.32$, $p < .01$, $d = 0.64$, were higher following the earthquake, suggesting that those surveyed after the earthquake believed more that their friends and family were preparing and told them more frequently that they ought to prepare themselves than those surveyed before.

Judgments of the efficacy of strengthening earthquake-prone buildings were *lower* following the earthquake, $t(544) = 2.57$, $p = .01$, $d = 0.22$. In regards to general preparation actions, the treatment group reported greater levels of personal preparation both in comparison to the control group, $t(267) = 4.54$, $p < .01$, $d = 0.56$, and to their own recollection of their prior preparation, $t(342) = 7.96$, $p < .01$, $d = 0.86$. However, participants in the treatment group only reported moderate intentions to prepare in the subsequent weeks or months ($M = 4.09$, $SD = 1.82$). The relatively neutral intentions to prepare in the immediate future likely reflects the quick decay in the motivational effect of the earthquake on behaviour.

Although we found that concern about earthquakes in general, and earthquake-prone buildings specifically, was higher for participants surveyed after the Kaikōura earthquake, these perceptions appear to differ from judgments about the strengthening legislation. The lower judgments of efficacy following the earthquake suggests that participants do not think the current legislation will be effective at reducing the risk posed by earthquake-prone buildings. In support of this suggestion, participants in the treatment group judged the appropriateness of the standard for modern buildings as not firm enough, as demonstrated by a one-sample *t*-test comparing the mean score ($M = 2.81$, $SD = 1.26$) with the neutral midpoint of the scale (4), $t(342) = 17.39$, $p < .01$, $d = 0.94$. Although this mean is still higher than the standard for the older buildings covered by the legislation ($M = 2.13$, $SD = 1.22$; $t(342) = 8.58$, $p < .01$, $d = 0.93$), this result shows that participants did not think buildings currently are being built to a high enough standard which may reflect the fact that most of the buildings severely damaged in this earthquake were relatively modern. However, as this question was not asked in Vinnell et al. (2018), it is not possible to determine with the available data if the earthquake did indeed affect the judgment of new building standards. The potential mechanism for this effect, relating to the distinctive damage to modern buildings, is discussed later.

Overall, these results are largely in line with predictions. The findings suggest that the earthquake did have an impact on risk-related knowledge, judgments, and behaviour, even though mean scores on the experience item did not change. Implications for these findings are presented in the discussion section.

Social Norm Effects Within and Between Groups

Table 4 presents the mean scores of the key dependent variables across norm conditions, as well as between the treatment and control groups. The two questions regarding the appropriateness of the standard and the expense of the legislation (questions 7 and 8 in Table 1, respectively) were combined to create the variable "Comparative risk tolerance" as both required participants to compare the risk of earthquakes to other risks. Spearman-Brown's coefficient, which is more appropriate than Cronbach's alpha for a two-item scale (Eisinga, Grotenhuis, & Pelzer, 2013), was at .52. However, the inter-item correlation of .37 meets the recommended level of either above .3 (Robinson, Shaver, & Wrightsman, 1991) or between .15 and .50 (Clark & Watson, 1995). The following tests were also run for the two items individually, which produced similar patterns of findings. Therefore, in the interest of parsimony and cohesion with previous research (Vinnell et al., 2017; Vinnell et al., 2018), the results for the two-item scale are presented. Lower scores on this scale represent lower tolerance for earthquake risk.

Table 4.
Mean scores for the key dependent variables across conditions and between the two groups, with standard deviations presented below in parentheses.

	Control group					Treatment group					
	Descriptive	Injunctive	Combined	Risk	Average	Descriptive	Injunctive	Combined	Risk	Control	Average
Support	5.65 (1.32)	6.00 (1.15)	5.99 (1.14)	5.72 (1.26)	5.84 (1.22)	5.36 (1.26)	5.87 (1.53)	5.69 (1.50)	5.17 (1.68)	5.35 (1.61)	5.50 (1.54)
Feasibility	4.68 (1.19)	4.68 (1.36)	5.03 (1.38)	4.56 (1.31)	4.74 (1.32)	4.78 (1.47)	4.57 (1.70)	5.11 (1.85)	4.71 (1.52)	4.41 (1.77)	4.72 (1.62)
Comparative risk	2.78 (1.11)	2.83 (1.14)	2.95 (1.11)	2.87 (1.14)	2.86 (1.12)	2.44 (1.19)	2.49 (1.09)	2.62 (1.39)	2.42 (1.22)	2.54 (1.03)	2.50 (1.19)

We used a series of 4 (norm condition: descriptive norm, injunctive norm, combined norm, and risk information) by 2 (group: treatment or control) two-way Analyses of Variance (ANOVAs) to test whether the norm manipulation affected key judgments differently for participants surveyed before and after the earthquake. These tests compare the means of a single dependent variable between groups split on two independent variables (in this case, norm condition and group). These tests show whether there is a difference between means in the dependent variable based on each of the individual independent variables (termed main effects), and whether those effects interact; that is, whether social norms have a differential impact on judgments for those surveyed before compared to those surveyed after the earthquake. Main effects are interpreted with follow-up tests to identify between which particular groups there is a difference. We report post-hoc Tukey HSD tests for the individual between-condition comparisons as these control for pairwise error rate (i.e., increased chance of finding significant effects due to the large number of comparisons). Because the control group survey did not include the same norm control condition used in the treatment survey, this condition was not included in the two-way ANOVAs. Therefore, we also report one-way ANOVAs comparing the mean scores for the different norm conditions within the treatment group. Finally, we report independent samples *t*-tests for main effects of group, as post-hoc Tukey tests are not computed when the variable only has two levels (treatment and control).

Support. Comparing the norm effects on support for the earthquake-strengthening legislation between the two treatment groups using a two-way ANOVA revealed no significant interaction between norm condition and group, $F(3, 543) = .61$, $p = .60$; experience of the earthquake therefore did not affect the influence of norms on support for the legislation. This finding suggests that, contrary to predictions, the norm effect on support was relatively stable even with increased knowledge and concern about the issue. We did however find a main effect of group, $F(1, 543) = 7.59$, $p < .01$, $\eta p^2 = .014$. Contrary to predictions, support for the legislation was *lower* after the earthquake, $t(523.67) = 2.67$, $p = .01$, $d = .23$, than before. We predicted that support would be higher following the earthquake as past research has repeatedly demonstrated that earthquake experience increases risk perceptions (Solberg et al., 2010), which could logically lead to more support for legislation to mitigate that risk. Implications for this finding, in the context of other results presented above, are discussed later. Further, we found a main effect of norm condition, $F(3, 543) = 4.43$, $p < .01$, $\eta p^2 = .024$. Overall, support for the legislation across both groups was significantly higher among those presented with the injunctive norm than risk information, $p = .018$, and marginally significantly higher than the descriptive norm, $p = .056$.

A follow-up one-way ANOVA of the treatment group to include the control information condition showed that support for the legislation varied significantly between norm conditions, $F(4, 338) = 2.50$, $p = .043$, $\eta p^2 = .029$. The injunctive norm led to significantly higher support than the risk information, $p = .006$, as did the combined norm, $p = .034$. These findings replicate those of Vinnell et al. (2018) and show that injunctive norms can be used to increase support for earthquake-related legislation. However, support in the injunctive norm condition did not differ from support in either the combined norm or the control condition. This suggests that past findings might be due to a negative effect of the risk information, therefore increasing the apparent effect of the injunctive norm.

Feasibility. As with the analysis for support, there was no significant interaction of norm condition and treatment group on judgments of the feasibility of carrying out the strengthening work, $F(3, 544) = 0.19$, $p = .91$. There was no main effect of treatment group, $F(1, 544) = 0.16$, $p = .69$, suggesting that these judgments of feasibility did not change after the earthquake. There was however a main effect of norm condition, $F(3, 544) = 3.08$, $p = .027$, $\eta p^2 = .017$. Post-hoc tests demonstrated significantly higher judgments of feasibility by those in the combined norm condition compared to both the risk information condition, $p = .039$, and in the injunctive norm condition, $p = .049$. These findings are in line with those found by Vinnell et al., (2018), except for the absence of the marginal effect found in Vinnell et al. where feasibility was judged higher in the descriptive norm condition than the risk information condition.

However, when norm effects were explored in the treatment group alone to include the fifth condition (control; no information), there was no overall difference in mean scores of feasibility, $F(3, 339) = 1.90$, $p = .11$, suggesting that the above main effect was driven by differences between norm conditions in the control group. Therefore, although the main effect of group was not significant, this lack of norm effects in the treatment group suggests that the influence of norm information did decrease following the earthquake.

Comparative risk. As with the above analyses, there was no interaction of norm condition and group for comparative risk judgments, $F(3, 543) = 0.097$, $p = .96$. There was also no main effect of norm condition, $F(3, 543) = 0.57$, $p = .63$. However, comparative risk did significantly differ between the treatment and control groups, $F(1, 543) = 13.16$, $p < .001$, $\eta p^2 = .024$. A follow-up *t*-test shows that those in the treatment group were significantly less tolerant of risk, $t(549) = 3.64$, $p < .01$, $d = 0.31$, than those in the control group. This finding suggests that participants saw more value in addressing the risk of earthquake-prone buildings after the earthquake, in contrast to the finding of lower support. It is possible that participants support strengthening but not necessarily in the manner mandated by the legislation.

Community identification. Finally, there was no interaction of norm condition and group for community identification, $F(3, 531) = 1.78$, $p = .15$. There was a significant main effect of group, $F(1, 531) = 4.92$, $p = .027$, $\eta p^2 = .009$, whereby community identification was weaker in the treatment group than in the control group, $t(537) = 2.16$, $p = .03$, $d = 0.19$, suggesting that the event did not lead to an increase in perceived connection with the community as was seen following the Canterbury earthquakes (Britt et al., 2011). Further, there was no main effect of norm condition, $F(4, 531) = 0.37$, $p = .77$. A follow-up ANOVA further demonstrated no norm effects in the treatment group, $F(4, 335) = 0.34$, $p = .85$. Similar to the findings for feasibility, this lack of an effect where one was found in Vinnell et al. (2018) suggests a weakening of the influence of norm information following the earthquake, although this decrease was not large enough to create a significant interaction.

Discussion

Exploring the impact of earthquake experience on related judgments and behaviour is challenging given the unpredictability of such events. Past researchers have used a variety of methods to address this challenge such as retrospective self-reports (McClure et al., 2011), use of existing longitudinal data (e.g., Milojev, Osborne, & Sibley, 2014), and comparing affected and unaffected areas (McClure et al., 2015). This study used a natural experiment design by running a replication of the same survey before and shortly after the 2016 Kaikōura earthquake. While the same sample could not be used because the first survey was anonymous, the same sampling methods were used with the same population to allow for more confidence in statistical comparisons. Only age differed between the two samples, and controlling for this had no effect on the pattern of results.

Reports of earthquake experience did not change after the Kaikōura earthquake, perhaps due to the question being interpreted as comparative to other Wellingtonians. It is also possible that the 2013 Cook Strait earthquakes had raised self-perceptions of experience to a level too high to be raised by a single subsequent event. The overall pattern of results consistent with predictions supports the assumption that the Kaikōura earthquake did affect behaviours and opinions of Wellingtonians, even though reported experience was not higher after the earthquake. Given that the shaking lasted two minutes, that GeoNet, NZ's earthquake monitoring and reporting website, received 15,840 reports of felt shaking, and that one study found a vast minority (<3%) did not feel shaking (Blake et al., 2018), it is unlikely that many people in Wellington did not experience the actual event. However, even if it was assumed that participants in the treatment group *did not* experience the actual shaking, experience of an earthquake extends beyond feeling the shaking. Following the earthquake, cordons were put up in the central business district, workers were encouraged to stay home, and several buildings were closed or demolished. Further, the experience of the event included a large number of news reports across all media and an increase in conversation around earthquakes, as evidenced by the increase in perceptions of norms seen in this study. It is therefore highly unlikely that the participants in the treatment group did not, in some way, experience the earthquake. Future research could consider including a wider range of questions regarding earthquake experience, including differentiating between experience of shaking and of impacts of shaking, as well as questions targeted to citizens' experience of the particular event under study. These items were not included in this study to keep the surveys as consistent as possible across the two time points; we acknowledge that this is a limitation in our methodology.

As expected, we found higher knowledge of the legislation and concern about earthquakes and earthquake-prone buildings after the earthquake. Further, and again as expected, reports of personal preparation were higher after the earthquake, although the neutral rather than strong intentions to prepare in the immediate future found here suggest that this increase might not be maintained, consistent with previous research (McRae et al., 2017). The stronger effect for the retrospective self-report measure of preparation suggests that participants in the treatment group, who completed the survey after the Kaikōura earthquake, did exhibit a hindsight bias; that is, they believed that they were less prepared before the earthquake, perhaps due to gaps in their preparedness highlighted by the event. For example, many people in areas of Wellington were not prepared to evacuate for a tsunami following the earthquake (Blake et al., 2018). This difference reveals one of the strengths of a natural experiment in that it tests more objective changes in preparation behaviour as the method typically does not rely on retrospective self-report measures which are prone to bias.

Reports of perceived descriptive and injunctive norms for preparation were also higher in the treatment group, suggesting that participants saw more people around them preparing for earthquakes and engaged in more conversations about the importance of doing so. This finding is encouraging as it implies that earthquake preparation is seen and discussed, at least at an interpersonal level; this is one of the key prerequisites for social norms to develop (Cialdini et al., 1990). The time following a hazard event could therefore be effectively used to increase preparation by taking advantage of the already-strengthened norms.

However, community identification was weaker after the earthquake. This could be due to the low levels of disruption from the Kaikōura earthquake (at least for our participants who live in Wellington) so that people were able to look after themselves without the help of their community. Given the important role that community and social networks play in the wake of a disaster (Britt et al., 2011), future research could explore the potential for a vital community response in Wellington and ways to increase both the probability of this occurring and the extent if it does occur.

Concern about earthquake-prone buildings was higher and tolerance of the risk of earthquake-prone buildings was lower after the Kaikōura event. However, both judgments of the efficacy of strengthening prone buildings and support for the legislation *decreased*. This unexpected finding could be due to the nature of the damage which occurred during the Kaikōura earthquake. In Wellington especially, several newer high-profile buildings were damaged to the extent of being unusable, such as Statistics House, completed in 2005 (Devlin, 2017). This building is not covered under the earthquake strengthening legislation as the changes made to the building code in 1976 meant that buildings constructed since then should already be at the standard required by the legislation. It is possible that the participants did not see important benefits of older buildings being brought closer to the standard of new buildings given that new buildings were the ones that failed. While there are explanations for this specific damage from engineering and seismological perspectives, it is likely that these explanations are not commonly known or understood.

Stevenson et al. (2017) suggest that this relative lack of damage to earthquake-prone buildings may lead to an increase in complacency. Although this study found greater concern following the earthquake, we did not find a commensurate increase in support for the legislation. This finding has important implications for how the legislation is communicated should public support be required, including recruiting experts to explain that the new buildings standards are in fact an improvement from those set before 1976 and thoroughly communicating explanations for the failure of modern buildings so that confidence in the current standards is not lessened.

A further purpose of this study was to test the robustness of norm effects following a large natural hazard event, as previous research suggests that norm effects are stronger when the situation is more ambiguous (Goldstein et al., 2007) and individuals are less biased (Morris et al., 2015). Knowledge of the legislation (i.e., situational ambiguity) and concern about earthquake-prone buildings (i.e., beliefs about the topic) were higher after the earthquake. While none of the two-way ANOVAs demonstrated a significant interaction of norm condition and treatment group, the pattern of norm effects differed before and after the earthquake as predicted. The descriptive norm had no effect on judgments of feasibility and the injunctive norm effect on support for the legislation was only found in comparison to the risk information condition. Further, where norm effects were found for feasibility and community identification in Vinnell et al. (2018), no such effects were found in the treatment group here. However, the finding of one significant norm effect in this study indicates that even a recent earthquake is not sufficient to nullify a norm message. This type of information is therefore useful to further explore in this context as it is at least partially robust to the impact of natural hazard events.

A major strength of this study is its natural experiment design. The two surveys were conducted within months of each other and the use of nearly-identical measures and recruitment increases confidence in suggesting that the Kaikōura earthquake contributed to differences between the control and treatment groups. This method reduces the impact of biases from using retrospective self-report among a single sample and the potential of mere measurement effects, where people answer questions differently in part because they have answered the same or related ones before (e.g., Morwitz & Fitzsimons, 2004). Demand for these types of methods is increasing due to the real-world relevance of the data they provide (Leatherdale, 2019).

The lack of a control group in Vinnell et al. (2018) was a significant limitation of that study, although the use of a proxy control in a similar previous study suggests that the impact of this limitation was minor (Vinnell, 2016). However, in the present study which does use a control group, the injunctive norm only increased support for the legislation compared to the risk condition and not compared to the control. This suggests that the positive effect of the injunctive norm might only be significant when paired with a negative effect of risk information. While the use of controls is relatively standard in experimental practice, further rigour in this regard is required.

This study used a natural hazard event to examine the impact of recent, direct earthquake experience on norm effects. While these effects of norm messages on judgments were lessened after the earthquake as expected, they did not disappear entirely, supporting the further exploration of social norms as a robust strategy to alter disaster-related judgments and behaviours. The study also showed that perceptions of norms of earthquake preparation can *increase* after a disaster, suggesting that the time post-event presents a valuable opportunity to use existing normative beliefs to encourage preparation conversations and actions. This can facilitate efforts to create a cultural shift in how people act and think in regards to disaster preparation.

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From physical disruption to community impact: Modelling a Wellington Fault earthquake

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Abstract

Modelling the economic impact of an earthquake event provides a means to support decision-making for investment options to improve disaster preparedness. Quantification of economic impact requires a comprehensive understanding of how damage to physical assets such as buildings and infrastructure networks translates into disruption to, and impact on, communities and businesses. This paper describes how a scenario narrative was developed as an essential prerequisite for an ex-ante economic assessment of a Wellington Fault event in Aotearoa New Zealand. The approach begins with the development of a suite of infrastructure asset damage and restoration maps, which account for infrastructure interdependencies. This data is then translated, based on expert elicitation processes, into a range of post-earthquake behaviours including population displacement, business disruption and relocation, and tourism effects. Lastly, these behaviours are set up as inputs for a novel economic model that captures out-of-equilibrium dynamics and behavioural adaptation. This narrative, alongside the economic modelling component, has been used to support decision-making around regional infrastructure resilience investment.

Keywords: *Disaster impact, socio-economic modelling, disaster recovery, Wellington Fault earthquake*

Disaster risk management interventions are often selected based on their ability to reduce economic losses in the event of a disruption. However, evaluation of intervention options is often limited to direct impacts and the links between physical and socio-economic disruption are poorly included (McDonald et al., 2018; Rose, 2004). To effectively evaluate the impact of disaster risk intervention options we need to understand how communities and the economy will respond to varying levels and types of disruption (McDonald et al., 2018). This paper describes how a scenario narrative was developed as an essential prerequisite to an ex-ante economic assessment of a Wellington Fault event to support resilience investment decision-making.

In 2016, the Wellington Lifelines Group (the Group) identified a need to collaboratively plan their infrastructure investment to maximise regional resilience benefits for a credible earthquake scenario. The Group comprises of critical infrastructure providers from across the Wellington New Zealand (NZ) region. The Group includes fuel, road, port, rail, electricity, telecommunications, and water/wastewater utility providers.

Each infrastructure provider identified a suite of potential infrastructure investment options to improve the vulnerable parts of their network and the Group collectively formulated several programmes of work. While the costs and benefits of these programmes of work could be measured in various ways, the Group explicitly decided to use an impact-based measurement associated with reducing the economic impacts of a hypothetical Wellington Fault event. The Group commissioned an economic impact assessment to determine the potential savings (i.e., reduction in economic losses) resulting from the proposed programme of works. Importantly, this included careful consideration of critical infrastructure interdependencies. This work is known as the Wellington Lifelines Resilience Project (WLRP).

In this paper we demonstrate how strong stakeholder engagement and integrated modelling enabled the development of a comprehensive and robust narrative to support decision-making for resilience-building investments in Wellington. First, we outline the modelling process undertaken, namely defining geo-physical disruption and translating these impacts into human behavioural responses. Second, we present the Wellington Fault story developed through the modelling process. Third, we conclude with a discussion reflecting on the modelling process and opportunities to improve how modelling can better support decision-making processes. We do not present the results of our economic modelling here as these will be detailed in a forthcoming paper.

Method

The impact assessment modelling process is described in Figure 1. The process begins with an assessment of the extent and duration of physical infrastructure disruption following a Mw7.5 Wellington Fault earthquake event with associated perils (fault rupture, ground shaking, liquefaction, landslides, lateral spreading, and subsidence). The event was selected as a suitable and credible event to measure the effectiveness of proposed infrastructure investment options as this event has a 10% probability of occurrence in the next 100 years (Rhoades et al., 2010). This assessment of infrastructure disruption is followed by determination of induced population and business behaviours and estimation of the flow-on economic consequences. The analysis is carried out on a comparative basis: first, for earthquake effects on the physical assets with no interventions (base case) then for earthquake effects with proposed interventions. Comparison between the cases allows for the effectiveness of the intervention options to be determined. Importantly, a requirement of our assessment is that it focused on disruption (measuring *flow* impacts; i.e., avoided net losses in economic activity), rather than on physical asset loss (measuring *stock* impacts; i.e., replacement or reinstatement costs). The latter is better measured using other methods (e.g., RiskScape; www.riskscape.org.nz).

The proposed investment packages were determined through a collaborative process between lifelines providers and subject-matter experts. A comprehensive discussion of the process is outside the scope of this paper, but is fully outlined in the Wellington Lifelines Regional Resilience Project Report (2018).

Physical Disruption

A comprehensive risk assessment framework was developed to model physical infrastructure disruption (see Figure 2). Infrastructure modelled included

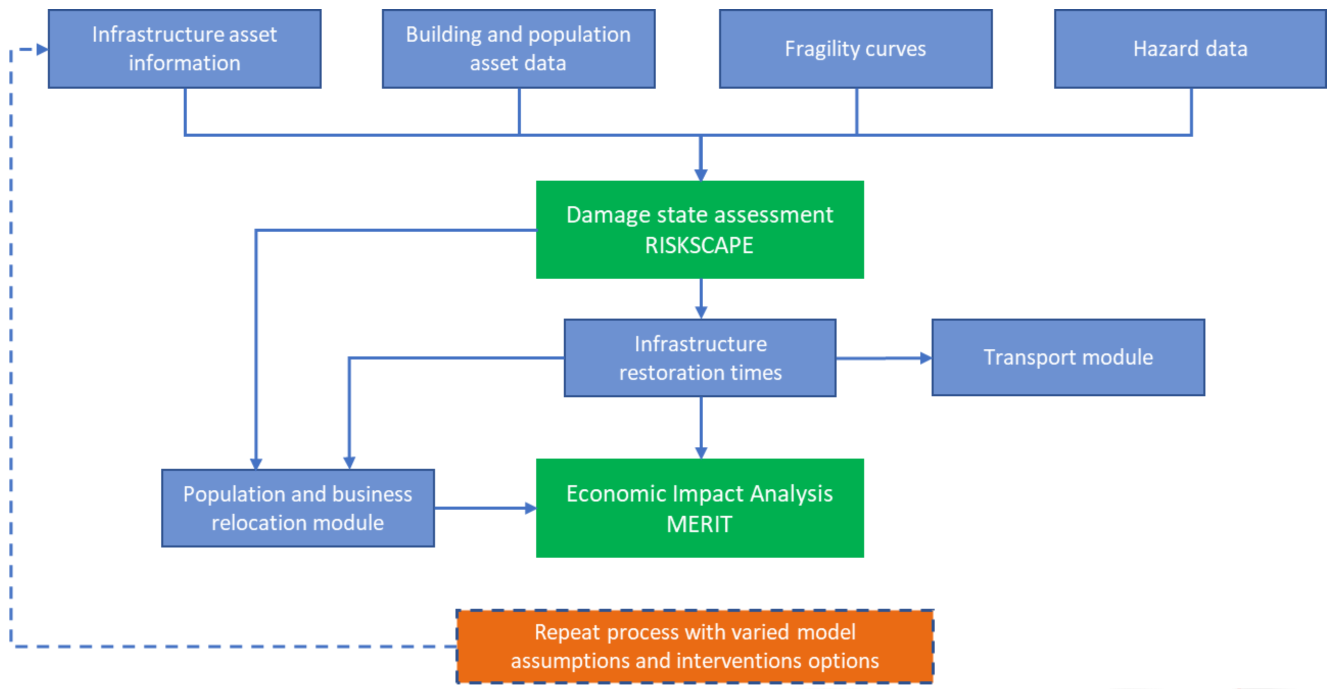

Figure 1. Linkages between the various stages of damage loss assessment and economic impact analysis for the Wellington Resilience Programme Business Case.

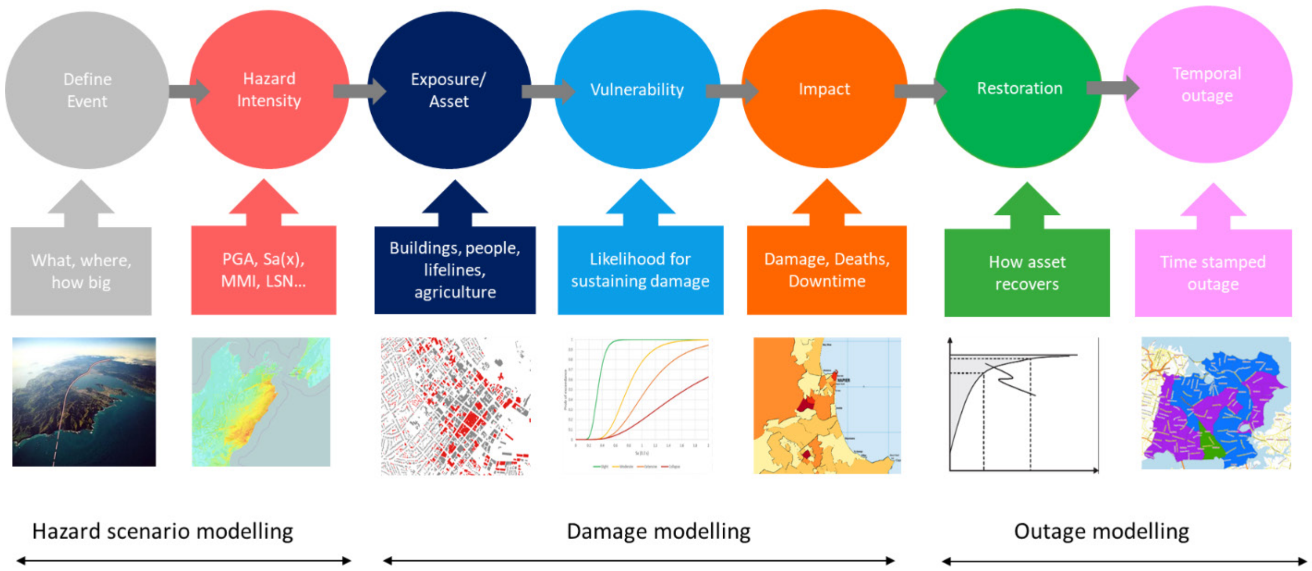

Figure 2. Stages involved in damage and outage modelling framework for a chosen scenario.

road, rail, port, airport, electricity, telecommunications, potable water, wastewater, fuel, and gas networks. Damage to buildings was also modelled to ensure a realistic representation of the benefits of infrastructure investment given the spectrum and multiplicity of experienced disruptions (e.g., a business with a significantly damaged building will be less impacted by loss of water to the site).

The risk assessment framework includes: (a) hazard scenario modelling, to predict the spread of hazard intensities across the region; (b) damage modelling, to predict the likely damage to buildings and infrastructure based on vulnerability characteristics; and (c) outage modelling, to estimate the time required to restore infrastructure services (expressed as a particular level-of-service provisioning). This framework accounts for collective damage to physical assets, interdependencies

Table 1.
Infrastructure damage and restoration estimation process.

Infrastructure	Damage estimation	Restoration
Road	Damage to assets estimated using modelling tool developed by GNS Science for New Zealand Transport Authority (NZTA; Sadashiva, King, & Matcham, 2017)	Expert judgement used to develop a travel matrix between 24 zones, showing additional travel time (above business-as-usual) in response and recovery phases. Reviewed by NZTA and local councils.
Rail	Engineering judgement verified by KiwiRail	Consultation with KiwiRail
Port	Expert workshops	Expert judgement and consultation with port authority
Airport	Meetings with airport authority. Assets divided into runway, hardstand areas, and buildings	Discussion with airport authority
Fuel	Discussion with New Zealand Oil Services LTD (NZOSL) management team	Expert judgment and discussion with NZOSL management team.
Electricity	RiskScape and in-house interdependency modelling tools, with fragility functions refined in consultation with electricity supplier	Discussion with Transpower and Wellington Electricity on repair and restoration strategies. Estimated based on a) modelled asset damage, b) prioritized list of electricity supply zones elicited from the infrastructure provider, and c) location and details of restoration resources available.
Telecommunications	RiskScape	Discussion with telecommunication providers on their preferred restoration strategies
Potable water	RiskScape	Estimated based on a) modelled asset damage, b) prioritized list of water zones elicited from the infrastructure provider, c) number of repair crews available, and d) rate of repair per crew.
Wastewater	RiskScape	As above
Gas	RiskScape	As above

on other networks, and demand for shared recovery resources.

Given the uniqueness of each infrastructure network, the analysis process was modified to suit each infrastructure, as detailed in Table 1. Generally, RiskScape (riskscape.org.nz) was used to carry out the hazard scenario and damage modelling. RiskScape is a multi-hazard risk assessment tool developed by GNS Science and NIWA that estimates damage and direct losses for assets exposed to natural hazards. The modelling software combines spatial information on hazards (e.g., earthquake, tsunami, and flood), assets (e.g., buildings, lifeline infrastructure, and people) and asset vulnerability to quantify the impacts on physical assets, as well as estimating the number of casualties and displaced populations.

In terms of infrastructure, the *damage modelling* predicted the likely damage to the components of the network, accounting for the variation of hazard intensities across the region as derived in the hazard modelling stage. The damaged components were assumed to be fully non-functional and, based on the network connectivity, the areas that are likely to be disrupted were identified. For the *outage modelling*, a participatory approach with infrastructure providers was adopted. The restoration of infrastructure networks is a complex process with many technical and human variables (e.g., availability of skilled labour and materials, individual decision-making, regulatory challenges, and organisational leadership and management). Each infrastructure provider was approached to verify the RiskScape-generated damage model and to describe their likely recovery strategies. Specifically, infrastructure providers were consulted to obtain information related to: (a) network configuration and geographical locations; (b) vulnerability characteristics; (c) functional dependency within the network; (d) restoration strategies; (e) key interdependencies; and (f) level-of-service provisioning under various damage states.

Estimated outage times for a given network were calculated based on the recovery strategies applied to restore the services, including both temporary and permanent solutions. Estimated outage times are heavily influenced by availability of personnel and materials at the time of the hazard event. Restoration of a given network is also affected by the interdependencies on other network services. For example, restoration of water service may require road access, fuel, and electricity. For each infrastructure, a time-stamped outage map was produced to represent the duration of disruption to the service. In some cases, this reflected the level-of-service provided (e.g., potable versus non-potable water). This process was repeated to include all items in the proposed investment packages.

Business and Population Behaviours

Within our economic model, there is an existing module that represents the behaviour of businesses following infrastructure disruption. These behaviours were developed using survey data collected following the Canterbury earthquakes of 2010/11 (Brown et al., 2019; Brown, Seville, Stevenson, Giovinazzi, & Vargo, 2015). In the Canterbury event, businesses and residents generally remained in the region and adapted to the disruption. Early modelling of the Wellington earthquake scenario suggested that physical disruptions may be at a level that tips both residents and businesses into non-adaptive behaviours. In particular, significant expected durations of infrastructure disruptions (notably electricity and water), isolation induced by roading damage, and limited functional building capacity to accommodate displaced businesses and residents within the region may cause people and businesses to leave the region.

As the next step to effectively model the Wellington Fault event, we had to build a realistic set of assumptions around how the population and businesses might respond to the expected levels of disruption both with and without the proposed interventions. An analysis of past events provided insight into the drivers for population and business behaviour.

The San Francisco Bay Area Planning and Urban Research Association (SPUR) have gathered evidence from several disaster events in the United States and surmise that if 5% of housing stock is uninhabitable then significant out-migration can be expected (SPUR, 2012). Other studies provide evidence that suggests population relocation is linked to socio-economic status (LeSage, Kelley Pace, Lam, Campanella, & Liu, 2011; Xiao & Van Zandt, 2012). Post-Hurricane Katrina, Xiao and Van Zandt (2012) found that income negatively correlated with population return; households with higher incomes were less dependent on low waged service industry jobs and were therefore more likely to be professionally and financially mobile. In contrast, low wage householders were more likely to remain in damaged housing, with fewer alternative options available to them. Longer term, low wage households which do not own property are more likely to relocate if living expenses increase or job opportunities reduce (SPUR, 2012). Recent research also indicates that there are other underlying factors that impact individuals' capacity and desire to relocate including social capital (Aldrich, 2012) and existing population growth/decline trajectories (Aldrich, 2011; Matanle, 2011).

Table 2 summarises studies of past events that have caused population relocation, business relocation, and closure. The existing studies are disparate. They report population and business impacts at different timeframes, use different metrics (e.g., there is often no distinction between permanent or temporary business closure), and use different analysis techniques (including different

Table 2.
Business change (closure and relocation), population change, and triggers for business change.

Disaster event	Location	Study timeframe	Business change	Population change	Triggers for business change	References
Hurricane Andrew	South Dade County	A few months after	• 89.9% of businesses closed immediately after the hurricane. • 29.2% temporarily relocated; • 12.5% have been permanently relocated (no data on whether relocated within or outside the region)	17% loss within first year 7% loss over first 2 years	• Transport issues for customers and suppliers • Sector: wholesale/retail most likely to close • More likely to relocate if business premises were rented rather than owned.	(Smith & McCarty, 1996; Wasileski, Rodríguez, & Diaz, 2011)
Hurricane Katrina	Southern Mississippi	8 years after	• A total of 6.9% of businesses verified as closed, and a further 10.3% were likely closed but were unverifiable.	9% loss a year after 2% loss six years after the hurricane	• None given	(Cutter et al., 2014; Schrank, Marshall, Hall-Phillips, Wiatt, & Jones, 2012)
Hurricane Katrina	Village L'Est	2 years after	• 10% loss of businesses	10% loss	• None given	(Aldrich, 2012)
Hurricane Katrina	Mississippi area	8 years after	• Around 10% immediately closed. • 25% business closure after 8 years	9% loss a year after 2% loss six years after the hurricane	• Overall age and health • Loss of utilities, inventory loss, and loss of customers/sales • Service sector less likely to be closed. • Specific geographical location relevant. • Endogenous effects: vulnerability to endogenous shock.	(Cutter et al., 2014; Sydnor, Niehm, Lee, Marshall, & Schrank, 2017)
Hurricane Katrina	New Orleans	0-12 months after	• None given	None given	•Loss of utilities •Low socio-economic status of customers •Neighbouring business failure •Level of impact from event	(LeSage et al., 2011)
Loma Prieta earthquake	Santa Cruz	A few months after	•7 5% of businesses closed immediately after the earthquake. Closure was from a few hours to several months. • 6.7% relocated permanently (no data on whether relocated within or outside the region).	<<1% loss	• Leased business space • Utility interruptions	(Wasileski et al., 2011)
Hurricane Ike	Galveston	3 months after for population estimates 7 months after for business estimates	• 41.4% businesses not operating from pre-disaster location	36% of households unoccupied	• Business return had a positive impact on household return	(Yu Xiao & Nilawar, 2013)

independent variables). These factors and the inherent challenges in making cross-contextual comparisons makes it difficult to definitively identify the factors that drive economic and community response to disruption.

Consequently, a series of workshops were held to augment the existing literature and develop some contextually relevant assumptions around population and business behaviours following a Wellington Fault event. Workshop participants represented the government sector, business sector, and key community functions and services (e.g., insurance, fast moving consumer goods, emergency management, and housing). Participants were asked to consider three different post-disaster "worlds":

a) The adaptive world: population and economy are disrupted but largely continues as normal;
b) The hostile world: significant but largely temporary relocation of individuals and closure of businesses; and
c) The apocalyptic world: large scale movement of people and businesses out of the region and Wellington's economy and community changes dramatically and permanently.

For each "world", participants were asked what types of disruption would tip the region into this situation. Participants were encouraged to consider:

a) Habitability: short-term basic survival needs (water, shelter, electricity, livelihoods etc.);
b) Liveability: medium-term quality of life factors (schooling, health care, community, transport etc.); and
c) Business viability – short to long-term feasibility of economic activity (demand changes, business confidence, insurance etc.).

Based on the above, a set of assumptions around population and business relocation and operability were determined (refer to Smith et al., 2017, for more details).

Economic Modelling

The physical disruption data and the assumed behavioural responses, discussed above, are designed to link into our economic model. The Measuring the Economic Resilience of Infrastructure Tool (MERIT) is a fully dynamic multi-sectoral economic model that captures the indirect consequences of infrastructure disruption events through time and across space for multiple stakeholders (Kim, Smith, & McDonald, 2016; McDonald, Cronin, et al., 2017; McDonald, Smith, Ayers, Kim, & Cardwell, 2016; McDonald, Smith, Ayres, Kim, & Harvey, 2017; McDonald, Smith, Kim, Cronin, & Proctor, 2017; Smith, McDonald, & Harvey, 2016; Smith, McDonald, Harvey, & Kim, 2017). MERIT is designed to imitate the core features of a Computable General Equilibrium (CGE) model. Among the advantages of these types of models is the whole-of-economy coverage which captures indirect and induced impacts. MERIT differs from a standard dynamic CGE model in that it is formulated in a systems dynamics framework using finite difference equations, which enables impacts over time to be simulated and inclusion of abnormal behaviour and adaptation, as exhibited during times of disruption, by economic agents (e.g., households, industries, and government).

Figure 3 shows how the physical disruption and resulting population and business behavioural responses connect to the MERIT model. The physical disruption modelling links through to:

- Population relocation module to estimate level of out-migration and corresponding household expenditure changes and labour availability changes;
- Business behaviours module to estimate level of out-migration and business operability over time;
- Cordon analysis to identify residents and businesses that will need to relocate due to building damage;
- Transport analysis to identify need for, and cost of, freight re-routing and identification of areas that are inaccessible and cannot trade; and
- Tourism analysis to identify likely loss of tourism demand over time.

The Wellington Fault Event Narrative

The geography of Wellington means that the region will be extremely isolated following a Wellington Fault event. Our infrastructure disruption modelling, undertaken in consultation with infrastructure providers, indicates that the Wellington region will divide into 23 road islands and will be isolated from the rest of NZ. It is estimated to be 28 days before a connection out of the region is restored and over 120 days before the last two road islands are connected to the rest of the roading network (R. Mowll (Wellington Region Emergency Management Office), personal communication, September 18, 2017*).* We estimate that the port will also be out of action for one to three months, creating challenges getting fuel into affected areas. Depending on location, our modelling shows that electricity will be disrupted for three to six months and water will be disrupted for between one to

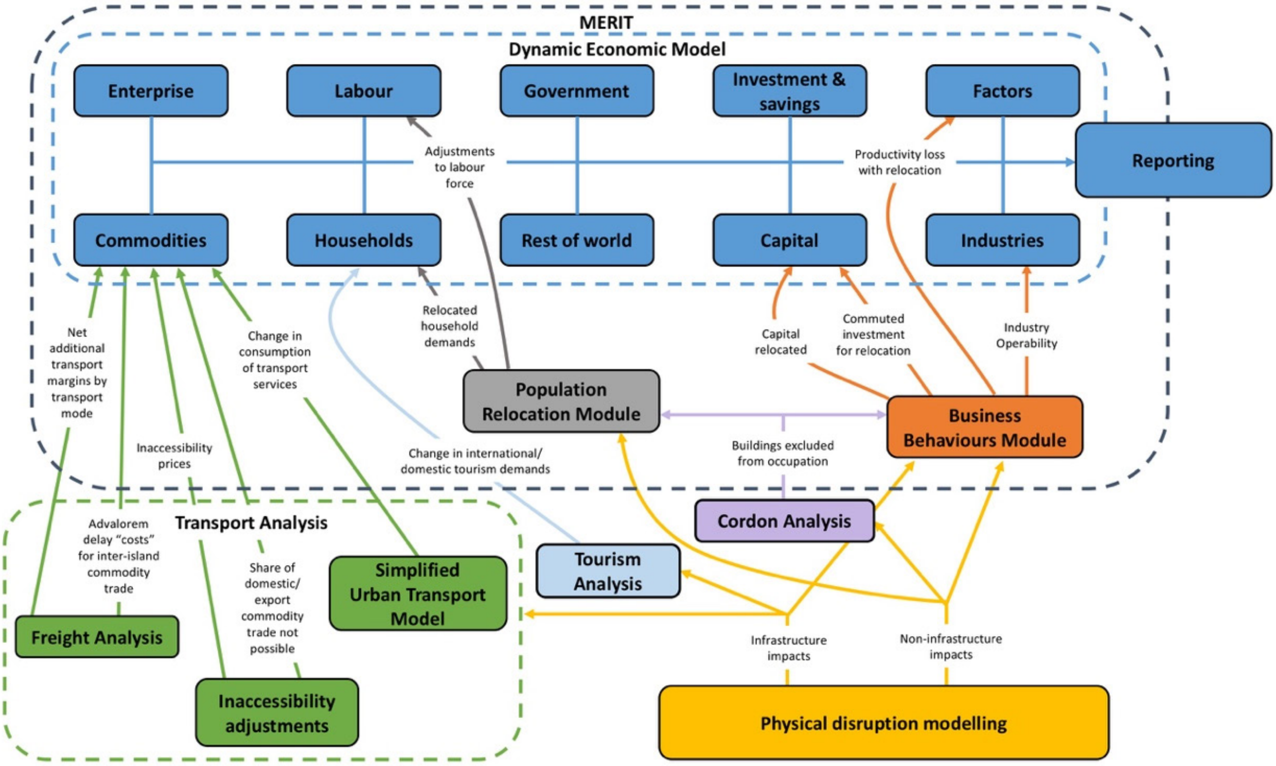

Figure 3. Overview of economic modelling process, including link to physical and behavioural modelling.

12 months for non-potable water reticulation and three to 12 months for potable water reticulation. Water restoration time frames are highly dependent on road, fuel, and electricity restoration.

The combined effect of all infrastructure and building disruptions is an estimated temporary population relocation of approximately 19% of the region and a further 6% of population permanently relocating (Table 3). We anticipate there would be an initial emergency evacuation of vulnerable persons (and their supports) via air and sea. Largely based on the Ministry of Civil Defence and Emergency Management (MCDEM) Mass Evacuation Guidelines (MCDEM, 2008), this would include aged, infirm, people with disabilities, people in prisons, and tourists. The estimates also include fatalities and serious injuries.

Table 3.
Estimated population relocation estimates for a Wellington Fault event.

	Left	Returned	Difference
Emergency Evacuations	38,100	37,900	200
Strategic Evacuations	4,800	0	4,800
Shelter Relocation	6,200	6,200	0
Voluntary Flight	75,100	49,700	25,400
Total	124,200	93,800	30,500
% of region	25%	19%	6%

Similarly, we anticipate a certain level of strategic evacuation of government officials and key business personnel (and their families) who feel they cannot operate effectively in the disrupted environment. The relocation of key government services will also likely pull supporting professional services away from the region. Evacuation will also come from those that cannot find shelter within the region. It is anticipated that persons that cannot shelter in place will either move in with neighbours, family and friends within the region (particularly in low-socio-economic groups), use temporary shelters, or will move out of region. In time, we anticipate that voluntary population flight will be driven by a low level of liveability which includes:

- Duration of disruption to one or more of water, electricity, and communications (including data) at household level;
- % of uninhabitable houses (causing community disaggregation); and
- Lack of connectivity to a) local CBD, b) Wellington CBD, and c) rest of NZ, affecting access to work, school, and services.

- The level of out-migration will also be influenced by the socio-economic status of households, with highest and lowest income groups being most mobile.

Our research indicates that business relocation will be driven by:

- Industry sector (nature of service, infrastructure needs, customer base, connection to place, and ease of relocation);
- Extent of commercial/industrial property damage in region;
- Duration of disruption to one or more of water, electricity, and communications (including data) at business premises; and
- Lack of connectivity to a) local CBD, b) Wellington Region CBD, and c) rest of NZ, affecting staff and customer access and transportation of goods.

Wellington is a knowledge economy (Norman & Oakden, 2014) and, as such, is relatively mobile. Without reliable electricity and communications infrastructure, these businesses can easily relocate and still maintain their staff and client base. This, in turn, may draw population away from the region. Our modelling shows that for those businesses which remain in the region, the combined effect of the infrastructure and building disruptions will suppress industry production levels until basic services are restored, at which point a recovery process will commence. Businesses will also experience challenges in finding and retaining staff.

We anticipate that the event will cause some initial loss of international tourism nationally, but that international tourists will quickly return across the rest of NZ. Domestic tourism numbers in the Wellington region will notably decline due to loss of hotels and other tourism infrastructure but will largely redistribute across NZ. The relocation of residents and businesses, the absence of tourists, disruption to roads, and the perception of disruption to Wellington businesses will heavily reduce the demand for services in the region.

The proposed infrastructure investment packages explored in this project were designed to significantly reduce the expected duration of infrastructure disruption following a Wellington Fault event. The economic modelling showed the difference in economic loss with and without the investment packages. The most beneficial investment packages were those that targeted infrastructure which enables restoration of other services (such as fuel, transport, and electricity) as well as those that best reduced population and business relocation (road access or water, electricity, and communications service restoration). The reduction in economic losses as well as the event narrative are key inputs into the investment decision-making process.

Discussion and Conclusion

The WLRP represents the most comprehensive investigation into the economic implications of any natural hazard event carried out within NZ. There are three key strengths of the study: 1) the robust stakeholder engagement process undertaken to deliver the study, 2) the all-of-infrastructure or system-of-systems view of infrastructure adopted, and 3) the use of a novel *impact-based investment approach* to support resilience-building within the region.

Strong governance and leadership facilitated the committed engagement of key stakeholders, including politicians as key project sponsor and advocate, infrastructure chief executives and members of senior leadership teams, experienced emergency management individuals, and leading professional experts. Without this sort of end-to-end engagement, a complete narrative of the Wellington Fault event would not have been possible.

The all-of-infrastructure approach treated the Wellington Fault event through a systems lens with infrastructure seen as a system of critically-interdependent sub-systems; that is, disruption in any sub-system may have repercussive consequences in other systems and, in turn, other sub-systems and so on. This so-called *infinite regress* may result in unforeseen failure in any sub-system indirectly, independent of whether it is affected directly. Specifically, the WLRP focused not only on horizontal infrastructures but on how these systems interacted with building damage, resident populations, and businesses.

Fundamental to understanding these interdependencies were stakeholder engagement and expert elicitation processes. While noted as a key strength, this engagement process has inherent limitations. The project team faced significant challenges in collating and analysing data from 10 different regional infrastructure networks. Each infrastructure network provider or authority used disparate storage mechanisms and attribute sets for their network data. Further issues and delays were encountered gaining access to the data, which had to be sourced from separate authorities, each of which had its own data access agreements. For example, the road network included road assets owned and managed by New Zealand Transport Agency (for State Highways) and the five local councils.

Where infrastructure providers could not supply information for modelling, engineering judgements were applied, particularly for estimation of restoration times. Each infrastructure type was treated slightly differently due to the varying nature of the infrastructure assets and services (e.g., distributed electricity network versus an airport with centralised assets; see Table 1) and the complexity of restoration. Inherent in these expert judgements were assumptions around expected level of organisational capacity, access to key resources and personnel, and dependence on other infrastructure services. Similarly, in development of the population and business behavioural assumptions, we asked professionals to speculate on a hypothetical event involving complex human behaviours. The assumed behaviours are shaped by the experiences and cognitive biases of the expert participants. Consequently, the narrative and behaviours described in this paper should be considered as a starting point for understanding and modelling a response to a large-scale disruption event in Wellington. The uncertainty in these "predicted" behaviours needs to be accounted for and continually evolved as knowledge and experience is gained through future disaster events.

Development of integrated, comprehensive narratives is of growing importance in modelling processes as we increasingly see a need to: a) move towards impact-based decision-making, b) use models as an input into development of plausible scenarios, and c) embed modelling in deliberative decision-making processes. There is increasingly a movement towards impact-based resilience investment decision-making (Morgan Stanley, 2018 ; The Rockefeller Foundation, 2012). This approach represents a movement away from basing decisions purely on conventional evaluation frameworks such as Benefit-Cost Analysis (BCA) and Multi-Criteria Analysis (MCA) which tend to focus on direct costs and benefits of investment. This impact lens requires widening to capture a fuller range of direct and indirect impacts (i.e., social, economic, and environmental) and to better acknowledge and communicate uncertainty. This project was based on a single highly-significant and credible event scenario. While advances in data science, probabilistic modelling, and prediction may help us better understand uncertainty around such a scenario they cannot fully account for that uncertainty. Emergent behaviours, tipping points and "unknown unknowns" exist, the occurrence, and particularly dynamics, of which cannot be easily predicted but need to be explored through the modelling and decision-making process.

A key reason supporting the movement towards impact-based investment decision-making is that increasingly decision-makers are faced with complex and deeply uncertain decisions and are having to balance competing objectives and stakeholder needs. In this project for example, infrastructure has long existence timeframes (typically anything between 30 to 100 or more years) and it is necessary to balance immediate needs (often driven by economic efficiency and effectiveness) with resilience-building that may or may not be tested. Thus, part of the movement to impact-based investment decision making is the imperative of decision-makers to provide integrated robust and cohesive storylines to support the case for resilience-building. Under this approach, modelling should be more an input into the development of plausible scenarios than taking a set of inputs and assessing resilience scenarios. The distinction here may be subtle, but it is important. If modelling is to be useful then it must be applied iteratively within a decision-making process to create evidence-based plausible and defendable storylines that remain robust under many different conditions. Development of the storylines is as important, if not more so, than the outcome modelling work itself. Modelling provides an integrating glue that ensures the storylines are plausible, coherent, and internally consistent, and can also help decision-makers to identify tipping and leverage points around which intervention options can and should be designed.

Modelling must sit within a deliberative process. In the end, and as noted above, decision-makers often face a plethora of complex considerations for which often no simple or perfect decision exists. The role of supporting evidence, where modellers often sit, is to provide enough evidence to aid in the decision-making process, and modelling narratives play a key role in this. To effectively support disaster mitigation intervention decision-making, models and modellers need to create a comprehensive narrative of disruption events, from physical disruption through to community and economic responses. The method described in this paper could be readily adapted to other geographic and hazard contexts. The infrastructure outage modelling process is an important step in extending traditional measures of infrastructure disruption modelling from asset disruption to network service level disruption. Work is currently underway to automate the estimation of network restoration times within RiskScape (incorporating infrastructure system interdependencies and resource sharing limitations) to improve our ability to determine indirect impacts across a range of events. Further, the method used to generate business and population behaviour model assumptions is transferable not only to other contexts but also to decisions relating to other disaster risk management initiatives. It is likely that the factors that impact business and population relocation identified in this project (accessibility/road connectivity, infrastructure service disruption, property disruption, and industry sector) will be common across other communities facing major disruption and will affect other risk management interventions such as building standards, urban planning, and emergency response planning. However, further ex and post ante research in other contexts would be needed to validate this.

This research demonstrates the critical and systemic links between physical, social, and economic disruption. Quality narratives will help decision-makers to understand the causal effects of complex decisions and will enable the holistic benefits of proposed interventions to be effectively valued. Development of these narratives must be collaboratively built with key stakeholders.

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Disaster resilience in Wellington's hotel sector: Research update and summary

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Abstract

Summarizing a research project exploring disaster resilience in the hotel sector, this update provides highlights of the different research components and presents a summary of findings. Disaster resilience in the hotel sector is studied from a mixed methods approach to develop the Disaster Resilience Framework for Hotels (DRFH). The DRFH uses a six capital (economic, social, human, physical, natural, and cultural) model to define predictors of disaster resilience for hotels. Exploration of the predictors within the DRFH uses survey data, semi-structured interviews, and secondary data to examine not only the framework but also lessons learned by Wellington hotels from the 2016 Kaikōura earthquake. Strengths for the studied hotels include social networks, economic fortitude, building standard compliance, and a developing culture of safety. Identified gaps for future emphasis include a need to approach disaster management from a multi-hazard perspective and integrate staff in disaster management planning.

Keywords: *Tourism, resilience, capital, hotels, disaster*

The tourism sector is growing in Aotearoa New Zealand (NZ). Wellington, the capital city, captures 9% of the nation's tourism market and acts as one of the entry points for tourists to New Zealand (Ministry of Business Innovation & Employment, 2016; Tourism Industry Aotearoa, 2018). Tourism in NZ and Wellington includes a combination of domestic and international travellers with both leisure and business objectives. Resilience in the hotel sector is an important and multifaceted topic (Brown, Rovins, Feldmann-Jensen, Orchiston, & Johnston, 2017). The economic value of resilience is evident when reviewing industry statistics. However, hotels' value as key infrastructure for recovery purposes is also noteworthy (Jiang & Ritchie, 2017). Hotels are an integral part of their community and so their resilience enhances the resilience of their communities (Brown et al., 2017).

Research examining disaster resilience measurements for the hotel sector summarized in this paper was conducted over three years from 2015 to 2018. Lessons learned from the Kaikōura earthquake, a M_W7.8 event on November 14, 2016, became embedded in the research through post-earthquake surveys and interviews conducted in 2017; these lessons from direct, recent disaster experience present a unique and informative aspect of the research. This research update seeks to summarize the different components of the research project as well as the key findings. Citations for the full-length articles detailing the different aspects of the project are provided within the body of this paper.

The 2016 Kaikōura earthquake shook Wellington, 258 kilometres from the epicentre, severely enough to cause physical damage to several buildings in the city centre (Elwood, 2016). As a result, people were cautioned to stay off the city streets following the earthquake until inspections could be made to understand damage and city blocks were cordoned off in the city centre (Stevenson et al., 2017). Ultimately, nine buildings housing government agencies and several other buildings and structures were identified as unsafe and scheduled for demolition (Stevenson et al., 2017). This research summary highlights the findings from research exploring disaster resilience in Wellington's hotel sector and lessons learned from Wellington hotels responding to disruptions caused by the Kaikōura earthquake. Wellington provides a particularly unique backdrop for hotel resilience research in the post-Kaikōura timeframe; hotels have a recent and fresh perspective of actual response to disruption. The quantitative and qualitative data collected from hotel managers and staff therefore became less theoretically based (i.e., "if this happened then we would…") than similar past research. Instead, a practical understanding of what happened and what the response included is part of the data. Furthermore, Wellington hotel managers and staff had a unique perspective of lessons learned to share.

Research Methods

This project studying hotel disaster resilience utilised a mixed methods explanatory platform. A literature review was conducted to define disaster resilience in a hotel context and better understand research into measures and methods of determining resilience (Brown et al., 2017). The definition of hotels used in this research was the definition used by the NZ accommodations sector from Qualmark:

> "The Hotel category includes properties with at least one licensed bar and restaurant, on the premises or adjacent, with charge-back facilities…All rooms have tea and coffee-making facilities and there is on-site management at all times. All provide breakfast whether in a restaurant or breakfast room, or via room service."
>
> (Qualmark, 2013).

Disaster resilience is a complex and multifaceted concept (Cutter, Burton, & Emrich, 2010). The research developed a definition of disaster resilience from a literature review of articles at the intersection of tourism, disasters, and resilience. The definition used is as follows:

> "A dynamic condition describing the capacity of a hotel, together with its stakeholders, to assess, innovate, adapt, and overcome possible disruptions that may be triggered by disaster."
>
> (Brown et al., 2017, p. 365).

Through literature analysis of measures and frameworks regarding resilience, the Disaster Resilience Framework for Hotels (DRFH; Figure 1) was developed (Brown, Orchiston, Rovins, Feldmann-Jensen, & Johnston, 2018). Frameworks reviewed and analysed examined resilience from community and organisational perspectives,

Figure 1. Disaster Resilience Framework for Hotels (DRFH: Brown, Orchiston et al., 2018, p. 70).

disaster preparedness and planning, and tourism crisis management. A detailed look at frameworks used in the development of the DRFH can be found in Brown, Orchiston et al. (2018). The DRFH expands capitals-based frameworks by Mayunga (2007) and Cutter et al. (2008) by adding constructs of organisational resilience by Lee, Vargo, and Seville (2013) and work published by a number of other authors (Brown, Orchiston et al., 2018). The DRFH has been used recently in work by Ivkov et al. (2019) which explores the resilience of hotels quantitatively in 12 European countries.

The DRFH builds on research examining resilience in communities, the tourism sector, and organisational resilience, blending the previous research into a capitals-based understanding of predictors of resilience for the hotel sector. For the purpose of this study, capitals were weighted equally, although a case could be made for refining the framework in the future through adding weight to capitals (Mayunga, 2007) based on the specific study area. The DRFH includes economic, social, human, physical, natural, and cultural capital groups, defining 18 predictors of resilience as well as suggesting measures from the literature (Brown, Orchiston, et al., 2018).

To explore the framework, a survey of 72 questions for staff and 84 questions for General Managers (GMs) was developed. The survey used the DRFH predictors and suggested measures to gauge the state of disaster resilience in hotels in Wellington (Brown, Rovins, Feldmann-Jensen, Orchiston, & Johnston, 2019). Managers are often the sole source of information when investigating questions within the hotel sector (Albattat & Ahmad, 2015; Chan & Hawkins, 2010; Nguyen, Imamura, & Iuchi, 2018). The inclusion of staff perspectives in this study allows for analysis of resilience from multiple organisational layers. All 28 hotels in Wellington were invited to participate in the data collection. The online survey links were sent to GMs both so that they could participate themselves and to distribute links to staff. Ultimately, 74% of GMs participated by answering questions, forwarding surveys to staff members, or both. Data collected were analysed using descriptive statistics, appropriate for the small sample size and total number of inquiries. While the data are not appropriate for inferential purposes (Gray, 2014), they do provide an exploratory view of disaster resilience in the sample. Data tables and further details regarding the survey can be found in Brown et al. (2019).

The surveys were followed by semi-structured qualitative interviews designed to clarify and add context to the data collected in the study (Gray, 2014). Three hotel properties that participated in the surveys consented to interviews with managers and staff. A total of 13 staff interviews and four manager interviews were completed in Wellington (Brown, Rovins, Orchiston, Feldmann-Jensen, & Johnston, 2018). Data collected were analysed using both inductive and deductive thematic analysis (Patton, 2015). The DRFH was used to define original themes with continued opportunity for emerging themes based on the interview responses.

Results and Discussion

The exploratory surveys and qualitative data illustrated current levels of disaster resilience for many of the predictors of resilience which were present for all capital groups. However, some gaps and possibilities for improvement were identified. The following section briefly highlights findings in each capital group to provide an overview of the research.

Economic resilience was exhibited by high rates of full-coverage insurance (84%), diverse customer bases and marketing to develop new customer bases (100%), high staff savings rates (87%), and financial reserves (65%; Brown et al., 2019). In support of these findings, secondary data showed increasing tourism projections for NZ (Statistics New Zealand, 2016). Low rates of disaster management budgets as a line item and low levels of staff insurance rates for personal property were identified as areas for improvement.

Social capital resources included strong connections across departments (84%) and team approaches to achieving organisational goals (95%). Team approaches to disaster management were less common but still prevalent (70%; Brown et al., 2019). An area for strengthening identified by GMs and staff was to improve connections with other organizations that may be useful in a disaster (Brown, Rovins et al., 2018). This finding was one of the key lessons learned following the Kaikōura earthquake. Participants mentioned a need for better information regarding the status of their facility and improved links to general disaster information. Further, guests wanted updates when staff had no news to report. Understanding these challenges can help hotels to improve their ability to function during and after disasters.

Human capital resources proved strong from survey and interview data. Staff had regular fire drills to practice evacuation (74%), many have first aid and CPR training (65%), and all understood earthquake protective actions (Brown et al., 2019). A gap identified in surveys showed a large portion of staff lived in the suburban areas of Wellington (60%) and while they were willing to come to work in a disaster, they felt they might encounter challenges travelling via motorways (Brown et al., 2019). Qualitative data indicated that only a few ad hoc staff members were able to provide sufficient support to the staff on duty and meet guest needs (Brown, Rovins et al., 2018).

Overall, hotel premises in Wellington satisfy current earthquake building codes with only two hotels currently on the “Wellington Earthquake Prone Buildings” list (Wellington City Council, 2017). Evacuation routes are well socialised (81%), including outside assembly areas once the building is clear. One important gap identified by the qualitative data was that many hotel staff in the central city do not have a clear idea of the risk posed by tsunami, nor do they have protective actions prescribed in case of a tsunami warning (Brown, Rovins et al., 2018). In some cases, staff did not have a clear idea of directions to give guests regarding tsunami evacuation following an earthquake. These findings illustrate the need to develop multi-hazard training and exercises to familiarize staff with best practices for different and cascading events.

Both natural and cultural capital resources were high. Staff demonstrated high levels (95%) of emergency preparedness in their homes. The vast majority of hotels in Wellington are actively recycling (96%) and NZ has a number of agencies actively monitoring the environment, a key draw for tourism in NZ. For example, the NZ Department of Conservation recently announced it is developing plans to manage tourist numbers and noise from aircraft in some areas to assist in maintaining natural resources (New Zealand Geographic, 2018).

A key area for improvement is the need for Wellington hotels to take an all-hazards approach to disaster planning. Developing budgets for disaster management activities and expanding exercises and trainings to include earthquake and tsunami hazards will increase hotel disaster resilience. Limitations of this study include the limited size of the sample, meaning that generalisations to a larger and broader population are not appropriate. Further, the GMs acted as gatekeepers for access to staff so biases in participant selection is possible (Gray, 2014). Additionally, only full-time staff participated; properties indicated close to 50% of staff were employed part-time. Further research looking at the role that part-time staff play and the particular challenges they face is necessary.

Conclusion

The earthquake activity in Wellington provides a unique opportunity to study hotels' disaster resilience in a post-disruption setting, including the 2016 Kaikōura earthquake. This research exploring Wellington's hotels highlighted that they have many resources contributing to their disaster resilience. While it is not known if these resources existed prior to the Kaikōura earthquake, the capital that these hotels have available can contribute to their ability to function in the face of future disasters. Further developing disaster management planning, guest information, and risk identification will add to their resilience.

The findings summarized above serve as an important starting point to understand disaster resilience from a hotel perspective in the wake of a recent event and illustrates the value of mixed methods for depth of understanding and context when looking at complex problems. Future research objectives include capturing larger segments of staff and expanding study areas to include locations with diverse risk; such research will add to the knowledge of disaster resilience within the hotel sector.

Authors' note

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Business recovery from disaster: A research update for practitioners

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Abstract

In the week following the Darfield magnitude 7.1 earthquake on September 4th 2010, researchers from the Resilient Organisations research group convened in Christchurch to set out a plan for learning as much as possible about the effects of the earthquake on organisations across their shaken region. This began a six-year process of data collection, analysis, and learning about the way organisations are affected by, adapt to, and recover from major disruptions. Between November 2010 and September 2016, our research team interviewed and surveyed over 1000 organisations across the Canterbury region through a series of earthquakes and disruptions, building a broad and rich dataset of insights that can now help other organisations facing disruptions in the future. In this article, we identify the top ten lessons for managing through crisis, being agile and adaptive in the face of change, and finding opportunities in disruption based on the experiences of real organisations. The lessons learned in the Canterbury event can inform resilience enhancement for the many organisations facing complex hazard risks, including those in New Zealand's capital, Wellington.

Keywords: *Business recovery, organisational resilience, disasters, disaster recovery*

The Canterbury Earthquake Sequence

At 4:34am on 4th September 2010 a magnitude 7.1 earthquake rocked residents in the Canterbury region of New Zealand (NZ). The event caused widespread damage and infrastructure disruption across Canterbury but there were no direct fatalities, partly due to the timing of the earthquake. Although the earthquake caused significant damage it was considered manageable and a local state of emergency was lifted after 12 days. Then, a destructive aftershock occurred on 22nd February 2011 at 12:51pm. This magnitude 6.2 earthquake, centred 13 kilometres from the Central Business District (CBD) of Christchurch, caused multiple building collapses and resulted in the deaths of 185 people. Consequently, a cordon was erected around the entire CBD. This cordon was reduced in size gradually over the next two and a half years as buildings were demolished and roads reopened. In the interim, over 51,000 workers and 6,000 businesses across the region were forced into different ways of operating to survive (Stevenson, Seville, & Vargo, 2012).

Since November 2010, the Resilient Organisations Research Group[1] has surveyed over 1000 organisations, interviewed over 100 organisations, and worked alongside scores of businesses and government agencies within the region to understand the impacts of and response to the Canterbury earthquake sequence. Through this process we have gained a rich view of how a major disruptive event can have lasting effects on a city and those who live and work there. These insights can now help other organisations and regions facing future disruptions. This paper details the top 10 lessons learned by Resilient Organisations researchers, and is supported by numerous references originating from the Resilient Organisations Research Group (Brown, Chang, Hatton, Malinen, Nilakant, Poontirakul, Sampson, Seville, and Stevenson). We present these lessons as a guide for organisations and the regions they support who may face disaster recovery in the

1 Resilient Organisations was formed in 2004 as a network of researchers across New Zealand interested in the newly-emerging topic of organisational resilience. In 2014, Resilient Organisations transformed into a social enterprise, continuing to research as well as offering consulting services to help organisations understand and develop their resilience.

future. More details about the methods used and specific results can be found in the papers cited throughout this article, which represents a brief overview of the main lessons drawn from the body of work carried out by our team.

Take care of your staff

"He aha te mea nui o te ao
What is the most important thing in the world?
He tāngata, he tāngata, he tāngata
It is the people, it is the people, it is the people"

Māori whakatauki (proverb)

Following the Canterbury earthquake sequence, businesses consistently reported that one of the most challenging aspects of the recovery was managing staff (Brown, Stevenson, Giovinazzi, Seville, & Vargo, 2015). Post-disaster staff well-being can be supported in a number of ways, including acknowledgment of the extra efforts of staff in the post-earthquake environment, providing increased autonomy and flexibility around job descriptions and performance management, commitment to well-being initiatives such as the five ways to well-being (Aked, Marks, Cordon, & Thompson, 2008), and helping to ensure staff have access to necessities (water, food, shelter, child care, etc). Organisations in Canterbury that undertook these initiatives saw staff better able to cope with difficulties and a noticeably more positive mood towards their ongoing challenges (Malinen, Hatton, Naswall, & Kuntz, 2018).

Although everyone experiences a disaster differently, common patterns tend to emerge (Figure 1). Understanding the highs and lows of recovery will help those working with people to anticipate and respond to challenges through the recovery period. Effective leadership and planning should consider the emotional journey of recovery to ensure that leaders as well as staff are supported as best as possible.

Organisations do not need to wait for a disaster or disruption to improve staff well-being. The recent release of the International Standard (ISO 22330) "Guidelines for people aspects of business continuity" focuses on the duty of care that organisations have to ensure staff well-being before, during, and after a disaster (International Organization for Standardization, 2018). Recovery agencies and authorities can assist their communities by ensuring these messages are available and accessible in the disaster aftermath as well as enacting them within their own organisations.

Look after your leaders

"You cannot pour from an empty cup."

Unknown

Leading in a post-disaster environment requires significant time and energy; this includes not just managing business matters but often also supporting staff, and sometimes customers, to cope with stress (Malinen et al., 2018). Leaders can come from unexpected places and looking after them is vital for ensuring your organisation can recover and thrive.

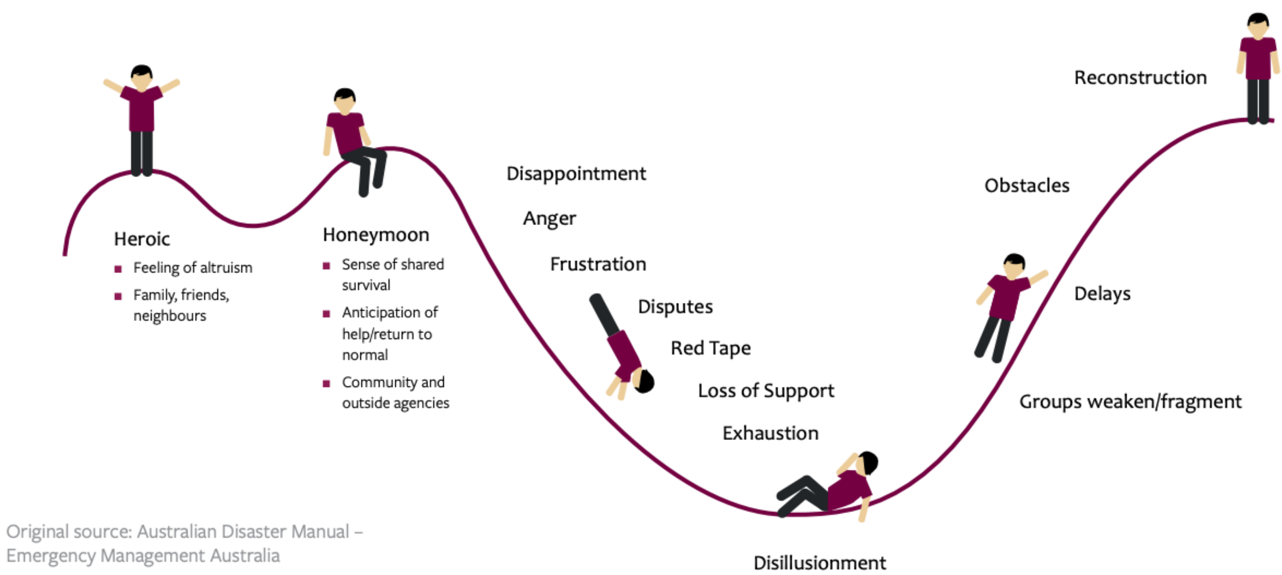

Figure 1. The highs and lows of disaster recovery (McNaughton, Willis, & Lallemant, 2015).

Organisations with high resilience tend to adopt a devolved style of leadership, empowering the leadership of many rather than one, to ensure that any issues that arise can be dealt with promptly (Seville, Van Opstal, & Vargo, 2015) and to reduce the potential for leader burn-out (Malinen et al., 2018).

Post-earthquake in Canterbury, our research group found that levels of staff engagement depended more on the leadership qualities demonstrated by their one-up manager than on senior leadership decisions (Nilakant, Walker, Rochford, & Van Heugten, 2013). Senior management may do well at expressing their support for employees, but line managers need to also have the understanding and skill to offer both practical and emotional support to their teams. It is therefore important to spend time with your managers pre-crisis and post-event to support them to be good leaders.

There is no such thing as too much communication

> "The single biggest problem in communication is the illusion that it has taken place."
>
> George Bernard Shaw

Disasters generate environments filled with uncertainty. Businesses must be prepared to communicate early and often with their staff, suppliers, customers, neighbours, insurance companies, and, in some cases, the public at large. In all cases, this means both delivering clear outward communications and soliciting and meaningfully responding to questions, concerns, and insights from those with whom you are communicating.

Internal communications should be a first priority for any organisation. Assessing staff well-being after an event and letting all people and parts of the business know about the situation as it unfolds is critical. Maintaining constructive two-way communication with staff can be difficult following a period of disruption. If not done well, employee performance and productivity can suffer (Malinen et al., 2018).

Ongoing two-way communication with suppliers and customers is essential throughout the response and recovery period. Customer perceptions can affect levels of demand following an earthquake. Ensuring that current and potential customers are informed about what happened and the impact on the organisation as well as reinforcing the customers' importance to the business can reduce the likelihood of misinformation, confusion, and mistrust. In Canterbury, organisations and business associations went to great lengths (e.g., site visits, marketing campaigns, websites, and social media) to demonstrate their capacity to deliver their products and services (Hatton, 2015). Frequent communication with a wide array of partners and stakeholders reduced negative outcomes and created opportunities for earthquake-affected organisations.

No organisation is an island

> "No man is an island, entire of itself; every man is a piece of the continent, a part of the main."
>
> John Donne

The ability of a business to deliver its product can be affected by a disturbance at any point in its supply chain. Following the Canterbury earthquakes, organisations whose suppliers were disrupted were significantly more likely to experience decreased productivity than organisations whose supply chains were entirely functional (Seville, Stevenson, Brown, Giovinazzi, & Vargo, 2014). Continuous open communication with suppliers and a willingness to adjust on both sides of a supply relationship is important. Following the Canterbury earthquakes, disrupted organisations that communicated well with their suppliers were able to negotiate changes to their supply arrangements and were more likely to receive donated supplies, discounts, extended credit, and deliveries outside of normal work hours (Stevenson et al., 2014).

Supply chain resilience can be built prior to a disruption by selecting suppliers with good track records (Mascaritolo & Holcomb, 2008), building social capital with suppliers (Stevenson et al., 2014), and diversifying the business's portfolio of suppliers (both in terms of organisational diversity and geographic diversity; Tang, 2006). Understanding your supply chain structures, including how information flows through the supply chain, can also help communications post-disruption and allow lessons to be learned and integrated collectively by all organisations throughout the chain.

Collaboration for success: Work with your old friends and make new ones

> "Naku te rourou nau te rourou ka ora ai te iwi.
> *With your basket and my basket the people will thrive.*"
>
> Māori whakatauki (proverb)

It is well established that building relationships pre-event is good practice in disaster preparedness (Aldrich, 2012). We also found many cases where successful collaborations were formed post-event based on no prior relationships. The majority of these involved organisations "moving in together", creating innovative new ways to satisfy their urgent needs for spaces from which to trade. Building trusting relationships between organisations, including competitors, customers, and business associations provided organisations with resources, moral support, information, and inspiration that supported recovery. For example, some customers offered to pay in advance, place extra orders, or defer orders in an effort to help impacted businesses. Treating customers well during business-as-usual will increase the likelihood of these offers of help occurring during disruption. Suppliers offered space and often flexibility over payment terms. These relationships were also the source of a much-needed sense of camaraderie and help in generating ideas of how to adapt to the post-disaster environment.

In some cases, the event spawned new ways of collaborative working that has had long-lasting benefits. The Enterprise Precinct and Innovation Campus (EPIC) Sanctuary is a purpose-built office complex in the Christchurch CBD. The complex includes shared meeting areas, kitchen, and bathrooms as well as individual offices for 17 companies in the Information and Communications Technology (ICT) sectors. EPIC was founded by a group of 40 small ICT business owners that had lost their premises in the earthquakes and were having difficulties finding alternatives. A major disaster with long-lasting effects creates many of the conditions theorised to enable swift trust (Beck & Plowman, 2013; Hatton, 2015). This means that providing opportunities for organisations to interact with each other, regardless of their prior interactions, is an important mechanism to enable emergent collaborations post-event.

Recovery for a new environment

> "A time in crisis is not just a time of anxiety and worry. It gives a chance, an opportunity, to choose well or to choose badly."
>
> Desmond Tutu

All too often, people and organisations rush to return to their pre-earthquake state. Sometimes this is out of an understandable and pressing need to make ends meet. However, earthquakes and other disasters can change the business environment positively or negatively and either temporarily or permanently. Changes are often seen in customer behaviours and demands (Sampson, Hatton, & Brown, 2018); suppliers, operational costs, and staff availability (Stevenson et al., 2011); and regulation changes (Chang et al., 2014). As a result, businesses need to evolve accordingly.

Following the Canterbury earthquakes, organisations faced the full spectrum of these disruptions. The University of Canterbury experienced a 16% reduction in student numbers as students sought to avoid the disrupted post-earthquake environment (University of Canterbury, 2012). Many businesses in the central city were forced to relocate, at first due to a cordon and then to enable the implementation of the Central City Blueprint for recovery (CERA, 2011). In some cases, this meant a loss of connection with a business community and loss of customer visibility, causing some businesses to re-think their business model (Hatton, 2015; Stevenson, 2014). Businesses need to be ready to adapt to a new environment and to take advantage of a unique opportunity to reinvent themselves to be ready for the future.

Recovery is a marathon not a sprint

> "There is no success without hardship."
>
> Sophocles

The anticipated duration of recovery changed dramatically over the seven years following the earthquakes as the long-term picture of Canterbury's future became clearer. Initial estimates were that the central city would be fully open to the public within six months (Stevenson et al., 2011). However, many did not expect that "six months" would turn into two and a half years (O'Connor, 2013).

The recovery period for many businesses was also longer than expected. More than two years post-earthquakes, Stevenson, Brown, Seville, and Vargo (2018) found that 99% of 541 surveyed organisations had reopened and resumed trading. However, 38% of organisations identified themselves as still being either in "survival mode" or "recovering" from the earthquakes. Table 1 illustrates the many different trajectories facing organisations post-disaster.

Organisations need to be prepared for a long journey. They need to be ready to adapt and change decisions if needed and keep moving forward in times of crisis, even with incomplete information. Recovery managers can help mitigate the stress of uncertain timelines by being open and honest around recovery estimates.

Table 1.
Self-assessed organisational recovery status two years post-earthquake.

Organisational Recovery Status	% of organisations
The earthquakes never impacted our organisation	12%
The earthquakes were positive for our organisation	27%
We have fully recovered from the earthquakes	22%
We are still recovering from the earthquakes	30%
We are still in survival mode following the earthquakes	8%
We are no longer trading	1%

Note. Table adapted from Stevenson et al. (2018).

The paradox of insurance

> "Yesterday is not ours to recover, but tomorrow is ours to win or lose."
>
> Lyndon B. Johnson

High insurance coverage has, counterintuitively, created some challenges for business recovery. Many features of the Canterbury earthquakes such as depopulation, the central city cordon, regulation changes, and delays in settling material damage claims meant that significant business losses were not covered by insurance (Brown, Seville, & Vargo, 2016). Fear of *capital flight* (from cash-settled insurance claims) and uncertainty around ongoing availability of insurance[2] (Chang et al., 2014) has also made some developers and business owners slow to re-invest in the city.

Some organisations fell into the trap of expending their time and energy on maximising their insurance pay-out while neglecting to ensure their business was sound in the post-earthquake environment. In some cases this led to worse outcomes than businesses that had no insurance at all (Poontirakul, Brown, Seville, Vargo, & Noy, 2017). While insurance is a good risk-transfer and cost-recovery mechanism, it cannot eliminate risks. Businesses need to understand the limit of their insurance coverage and to ensure their post-disaster efforts are focused on the long-term direction of their organisation.

2 After each significant earthquake event, an insurance moratorium was put in place as insurers reassessed their risk profile.

Staff engagement: More than just a buzzword

> "The way your employees feel is the way your customers will feel. And if your employees don't feel valued, neither will your customers."
>
> Sybil F. Stershic

Organisations benefit from focusing on improving employee engagement pre-event. An employee that is engaged and supported is more likely to go above and beyond for the organisation when a crisis occurs (Seville, 2016). Past studies have shown that organisations with engaged employees tend to perform significantly better than organisations where employee engagement is below average (Harter, Schmidt, & Hayes, 2002) in times without crisis. If your employees are motivated to perform well every day for the good of the business due to their high level of engagement, they can pull together even more when the business is in need. Engaged employees in Canterbury provided solutions for business problems, endured difficult conditions, and supported management and each other through the difficult post-disaster conditions. An engaged team is competent (skilled, practiced, and ready to improvise) and made up of committed people who are empowered to be part of the solution.

Planning and preparedness: Plan to adapt

> "Resilience is 50% planning and 50% agility."
>
> Resilient New Zealand (2016)

Good business continuity planning arrangements enable organisations to reduce the impacts of events and begin their recovery journey more quickly. Canterbury organisations that had good communication plans were able to cover the basics such as checking on staff and contacting key customers and key suppliers quickly and efficiently. ICT backups enabled ready access to important information. Unfortunately for some organisations without good ICT backups, the loss of customer and accounting databases created a major task in medium to long-term recovery (Hatton, 2015). Having clearly-defined critical functions enabled organisations to begin their recovery arrangements quickly and with a lower likelihood of effort wasted on non-essential actions (Hatton, Grimshaw, Vargo, & Seville, 2016).

However, those key elements of a business continuity plan alone are not sufficient in a major regional event. Plans need to also take into account the level of societal and personal disruption that is likely to occur, including loss of access, impacts on staff, and changes to demand. While these may be hard to specifically plan for, there are steps that can be taken pre-event to position organisations to better adapt in the post-disaster environment:

- Include principles in your plans to support staff post-event;
- Build the personal resilience of employees in non-crisis times;
- Identify and develop leadership at all levels within the organisation;
- Ensure plans remind you to consider the opportunities in the post-disaster environment; and
- Build an organisational culture that captures lessons learned promptly and enacts rapid improvement.

Conclusions

There is no one-size-fits-all approach to disaster recovery. The experience of every organisation in the aftermath of a disaster will be unique, but there are steps that all organisations can take to improve their ability to survive and thrive. Following an event, organisations need to be adaptive in an environment that will be constantly changing. They need to communicate fully and openly, value and support staff, leverage existing and new relationships, and have a clear vision of where their organisation is going. Those who build the resilience of their organisation and people before disaster strikes reap rewards not only during a time of crisis, but in business-as-usual too. Preparing for the worst ensures that our organisations will manage well through crisis, be agile and adaptive in an ever-changing environment, and find opportunities to thrive in disruption.

Acknowledgements

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Wellington City's emergency management response to the November 2016 Kaikōura earthquake

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Abstract

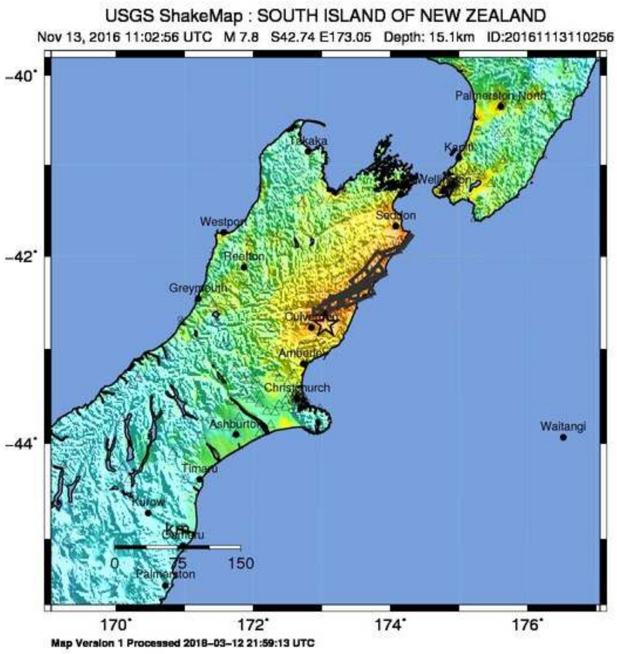
A magnitude 7.8 earthquake struck near Kaikōura township, Aotearoa New Zealand, on the 14th of November 2016 causing widespread damage and disruption. In the worst-affected areas (including Wellington City), Civil Defence and Emergency Management response organisations activated for extended periods of time to ensure safety and provide welfare support to affected people. The main priorities included taking charge of response efforts while collaborating with the emergency services and lifeline utilities. This ensured public safety, welfare support, and early preparation for the transition to recovery. In Wellington, approximately 80 buildings within the central business district were damaged, including the port area which suffered liquefaction. The overall cost of repairs, including insured losses to the city's buildings, infrastructure, and economy was approximately NZ$2 to 3 billion. Repairs will take many years to complete. However, feedback from lifeline utilities suggested that most services were not severely affected, except for the port. Roads, electricity, potable water, sewerage, and communications were the critical priorities for restoration. Despite ongoing remediation programmes, the Wellington region's infrastructure (including Wellington City) remains vulnerable to the effects of a future large earthquake.

Keywords: *Civil Defence, emergency management, disaster response, Kaikōura earthquake*

Disclaimer: This article is the personal view of the author and not the view of either the Wellington City Council or the Wellington Civil Defence and Emergency Management Group.

On 14 November 2016 at 12:02 am local time, a large magnitude 7.8 earthquake struck near Kaikōura township, Aotearoa New Zealand (NZ; see Figure 1). The earthquake caused widespread damage to roads, buildings, utilities, and other infrastructure across a wide geographical area which included the upper South Island and the Wellington region of the North Island (GeoNet, 2017). There were two deaths in Kaikōura, but few other people were injured in the affected areas (Ministry of Civil Defence and Emergency Management, 2017a).

Although the epicentre was located more than 200 kilometres from Wellington, many commercial buildings and the port infrastructure within the city were damaged. The port suffered liquefaction and many high-rise buildings between eight and 15 stories were damaged (Kestrel Group Limited, 2017). The estimated value of insurance losses in Wellington totalled NZ$2 to 3 billion (McBeth, 2017). This estimate has the potential



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL INTENSITY	I	II–III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

Figure 1. Map of New Zealand showing zones of tremor intensity radiating from the Kaikōura earthquake (United States Geological Survey, 2018).

to increase, with decisions on the fate of some buildings undecided at the time of writing this article (Devlin & Stewart, 2017). However, despite numerous electrical power outages and fractures in water pipes, there was comparatively little damage to utilities, considering the magnitude of the earthquake.

On the 14th and 15th of November, states of emergency were declared in the Kaikōura District, Hurunui District, Canterbury region, and Dunedin City but not Wellington City (the capital city of NZ) because it was deemed that local, regional, and national Civil Defence Emergency Management (CDEM) responses could be run from Wellington. Immediately after the earthquake, Wellington City Council's CDEM Emergency Operations Centre (EOC) was activated to support emergency services (Wellington City Council, 2017). It was active for 12 days before responsibility for the city's recovery was handed to Wellington City Council's recovery team. Response efforts were challenged by a sizeable storm with associated flooding on the 15th of November, the day after the earthquake ("Rain brings commuter chaos to capital highways", 2016).

Wellington City Council's CDEM EOC was established as part of the NZ government-mandated Coordinated Incident Management System (CIMS) framework under which CDEM is delivered. Within CIMS, local, regional, and national coordination centres are organised and managed in the same manner. Each EOC has six desk functions: Welfare, Logistics, Intelligence, Planning, Operations, and Public Information Management (PIM). In each EOC, a Local Controller oversees the six functions.

Figure 2. Damage to State Highway 1 and the railway track near Kaikōura (GeoNet, 2016; photo credit Julian Thomson).

I was the Primary Local Controller of the Wellington City EOC during Wellington City's CDEM response to the Kaikōura earthquake. In the following report, I summarise my perspective on and experience of the initial assessment of building damage, legalities associated with damaged buildings, public issues, and issues with utilities, in particular electricity, and present a subjective evaluation of the CDEM response based on personal observations.

Initial Response and Building Damage Assessment

During the first few days of the response, most central government attention was focused on the damage in Kaikōura which was more severe than in Wellington. Kaikōura is in a remote coastal area. Severe damage to State Highway 1 and the railway line running from Picton township to Christchurch (see Figure 2) caused significant disruption of freight and passenger traffic between the north of the South Island and Christchurch City ("Kaikoura earthquake", 2016).

Wider afield, a small flotilla of foreign warships visiting Auckland for the Royal New Zealand Navy's 75th anniversary celebrations sailed to Kaikōura to render assistance to stranded tourists and homeless residents. Their helicopters were utilised for evacuations (see Figure 3) and delivery of essential supplies (Nichols, 2016).

Figure 3. Naval helicopters evacuating stranded people from Kaikōura township. Photo supplied by the New Zealand Defence Force.

Immediately after the earthquake, Wellington City Council's EOC was activated to support the emergency services (see Figure 4). The EOC had to deal with several high-impact, complex, hazardous, and potentially life-threatening scenarios that initially stretched its ability to cope (Wellington City Council, 2017).

Figure 4. Wellington City Council Emergency Operations Centre (EOC) in action. Photo supplied by Wellington City Council.

An hour after the earthquake, while damage reports were still being received, the Ministry of Civil Defence and Emergency Management (MCDEM) also issued a national tsunami warning (Ministry of Civil Defence and Emergency Management, 2017a). The tsunami warning caused confusion and frightened many people who were already stressed and fearful after the earthquake; many people evacuated to higher ground causing major road congestion (Stevenson et al., 2017). This made it difficult for emergency services to respond to the incident and undertake reconnaissance. The difficulties were exacerbated when the emergency telephone system (111) within Wellington was inoperable for some time after the initial earthquake due to evacuation of key buildings within the central business district (CBD).

Initial reports from inside the Wellington CBD suggested that although glass and debris from buildings covered many streets, most roads were passable and the damage from the earthquake was not critically serious. However, three hours after the earthquake, the first reports of liquefaction and extreme damage to the Statistics New Zealand building (Ministry of Business, Innovation and Employment, 2017b) in the vicinity of Wellington's port (CentrePort) suggested that the extent of building damage might be more severe than initially thought.

On the first day of the response, people were discouraged from entering the CBD. When daylight arrived, Wellington City Council's building inspectors commenced "rapid external building assessments" of all buildings within the CBD. The council's mandate did not include full structural inspections, which was not widely understood at the time causing considerable misunderstanding (Ministry of Business, Innovation and Employment, 2017a). Due to the heightened risk of injury during building inspections, an Urban Search and Rescue (USAR) team was deployed to support the building inspectors. Concurrently, many building owners arranged for commercial engineers to undertake more comprehensive building inspections, in many instances at the request of their insurance companies.

By 15:00 local time on the 15th of November the EOC received a report from structural engineers who had inspected a high-rise building in Molesworth Street, Thorndon. The building had severe structural damage and was considered at risk of collapsing during a subsequent large aftershock. A cordon was soon established around the 37-metre-tall building by the Fire Service at 60 metres (at least 1.5 times the height of the building) to protect the public. Since a state of emergency had not been declared the cordon was enforced initially by the Fire Service (now Fire and Emergency New Zealand; FENZ) and USAR, under the Fire Service Act 1975. Cordon control was subsequently handed over to the Wellington City Council CDEM Local Controller the following day. It was determined that the building was beyond economically viable repair. Preparations began to demolish the building, enforced by Wellington City Council using powers available under the Building Act 2004.

Over the next four days, structural engineers and the council's building inspectors accompanied by the USAR team checked the CBD. A considerable number of buildings were identified that had significant structural damage (Engineering New Zealand 2016). Cordons were established around buildings while repair schemes were decided. Building owners consulted with insurance companies to assess what needed to be done and decide on who was going to pay for repair or demolition. Unexpectedly, a sizeable storm with associated flooding overwhelmed Wellington on the 15th of November which complicated the earthquake response efforts. Although people were able to return to work within the CBD on that day ("Rain brings commuter chaos to capital highways", 2016), many struggled to return home that evening due to the flooding.

By the 17th of November, the number of evacuated buildings in the Wellington CBD had increased to the point that central government was concerned that some government functions could potentially be at risk. This led the Ministry of Business, Innovation, and Employment (MBIE) to instruct Wellington City Council

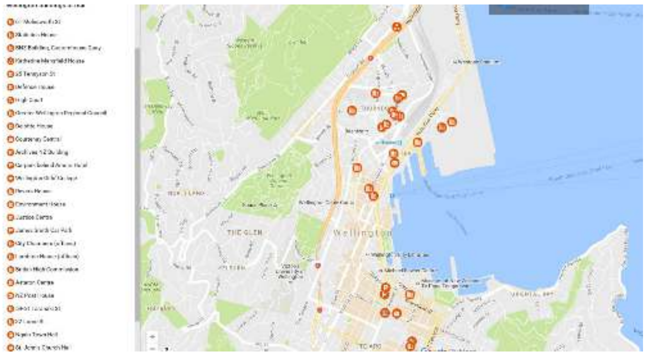


Figure 5. Location of damaged buildings in Wellington City. Provided by Wellington City Council

to a) determine the total number and type of buildings damaged (see Figure 5); b) undertake more detailed inspections of buildings that had been damaged; c) establish why only certain building types had been damaged; and d) determine if the geographical zone encompassing the inspected damaged buildings needed to be expanded.

Response to Other Issues Arising from the Earthquake and Severe Weather

Wellington's undulating landscape causes frequent road and public transport network congestion. On a normal working day, 80,000 commuters join Wellington's 200,000 inhabitants that travel to and from work and educational establishments, putting pressure on roads and the public transport network. People were discouraged from coming into the CBD on the day of the earthquake. Unfortunately, the weather forecasts available on that day did not accurately predict the storm and consequential flooding that engulfed the region (Hurley, Burrow, & Baird, 2016). The rail network was shut down due to torrential rain and flooding and the three state highways that traverse the region were all blocked. This led to traffic congestion that delayed and disrupted response efforts ("Wellington cut off", 2016).

During the first 48 hours after the earthquake, many people were still in shock, and matters became worse when several large buildings were evacuated at short notice. Temporary accommodation was provided to help displaced people. Welfare provision is a core responsibility of local authorities in Civil Defence emergencies (Ministry of Civil Defence and Emergency Management, 2015a).

Despite numerous electrical power outages and fractures in water pipes, there was comparatively little damage to utilities, except for the port where the earthquake caused major damage and disrupted operations. This included widespread liquefaction and significant damage to three large travelling cranes, jetties, storage areas, and buildings. As the damage assessment and understanding of the impact of the earthquake became more complete, Civil Defence staff were able to more effectively help displaced residents and struggling businesses.

The public and media questioned why a cordon was not established around the centre of Wellington City making it a "Red Zone" as was done following the 2010 and 2011 Canterbury earthquakes. The option of a cordon was investigated and decided against because it was impossible to provide temporary accommodation for the tens of thousands of residents who lived within the affected area and none of the 80 badly damaged buildings had collapsed. The public were also concerned as to why certain buildings were severely damaged and others largely undamaged. A combination of earthquake magnitude, shaking duration, ground substrate beneath Wellington, and distance from the earthquake's epicentre led to resonant vibrations predominantly affecting buildings between eight and 15 stories in height. There was also a public perception that the damage to land, jetties, and buildings in the CentrePort area was due to their construction on reclaimed land. After careful geotechnical and structural analysis, the public were reassured that the extent of damage was related to the vertical distance between the building foundations and the bedrock below.

By the 18th of November, most damaged buildings had been identified and appropriate cordon management put in place. All civil and structural engineers working in Wellington had been told to report their findings to a building assessment team attached to the EOC so that a complete picture of structural damage and common failure modes could be corroborated (Kestrel Group Limited, 2017).

The EOC remained active for a further week (until the 25th of November) when responsibility for public safety was handed over to a full recovery team led by Wellington City Council. The council's brief was to take over responsibility for ongoing actions. This included demolishing a building on Molesworth Street and a large car park on Wakefield Street and assessing more buildings (Wellington City Council, 2017).

Legalities Associated with Damaged Buildings After an Earthquake

After an earthquake, it is usually unclear to the public who is responsible for safety in and outside buildings, who should inspect buildings, and how the inspections should be done. In NZ, the Civil Defence and Emergency Management Act 2002 requires local authorities to "take all necessary steps to undertake civil defence and emergency management or to perform these functions and duties" (s 59). Local authorities (e.g., Wellington City Council) are also the road controlling authorities for public roads (except state highways) and, by definition, have control over publicly owned roads, pavements, and utilities in accordance with the Land Transport Act 1998. Furthermore, local authorities have powers under the Building Act 2004 to prohibit entry, and to compel building owners to take a range of actions (including demolition) in respect of "dangerous, affected, earthquake-prone or insanitary buildings" (s 120).

Local authorities and regional CDEM groups collectively have responsibility to ensure public safety and to take whatever action is required in the event of an emergency requiring a coordinated CDEM response. Common law dictates that building owners are still responsible for the material state of their property, for themselves, and for any tenants that may occupy these buildings. Furthermore, companies who rent or lease space have a primary duty of care to their employees to "provide and maintain a work environment that is without risks to health and safety" in accordance with Section 36 of the Health and Safety at Work Act 2015.

In NZ, local authorities provide the CDEM response in the immediate aftermath of a large seismic event. Where there is a concern that buildings and other structures may have been damaged significantly such that they could pose a threat to public safety, rapid external building assessments are undertaken initially. These are followed by more comprehensive structural assessments by the building owners to meet their legal requirements as outlined above (Ministry of Business, Innovation and Employment, 2017b).

Extensive analysis of earthquake damaged buildings in many countries has shown significant correlation between peak ground acceleration (PGA) and the extent of damage. The total strain energy imparted is important for long-duration earthquakes, such as the Kaikōura earthquake, which lasted for more than 90 seconds setting up a series of resonant vibrations (Richards, 2012). Immediately after the Kaikōura earthquake, Wellington City Council, MBIE, and GNS Science (Cousins, Zhao, & Perrin, 1993) worked together to establish a threshold PGA that would inform Wellington City Council when to undertake rapid external building assessments of all buildings within an affected zone. The PGA threshold subsequently adopted in Wellington was 0.2G (where G = 9.81 m/s^2; see Figure 6).

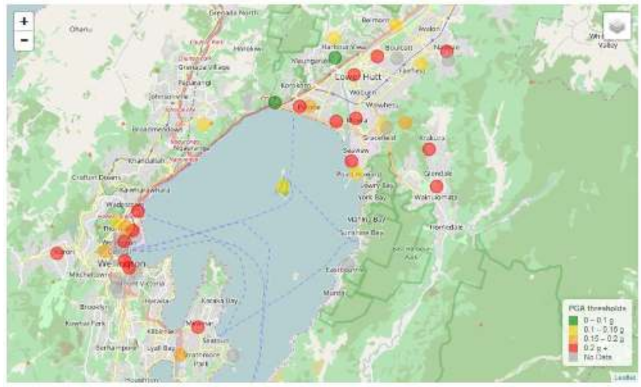


Figure 6. Peak ground accelerations experienced in Wellington during the Kaikōura earthquake. Red spots indicate localities that experienced ≥0.2G during shaking. Provided by Wellington City Council.

Finally, whenever an earthquake occurs, response organisations intuitively focus on the magnitude and the depth of the fault rupture. In the case of the Kaikōura earthquake, the geotechnical condition of the ground and supporting structure underneath buildings was also important in terms of understanding how and why buildings suffered damage.

Lifeline Utilities

Restoring lifeline utilities is essential after a natural hazard event such as an earthquake. These lifelines include potable water, sewerage, electricity, fuel, communication systems, and navigable roads. All are necessary and are interdependent on each other (Ministry of Civil Defence and Emergency Management, 2017b). Within the Wellington region, the Wellington Regional Emergency Management Office and the local authorities have prepared a list of priority services deemed essential for public safety (see Table 1). In addition to obvious facilities such as hospitals and key government and emergency services, the list includes many important lifeline services that are Civil Defence's priority for restoration. The operating functionality of lifeline utilities is given special attention after a disaster. These facilities are checked during the first round of communications and have a higher priority for response co-ordination than many other services.

Using electricity restoration as an example, all the lifeline authorities work closely with the Local and Group Controllers to ensure that priorities for electrical restoration are aligned between the CDEM authorities and electricity companies, such as Transpower and the lines companies (Ministry of Civil Defence and Emergency Management, 2015b, 2017b, 2018). In NZ, most electricity is generated by hydro-electric schemes in the South Island, but two-thirds of the load is in the North Island. Transpower noted that transmission performance and resilience during recent large earthquakes (Canterbury in 2010 and 2011, Cook Strait and Seddon in 2013, and Kaikōura in November 2016) was credible, with few significant issues (A. Renton [Transpower], personal communication, April 20, 2017). Nonetheless, if a sizeable seismic event struck Wellington, widespread damage may cause significant power outages despite pre-planned contingencies. Although the electricity-related assets may survive the seismic event, other second order effects may prevent access to facilities or cause electrical isolations. These include building collapses and sites with multiple fatalities. At a local distribution level, supplies could be lost for a sustained time after a major earthquake.

There is a strong desire to improve electricity supply resilience in NZ. Some investigative work has been undertaken jointly by several power companies. However, the regulatory regime under which the national grid and lines companies work is based on "normal" events and does not cater for reducing the risk of high impact, low probability events such as earthquakes. Work is progressing to reduce risk, but the process will require significant financial resources, administrative commitment, and time to resolve. For example, wind-powered electricity could potentially be available from several companies and, dependent upon wind conditions and generator availability, could provide additional local supply capacity (Meridian Energy, 2017).

Wellington Electricity's feedback after the incident response noted good liaisons with other utilities (in particular Wellington Water and CentrePort) following the Kaikōura earthquake. They knew about Civil Defence's priority services and their procedures focused on restoring these first. The emergency services knew from previous events that they would liaise with CDEM authorities if priorities needed to change during a response event for any reason (R. Hardy [Wellington Electricity], personal communication, April 18, 2017).

Table 1.
Top regionally important lifeline sites in Wellington.

	Sector	Asset Owner	Asset	Features
1	Medical	CCDHB	Wellington Hospital	Partial Alternates Serves 100,000+ People
2	Medical	CCDHB	Kenepuru Hospital and Mental Health Campus	Partial Alternates Serves 10,000 – 100,000 People
3	Medical	Wairarapa DHB	Wairarapa Hospital	Partial Alternates Serves 10,000 – 100,000 People
4	Medical	CCDHB	Kapiti Health Centre	Alternates Exist Serves 1,000 - 10,000 People
5	Medical	Hutt Valley DHB	Hutt Hospital	Partial Alternates Serves 100,000+ People
6	Police	NZ Police	Police National HQ	Partial Alternates Serves 100,000+ People
7	Police	NZ Police	Wellington Victoria Street Station	Partial Alternates Serves 100,000+ People
8	Police	NZ Police	Porirua Police College	Serves 1,000 People
9	Fire	FENZ	Wellington City Station	Serves 10,000 – 100,000 People
10	Fire	FENZ	Avalon Station	Serves 10,000 – 100,000 People
11	Ambulance	WFA	WFA HQ (Thorndon)	Serves 100,000+ People
12	CDEM	MCDEM (DPMC)	Beehive Bunker (NCMC)	Serves 100,000+ People

Note. CCDHB = Capital & Coast District Health Board; FENZ = Fire and Emergency New Zealand; CDEM = Civil Defence and Emergency Management; MCDEM = Ministry of Civil Defence and Emergency Management; DPMC = Department of the Prime Minister and Cabinet; NCMC = National Crisis Management Centre; WFA = Wellington Free Ambulance.

Evaluation of the Earthquake Response

The Kaikōura earthquake tested the leadership strength of both CDEM and the community. There was a lack of understanding of Civil Defence's mandate during the disaster response. The lessons learned from the CDEM response are valuable for responders in the electricity supply industry and lifeline authorities. These lessons will help such utilities to provide a better response to a future event.

An evaluation of some of the key areas of the response and recovery are outlined in Table 2. The assessment included the categories "Good" (three key areas in total), "Fair" (four in total), and "Developing" (three in

Table 2.
Assessment of key response areas.

Key response area	Assessment	Comment
Initial CDEM response	Good	The EOC was activated promptly with experienced people. Good support was received by the emergency services (including a USAR team), volunteers and the Capital and Coast District Health Board.
Initial decision-making and determining the scale of the event	Fair	Decision-making was reasonable initially, but lacked effective situational awareness, particularly with respect to the tsunami warnings and the extent of damage to the region's building stock.
Declaration of state of emergency	Fair	The MCDEM directors' guidelines were followed closely. The threshold for a state of emergency was not reached. There was debate on whether the threshold should be revised.
Situational awareness	Developing	The size and scale of the event, and complexity of the damaged buildings made it difficult for structural engineers' to initially obtain an accurate picture of the zone of damage. Many building owner's reluctance to share information with the Council was an obstacle. The ability to build situational awareness was patchy across the CDEM sector, and there were technical solutions that could have been implemented.
Control of public safety	Good	A key decision was made initially to discourage people from entering the CBD. No red zone was declared because conditions did not warrant it. Buildings and locations deemed unsafe were cordoned off quickly. Cordons were vigilantly enforced.
Welfare arrangements	Good	Welfare arrangements for displaced people were handled and administered well, including dealing with people who were socially vulnerable, or had special needs.
Communications	Fair	Local communications were handled well and were proactively managed across a variety of media types, including television, radio, conventional media, and social media. The diversity of media confused the public (e.g. websites and social media channels belonging to public organisations including WCC, WREMO, GWRC, NZTA, Metlink, and MCDEM).
Liaison with lifeline authorities	Fair	This was not the major focus as building damage dominated this event. The electricity supply industry was generally well organised. Other services operated independently without an awareness of CDEM priorities.
Sustainability	Developing	Any prolonged response quickly puts a strain on staff resources, and this became evident after the first week of the response. This is an area that requires national-level support to provide additional resources that can be deployed at short notice.
Transition to Recovery	Developing	While the need for a dedicated Recovery team was identified early in the piece, Recovery was complex and had not been required locally after other recent earthquakes. Therefore, transition took longer than it should have done.

Note. CDEM = Civil Defence Emergency Management; EOC = Emergency Operating Centre; USAR = Urban Search and Rescue; MCDEM = Ministry of Civil Defence Emergency Management; WCC = Wellington City Council; WREMO = Wellington Regional Emergency Management Office; GWRC = Greater Wellington Regional Council; NZTA = New Zealand Transport Agency, Metlink = Greater Wellington Region Public Transport Network; CBD = central business district.

total). Noting that the earthquake was a large, complex event leading to a significant scale of damage, there are credible and systemic reasons for the "Fair" and "Developing" (i.e., Poor) assessments. Many of these were caused by generic difficulties in training and maintaining a cadre of part-time, local government staff who could respond to low probability, high impact, and extreme risk events.

Given the impact of the earthquake on Wellington City and the proximity of the epicentre to the city, the decision not to declare a state of emergency for Wellington was widely criticised and was a subject of a government review (New Zealand Government, 2018). There is no doubt that performance within the CDEM sector has improved dramatically during the many response and recovery efforts that have occurred in recent years. Nonetheless, more improvements are needed before performance across all key areas is consistent. Capability gaps were obvious in some areas, such as situational awareness. There are potential solutions to these gaps, including updating technology.

Conclusion

Wellington City Council has a strong CDEM capability, which quickly responded to the city's needs after the Kaikōura earthquake. Damaged buildings were quickly assessed and cordoned off to protect the public. Major damage at the Wellington port was assessed. Although a severe storm on the second day that caused flooding challenged responders, the public were able to return to work quickly. As the damage assessment and understanding of the impact of the earthquake became more complete, Civil Defence staff were able to effectively help displaced residents and struggling businesses. Despite numerous electrical power outages and fractures in water pipes, there was comparatively little damage to utilities, except for the port which suffered widespread damage.

Further work is required locally and nationally to improve response performance and ensure that response capability within NZ is consistent and aligned with the public's expectations. This is important as some of the underlying reasons given for areas of response needing improvement were also identified during the Canterbury earthquakes in 2010 and 2011 (Canterbury Earthquakes Royal Commission, 2011).

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Wellington resilience workshop: Creating shared ideas and meanings

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Abstract

Co-creation of knowledge is an important method for developing policy and programmes in the disaster space. A workshop that engaged attendees in a highly participatory format was designed to further institutional, academic, and community knowledge acquisition objectives regarding cultural and community resilience by Aotearoa New Zealand's QuakeCoRE Flagship Programme 5. The workshop, which took place in Wellington, New Zealand, in June 2018, brought together members of disaster management organisations and academia, community members, and members of local and central government in a full day of learnings and activities. The aim was co-creation of knowledge in defining cultural and community resilience as well as developing a shared understanding of how to integrate resilience programmes that are meaningful and appropriate for communities in Aotearoa New Zealand.

The contribution of the workshop to the existing literature concerning the role of culture in disasters, beyond the co-creation model, includes a need to emphasise cultural activities during disaster recovery, the value of improving collaboration between stakeholders such as iwi, hapū, and marae (parts of the indigenous Māori community) in disaster management planning, and the importance of understanding local motivations and needs within our communities when designing and building disaster resilience programmes.

Keywords: *Resilience, culture, community, co-creation, participatory*

The Aotearoa New Zealand (NZ) centre for earthquake resilience research (QuakeCoRE) convened a workshop designed to co-create knowledge regarding cultural and community resilience. The workshop followed the 11th Australasian Natural Hazards Management Conference held in conjuction with the New Zealand National Emergency Conference. The objectives of QuakeCoRE's Flagship Programme 5 include identifying how societal decisions and choices affect the social, cultural, and economic resilience of communities. The full day workshop developed knowledge in two areas: cultural resilience and community resilience. The workshop, held June 1, 2018 in Wellington, was supported and hosted by QuakeCoRE, the New Zealand Ministry for Culture and Heritage (MCH), and the Wellington Region Emergency Management Office (WREMO) in conjunction with the Natural Hazards Research Platform, Resilience to Nature's Challenges National Science Challenge, and the Rockefeller Foundation's 100 Resilient Cities initiative. This article describes the development, aims, format, and results of the workshop.

The two sections of the workshop, "Understanding Cultural Resilience" and "Community-Based Resilience", were designed to address the research priorities of the Flagship 5 programme. The workshop utilised a co-creation of knowledge approach through a series of short informational talks followed by the 80 attendees undertaking group table-top activities, with the aim that this would lead to innovative new ideas for the development of policy and projects (Frow, Nenonen, Payne, & Storbacka, 2015; Hong, Heikkinen, & Blomqvist, 2010). This article will discuss the process and the knowledge produced during each of the workshop segments which contributes to the literature in the field.

The workshop provided both the MCH and WREMO with the opportunity to generate new ideas and actionable learnings to improve their current perceptions of resilience, as well as aiming to enhance understandings and knowledge for all participants in the event. The data produced by participants can be used to inform policy and contribute to the development of programs to build both cultural and community resilience; some participants commented when interviewed after the workshop that these intended benefits are already manifesting. The workshop provided an opportunity to involve community leaders and members at the policy-formation level in the process of identifying essential learnings. Co-creation of knowledge between experts and potential users considers knowledge as a process rather than something tangible (Roux, Rogers, Biggs, Ashton, & Sergent, 2006). Community involvement in knowledge development can also increase support and create sustained relationships with communities (Roux et al., 2006). The workshop aids in answering the overarching question of: "How does a community make itself resilient to future disasters?" (Wellington Region Emergency Management Office [WREMO], 2014, p. 5). Furthermore, the workshop is a step forward in the creation of participatory policy formation activities and guidelines with opportunities to initiate lasting connections between the creators and users of policies and programmes.

The following brief literature review aims to define key terms used in this workshop. A common understanding of terms is essential to convey data so that they can be similarly and accurately understood by the full variety of interested individuals. However, one of the objectives of the workshop was to gain a personal understanding of resilience as it pertains to culture and community from attendees in order to advance the group's common understanding. Therefore, this review will provide definitions from academia and regional and international initiatives while recognizing that the collecting of meanings from workshop attendees adds to the value of these definitions.

What is Resilience?

The term resilience requires an understanding of parameters to be accurate. In other words, the resilience "of whom" and resilience "to what" (Cutter et al., 2008; Martin-Breen & Anderies, 2011). Resilience is complicated by the understanding that a universal definition is not possible and frameworks need to be customised to specific populations and unique contexts (Nowell & Steelman, 2013). However, general definitions may serve as a starting point to approach more specific aspects and details of definitions. The United Nations Office for Disaster Risk Reduction (UNDRR, formerly UNISDR) defines resilience as:

> The ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions through risk management (UNDRR, 2017).

The Sendai Framework for Disaster Risk Reduction 2015-2030 (SFDRR) highlights resilience as a tandem concept to disaster risk reduction, citing reduction of risks as a contributor to strengthening resilience (United Nations, 2015). However, resilience to disasters includes more than preparedness and risk reduction before an event despite these common beliefs, particularly within the government and policy sectors (e.g., Madrigano, Chandra, Costigan, & Acosta, 2017). For example, the emBRACE initiative, in the European Union, describes the importance of learning and innovation in post-disaster settings as critical to adaptation and resilience (emBRACE, 2015). The limitation of the focus of the discussions during the workshop in terms of how resilience relates to each phase of the disaster cycle is elaborated in the conclusion section.

In recognition of the importance of resilience, NZ's Ministry of Civil Defence and Emergency Management (MCDEM) charged the Civil Defence and Emergency Management (CDEM) sector to develop a National Disaster Resilience Strategy designed to encourage an holistic approach to resilience building (New Zealand Civil Defence and Emergency Management [NZCDEM], 2019). This strategy uses a definition of resilience that includes absorbing the effects, minimising disruption, and having the capacity to adapt to the current situation and capture learnings for the future. The National Disaster Resilience Strategy therefore includes preparedness and risk reduction as well as focusing on adaptation and response. For example, the strategy recognises that building resilience offers co-benefits to the community. In addition to addressing risk, investing in resilience nurtures communities by saving costs over the long-term and providing social benefits in the short-term. As an example, the strategy offers development of flood protections that double as pedestrian walkways and community parks (NZCDEM, 2019).

The city of Wellington is one of the Rockefeller Foundation's "100 Resilient Cities"; the Wellington Resilience Strategy defines resilience for the city and develops projects aimed at building resilience in the community (Wellington City Council, 2017). The strategy looks forward to not only Wellington's survival post-event but to the ability of the city to thrive. The strategy is people-centred with a commitment to connect and empower the community, integrate decision-making, and create a robust natural and built environment (Wellington City Council, 2017).

While definitions are nuanced across organisations and disciplines, the heart of resilience remains constant. From the Latin root *resiliere*, meaning jump back, an important inclusion in social science definitions is that jumping back may not be possible or desirable (Paton, 2006). The idea of resilience often includes a *new normal* where entities thrive and push forward from their previous state (Phillips & Moutinho, 2014; Seville, Van Opstal, & Vargo, 2015). To that end, many different types of resilience are discussed in the both the literature and in developed strategies. These include community resilience, social resilience, cultural resilience, economic resilience, infrastructure resilience, and environmental resilience (Cutter et al., 2008; Johnston et al., 2009; Kwok, Doyle, Becker, Johnston, & Paton, 2016; NZCDEM, 2019; Rose, 2006; Wellington City Council, 2017). The complex nature of resilience requires well-defined and narrow parameters when seeking to assess the resilience-building process (Brown, Rovins, Feldmann-Jensen, Orchiston, & Johnston, 2017; Cutter et al., 2008). The workshop discussed here, designed to gain meaningful knowledge, narrows the more generic concept of resilience down to focus on cultural and community resilience.

Cultural Resilience

Culture is a term that has been proven difficult to define (Goldstein, 1957; Spencer-Oatey, 2012; Tharp, 2009). In 1871, Sir Edward B. Tylor defined culture as a "…complex whole which includes knowledge, beliefs, arts, morals, law, customs, and any other capabilities and habits acquired by [a human] as a member of society." (CARTA, n.d.). This definition still grounds many current thoughts about culture (Tharp, 2009). As with other terms, culture is multifaceted and has been debated in the literature (Goldstein, 1957). In an attempt to simplify the debate, Tharp (2009) writes that culture is "…simply what people think, what people do, and what people make" (p. 3). Defining culture was one workshop topic with which participants grappled.

Some common ideas of culture include that culture occurs at different levels, exists in a space between individuals and human nature, and is "shared" (Spencer-Oatey, 2012). Furthermore, both risk perception and risk-related behaviours can be influenced by culture (Kulatunga, 2010; Spencer-Oatey, 2012). Culture has influenced both "…survival of communities from disasters…as well as being a …barrier for effective disaster risk reduction activities" (Kulatunga, 2010, p. 304). Defining aspects of culture discussed during the workshop are presented in the following results section.

The National Disaster Resilience Strategy defines cultural resilience as including "cultural values, places, institutions, and practices, our identity as New Zealanders, and our history and heritage" (NZCDEM, 2019, p. 19). This strategy emphasises the importance of cultural norms and values in contributing to resilience. The strategy further emphasises the need to put people at the centre of resilience. The vision of the strategy includes the comment that "People make the connection between resilience and their own culture, values, traditions, and sense of identity and place" (NZCDEM, 2019, p. 24). The Wellington Resilience Strategy calls for a focus on the development of disaster risk management plans for heritage areas, supporting the value that cultural resilience lends to overall resilience (Wellington City Council, 2017).

The SFDRR links reduction of disaster risk to cultural heritage preservation (United Nations, 2015). The framework calls for investment in cultural resilience by, among others, individuals, communities, and nations to protect both cultural heritage and assets; this includes protection of institutions themselves charged with protecting cultural heritage in communities. The framework encourages cultural perspectives to be integrated into all policies and practices.

Community Resilience

Community resilience is a well-documented topic in the literature. The concept includes preventing damage and harm where possible, recovering to the same or better level, and learning from the past to improve future outcomes for the community (Chandra et al., 2011). Lerch (2015) defines community resilience as "the ability of a community to maintain and evolve its identity in the face of both short-term and long-term changes while cultivating environmental, social, and economic sustainability" (p. 10). Resilient communities have robust social networks that aid them in not only surviving in disaster but thriving (WREMO, 2014). The complex nature of disaster management activities requires relationship-building and network development before a disaster (Doyle, Becker, Neely, Johnston, & Pepperell, 2015). Core features of community resilience include "local knowledge, community networks and relationships, communication, health, governance and leadership, resources, economic investment, preparedness, and mental outlook" (Patel, Rogers, Amiot, & Rubin, 2017, p. 1). The Patel et al. (2017) definition highlights an overlap of culture and community resilience.

The Wellington Resilience Strategy looks at building community resilience through enhancing well-being, empowering communities and innovation, and adding focus on sustainable activities (Wellington City Council, 2017). Leveraging community strengths to enhance resilience, the plan includes ideas for building neighbourhood networks and relationships through activities and space development. Co-benefits of the strategy include building capacities of vulnerable populations which will help to reduce inequality and build social cohesion (Wellington City Council, 2017). Also important is building economic redundancy and improving planning in the private sector, which also contributes to minimising impacts in disruptive events.

The above definitions are provided for general guidance regarding how these terms are viewed. Exercises and activities at the workshop were undertaken to refine views of cultural and community resilience held by relevant stakeholders. Furthermore, through collaborative exercises attendees were able to share personal meanings of resilience which added to the conversations around developing a shared understanding of the concept.

Method

As an objective of the QuakeCoRE Flagship 5 research programme, the development of Wellington case study projects aims to create innovative recommendations and advice for practical implementation of resilience-building within the region. While the majority of participants were from Wellington, several attended from other parts of the country and from national stakeholders, increasing the relevance of what was learned for the entire country. The workshop was developed as an engagement platform (Frow et al., 2015) to invite collaboration and co-creation of meanings and knowledge around the topics of cultural and community resilience. Similar collaborative case study designs have been used in the development of community resilience frameworks such as emBRACE (emBRACE, 2015). One advantage to this type of co-creation engagement is that stakeholders participate in the process which allows ad hoc peer-review to take place during knowledge development (Regeer & Bunders, 2009). Co-creation of knowledge aids in creating shared visions, expectations, language, and practice (Regeer & Bunders, 2009) and allows for the translation of theoretical concepts into practical and policy applications (emBRACE, 2015).

A priority in developing the workshop was to get a variety of stakeholders to attend. The workshop was scheduled immediately following the 11th Australasian Natural Hazards Management Conference to capitalise on attendees' presence in Wellington. The conference website was used to publicise the event. Additionally, the mailing list from the conference, Flagship 5, MCH, WREMO, and researchers, networks were utilised to solicit participation from a diverse group. Participation solicitation included representatives from local government, central government, the science and research sector, the private sector, health and emergency management services, and non-governmental organizations. Workshop presenters also demonstrated a diverse range of backgrounds, showcasing members from different CDEM groups throughout the country, academia, local marae, private companies, and public institutions. This offered a plethora of knowledge that helped steer engaging conversation amongst participants.

Workshop Design

The workshop was designed to be highly participative. Presentations were kept to less than 30 minutes with activities promoting knowledge-sharing and innovation following each presenter or group of presenters. When aiming to develop new ideas, it is important to bring together those requiring information and those providing information at many different levels so that all have an opportunity to further their understanding (Regeer & Bunders, 2009). The workshop was conceived and designed by a variety of different stakeholders to produce diverse and high-quality results.

Promotion of Shared Creation of Knowledge

The workshop utilised expert presentations to set the stage for discussion, providing background information to the groups. This allowed for the development of common understanding from which to start the group discussions. Interactive workshops which present information for participants to expand on or revise are examples of knowledge co-creation (Regeer & Bunders, 2009). There were 10 round tables and the 80 attendees were asked to move around at different intervals of the workshop. Small groups worked together to create common ideas and then shared their outputs with the larger group for additional comment and discussion. Sticky notes with participants' ideas and concepts were collected for further study by the workshop hosts. Morphological analysis then categorised the outputs to create points for further development (Frow et al., 2015).

Two artists attended the workshop and used the audible conversation and participants' sticky notes to design a visual representation of the outputs of the workshop (Figure 1). The mural, as a visual reminder of the day, summarized and reinforced the knowledge created by participants. The narrative within the artistry follows a

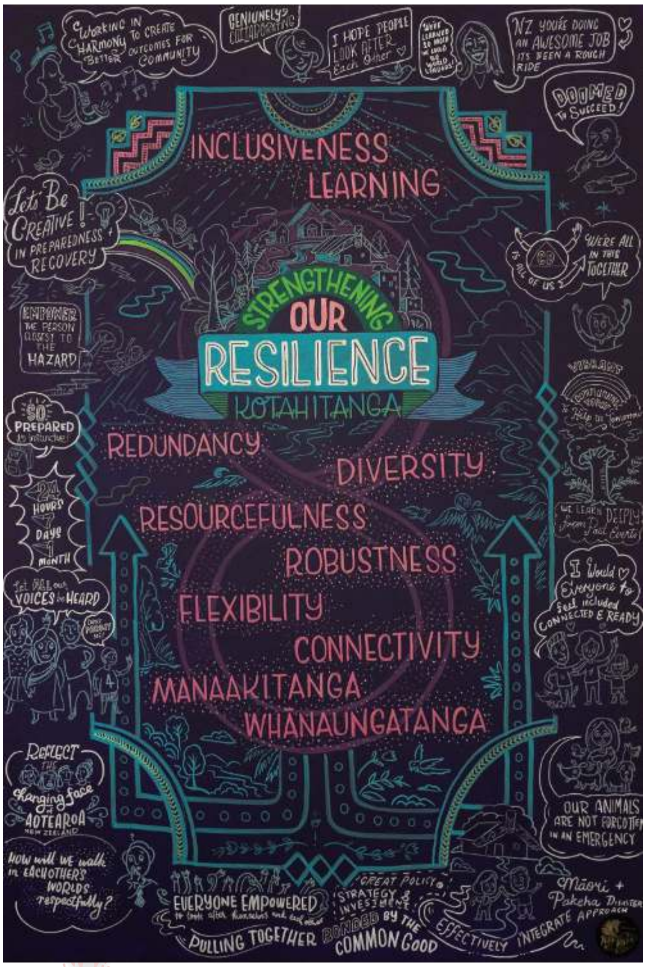

Figure 1. The mural created live during the workshop summarizing the key aspects of the discussions.

process reflective of much of Aotearoa NZ's history and culture: storytelling as a communication tool used by communities and individuals for effective information dissemination.

Understanding Cultural Resilience

The morning session of the workshop focused on cultural resilience. The intent was to explore cultural resilience in an Aotearoa NZ context and establish ideas for better integrating the concept into disaster management planning. Themes included the significance of culture to communities, the role of culture in disaster risk reduction, response, and recovery, and the value placed on heritage in recovery from a disaster. The specific topics the group grappled with included "What do we mean by cultural resilience?" and "How do we demonstrate the role of culture in building resilience?" The MCH aimed to generate knowledge during this workshop as the first step of creating an overarching policy approach to cultural resilience, including developing and defining the scope for future projects and collaborations.

Results

What Do We Mean by Cultural Resilience?

The groups developed and shared more than 50 different ideas of what resilience encompasses, including:

- bouncing forward;
- adaptability;
- community cohesion and strength;
- a new normal;
- connections;
- stability;
- redundancies;
- thriving (not just surviving);
- learning from the past;
- evolving, resourcefulness;
- a buffer against external challenges; and
- opportunity in adversity.

These ideas offered by workshop participants broadly capture the themes of resilience offered by the literature. The understanding of adaptation and change were well-documented in the discussion. Participants also discussed the idea that resilience is a process as opposed to an outcome and that bouncing back to the previous state is not the objective. Instead, participants agreed, resilience is finding the new equilibrium in the new environment by incorporating lessons from experiences.

Some participants aligned resilience with recognition of vulnerabilities in a community while others included motivation and willingness as attributes of resilience. Some participants also included drawing support from a collective group in times of stress as a characteristic of resilience. These ideas were developed in group discussions (three to eight people) and communicated with the whole group for further comment and creation of shared meanings. Many group spokespersons commented that their ideas overlapped in a number of places with other groups. From this exercise defining resilience, the whole group was then asked to consider what culture means in relation to resilience.

Groups took different paths in this exercise with some defining what culture meant to the group while others considered how cultural resilience characteristics might be defined. Aspects of culture given by participants included:

- oral histories;
- traditions;
- diversity;
- networks;
- whānau (community);
- identity;
- natural landscapes;
- built heritage;
- tūrangawaewae (places to which people feel empowered and connected);
- values;
- attachments to places; and
- the intertwining of physical, social, geological, environmental, and financial aspects of society.

The workshop participants agreed with definitions of culture from the literature discussed previously, with the exception of their inclusion of natural landscape as an important aspect. Additionally, some participants cited the loss of heritage buildings in the Canterbury earthquakes as a loss of culture to that community while others described culture as not being defined by objects but by *whanaungatanga* (sense of family connection through shared experiences). Groups commented that Aotearoa NZ has rich cultural diversity and noted that different cultures have different levels of resilience.

Ideas of how to express cultural resilience included the need to preserve and protect specific places and objects which are important to communities. Other participants suggested that cultural resilience should be activated at the community level based on that community's specific views of their culture. There was a consensus that while culture had some different emphases within the diverse group, protection of culture was essential to a community's recovery.

How Do We Demonstrate the Role of Culture in Building Resilience?

The role of culture in overall resilience was presented as the next topic: in particular, how to demonstrate the role of culture in building Aotearoa NZ's resilience to natural hazards. Groups discussed the topic of culture and resilience-building and shared a number of ideas that demonstrate culture as it intersects with resilience.

Community events such as summer concerts provide an opportunity to connect community members, building resilience through cultural activities. Community libraries and sporting events were cited as important to cultural resilience. Others suggested building connections with local iwi, hapū, and marae could link culture and resilience. The role of community leaders in fostering community engagement activities was recognised as vital for developing cultural resilience.

During recovery from a disaster, culture was cited as having key contributions to a community's resilience. Community projects in Christchurch were highlighted as recovery tools; arts and entertainment created through grassroots efforts and the *farmy army* helping to clear debris with farm equipment were two examples given. Many groups echoed the importance of starting up cultural activities following a disaster as soon as possible to relieve the stress of the event and to give people ways to come together and share positive experiences. Engagement in cultural activities was considered to be at least equally important as the restoration of the built environment. A workshop attendee commented that capturing diverse community knowledge and engaging distinct communities in emergency management activities is a core challenge for Aotearoa NZ's emergency managers. Some participants from outside Aotearoa NZ commented that the development of this workshop on cultural resilience shows how far ahead the nation is in development of emergency management compared to some countries which have just begun to consider resilience in relation to disasters.

Culture has a varied meaning for different people, but all participants placed a high value on fostering positive cultures in communities. The significance of culture was discussed as intertwined with well-being for community members and linked to community resilience. Cultural resilience was thought to encompass the protection of ideas and values as well as heritage sites. As reported by participants, in the days following a disaster, community cultural activities were vital for giving community members opportunities to come together to create meaning from previous events and to develop positive spaces for fellowship.

Community-Based Resilience

The stated aim of the second half of the day was to explore community resilience at multiple levels including national, regional, and local. In recognition of the role that community resilience plays in the ability to withstand and recover from disaster, this workshop sought to present a variety of ideas and projects to spark conversation on this important topic. The groups were asked to consider and discuss the attributes of a resilient community, existing programmes nationwide aimed at developing community resilience, and how national resilience does or should relate to community resilience. Presentations from members of different emergency management groups throughout Aotearoa NZ were designed to provide a basis for group-centred dialogues in the subsequent discussion sessions.

Results

The Attributes of a Resilient Community

The table groups built on the previous cultural resilience discussions when considering community resilience. A focus of many comments included a bottom-up approach as opposed to top-down leadership. Engagement through networking was also advanced as important in community resilience. Community resilience was communicated as needing partnerships and innovators. Groups agreed that the process of defining these terms is important and that agreed-upon definitions should be integrated throughout communities.

Discussions of Existing Programmes to Develop Community Resilience

The groups were presented with programmes aimed at building resilience from five CDEM groups representing different regions in Aotearoa NZ (Wellington, Christchurch, Auckland, Southland, and Hawke's Bay). Programmes ranged from collaborations with groups such as the Red Cross, business associations, and schools to the development of community hubs for activation during a disaster response. Each presentation discussed the need to engage community members in the development of resilience-building activities. Such input, presenters discussed, helps to create programmes which are meaningful to the community and to enhance engagement from the community in those programmes. Engagement of communities included reaching neighbourhoods, petitioning embassies and consulates for the involvement of diverse communities, and seeking input from new arrivals (e.g., refugees resettled in Aotearoa NZ).

Participants found the discussed programmes to be effective and innovative, suggesting that this platform for sharing success is valuable for positive reinforcement. Groups also commented that emergency management should consider ways to harness existing community synergies to help with developing disaster management activities to build resilience. Group discussion included social capital resource development as critical for building community resilience and that all activities should be designed to strengthen communities on multiple fronts.

How National Resilience Does/should Relate to Community Resilience

During this session, a representative from the CDEM office presented information from the national perspective regarding resilience and the (then) proposed National Disaster Resilience Strategy. The information given included the usefulness of considering national concepts, rather than plans, which could be used to align local strategies. The speaker expressed valuable contributions of resilience development including helping not only to avoid or decrease loss in disaster but also encouraging development with co-benefits of social and cultural enhancements. The national strategy was passed in April 2019.

Many in the room discussed the national strategy as one way to develop consistent vocabulary and professionalism across different regions. Ideas for collaboration aimed at the development of community resilience included national participation in developing baselines for successful engagement, networking regions for sharing ideas and successes, and fostering the inception of national resilience forums and working groups. National input regarding key language and term standardisation, developing datasets to share across regions, and establishing standards for measuring and evaluating success was also put forth by group participants. Another area of potential value from national contributions was developing platforms to work with social media for improved communication of pre-disaster activities as well as critical data during disaster response and recovery phases.

Participants in the workshop heard stories of resilience from other attendees, including discussions around the 2016 Kaikōura earthquake. One attendee related learning about the community resilience displayed by the business community; businesses assisted each other in operations where once a more competitively focused environment was the norm. Participants also commented that further understanding of the role of marae in community resilience would be mutually beneficial. One participant shared that emergency managers need to learn from Māori communities which have demonstrated resourcefulness in adversity.

Discussion

Abductive research combines data gathered with existing literature-based ideas and can be helpful when advancing current theoretical constructs (Frow et al., 2015). The following discussion will look at outputs from the workshop in relation to literature in the field as a method for validation of knowledge generated through workshop discussions. As one attendee said, having academics and practitioners in workshops together with other members of communities is extremely valuable and an experience from which everyone benefits. One participant commented that "The workshop in association with the conference helped validate the discussion, that cultural practitioners have a legitimate place in emergency management."

A shared consensus on many topics was not possible. However, for the MCH and the present CDEM groups, in collaboration with academics, the workshop gave the opportunity to widen their views of cultural and community resilience and begin a conversation of ways to continue linking groups together to create strategies that better reflect the communities they serve. The opportunity to gather perspectives and data from and by diverse stakeholders is a step forward for those communities, but also potentially increased resilience through the development of new networks. Consensus regarding the definitions and important aspects of cultural and community resilience gives participating organisations a shared point for forward momentum and sets the stage for future workshops and further development of co-creation of knowledge in resilience science.

Culture and resilience, as defined by the group, share many similarities with academic references. Resilience as movement forward, not back to a previous state, is a theme found in academic discourse (Patel et al., 2017). Resilience can also describe a group's ability to come together and work toward a shared objective (Berkes & Ross, 2013). The group's addition of motivation and willingness as factors is valuable to CDEM programme managers. The importance of understanding that underlying motivations for participation in resilience-building activities may differ between cultures is a key factor for Aotearoa NZ's diverse populations.

Culture has hundreds of different definitions within academia broadly (Spencer-Oatey, 2012). The aspects of culture given during the workshop, ranging from tangible to intangible, reflect the diversity of the participants and Aotearoa NZ generally. The NZCDEM (2019) strategy states that it aims to "…recognise the importance of culture to resilience, including to support the continuity of cultural places, institutions and activities, and to enable the participation of different cultures in resilience" (p. 28). One of the aims of the strategy is to enhance the understanding of the role culture plays in overall resilience as part of strengthening societal resilience to disasters.

Elements of culture can include norms, language, values, symbols, and tangible creations designed to communicate intangible ideas (Kulatunga, 2010). The idea of the availability of cultural activities being essential to build community resilience before an event and during recovery could be integrated into disaster management planning as a tangible way to work with communities to build their wider resilience. This concept is supported by the idea that a feature of culture is "…a way of life" (Kulatunga, 2010, p. 307). One participant commented that "When disaster brings disruption, cultural life provides an element of certainty/routine." Participants discussed that activities help to define a community's culture and give people opportunities to gather as a group for different reasons, both important to recovery. Activities could be local athletic competitions, musical presentations, or any number of locally designed events.

Attendees agreed that developing a national language for disaster management is an important objective. Definitions can change over time but are necessary to develop common understandings (Rockett, 1999).

Development of consistent terminology is just one of the ideas that participants from WREMO and other groups reported taking from the workshop. Another important outcome from the workshop reported by participants was the highlighting of the value of resilience-focused thinking for designing disaster management plans and activities. Building resilience into communities through various methods including cultural activities, networking, and social connection development (Berkes & Ross, 2013) promotes community and emergency management objectives in unison. Community development projects can empower groups through a series of small successes, building cohesion, and setting the stage for future problem-solving (Berkes & Ross, 2013).

The workshop functioned as an opportunity for many different groups to develop new relationships and some cohesive views. The workshop was a resilience-building activity; the event gathered stakeholders, pulled knowledge from a variety of sources, and facilitated the co-development of shared understanding (Berkes & Ross, 2013). The single-day format for this workshop placed certain limits on the depth of conversation possible. However, comments from participants and observations of the authors suggest that the objectives of the event were achieved: developing co-created knowledge in the areas of cultural and community resilience. The information gathered can be utilised by both WREMO and MCH to improve their policy and planning and ultimately add to Wellington's resilience.

Conclusions

Attendees from the workshop, representing people working in the field of community resilience, developed a set of priorities to advance the sector's maturity. It is hoped that this is just one of many workshops to offer a collaborative platform to multiple stakeholders in the disaster management space. Future workshops could focus on other facets of disaster resilience (e.g. economic resilience), developing actionable plans and programmes for different local populations, and establishing commonalities between stakeholder groups as well as points of diversion.

Limitations of the workshop include the development of the topics being participant-led and therefore reflecting participants' biases. Topics developed a response and recovery trajectory with limited discussion in terms of mitigation. Concepts such as community recovery activities could be translated into mitigation and planning; however, the group's focus was not disaster risk reduction oriented. Resilience is commonly conflated with preparedness, particularly from the government and policy sectors (Madrigano et al., 2017); this workshop also had a somewhat narrow view of resilience as comprising mostly one part of the process, though in this case the focus was on response and recovery rather than risk reduction. It is important to ensure that when stakeholders talk about resilience-building they are fully engaging with the breadth of the concept across all parts of the disaster cycle. Furthermore, the majority of the group were New Zealanders, making translation of these results to other regions of the world problematic.

Conversations like those by stakeholders at the workshop allow for response and planning organisations to prioritise key values and needs in their community. Addressing the community members' priorities can help engage communities in resilience-building. Clearly, resilience-building should be done with the community, not to the community. Further, the opportunity for stakeholders to share current and past successes can develop into collaborative follow-on innovations and programmes.

The importance of community activities as a priority for community resilience, before and immediately following a disaster, was endorsed across the range of stakeholders. The need to develop a uniform language at the national level while still involving local stakeholders in plan and policy development was also clearly voiced. Participants had an opportunity to view concepts from multiple perspectives allowing for new shared ideas. The reported value of the workshop is a credit to the participants who gave their time and fully engaged in conversation and debate to improve their personal and organisational understanding of cultural and community resilience.

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Operationalising theory-informed practice: Developing resilience indicators for Wellington, Aotearoa New Zealand

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URL: http://trauma.massey.ac.nz/issues/2019-2/AJDTS_23_2_Kay.pdf

Abstract

Moving resilience thinking from theory to practice has been a national and international strategic imperative over the last decade. An ongoing collaboration between the Wellington Region Emergency Management Office (WREMO) and researchers associated with the International Research on Disaster Risk's International Centre of Excellence in Community Resilience (ICoE: CR) and Resilience to Nature's Challenges (RNC) Kia manawaroa – Ngā Ākina o Te Ao Tūroa National Science Challenge made progress towards operationalising theory-informed practice for disaster resilience measurement in the Wellington Region of Aotearoa New Zealand. Between 2014 and 2018, researchers, WREMO, and other key stakeholders engaged in a multi-stage co-learning process, including defining resilience, determining the measurement focus, and identifying measurable indicators. The process merged bottom-up and top-down resilience indicator identification and selection methods. This resulted in 10 resilience indicators that both link to national and international policy and meet the strategic, regional needs of WREMO.

Keywords: *Resilience measurement, operationalisation, knowledge co-production, top-down and bottom-up assessment*

Theory-informed practice is a model where gaps between research-based evidence and practice are identified. Community needs, values, and preferences, practitioner experience, and the best available research and theory are integrated to aid decision-making and intervention planning (French, Green, O'Connor, McKenzie, & Francis, 2012). Research should help inform practice and support practitioners' critical thinking, while integrating their experiences and judgements. This method allows for the development and implementation of successful community interventions in an environment that may have changeable goals, conditions, and experiences (Nevo & Slonim-Nevo, 2011). Although this may sound intuitive, negotiating this in real world situations is not always straightforward. In practice, researchers are seen as seldom producing information on Disaster Risk Reduction (DRR) that is directly usable by practitioners and decision-makers often face barriers to integrating scientific information when developing community interventions (Doyle, Becker, Neely, Johnston, & Pepperell, 2015; Weichselgartner & Kasperson, 2010; Weichselgartner & Pigeon, 2015). There needs to be continued efforts to shift the research and practice agenda towards increasing cross-sectoral relationships.

There are limited examples of how theory has been operationalised to improve resilience measurement in a way that helps communities understand and build their resilience (e.g., Paton, Kelly, Burgelt, & Doherty, 2006). This paper details a co-creation exercise involving researchers and practitioners to develop indicators of disaster resilience, referred to simply as resilience hereafter, for the Wellington Regional Emergency Management Office's (WREMO) Group Plan. An indicator is defined as an observable factor that influences the level of resilience in a community (e.g., social connections within a community) and is typically quantified by a metric (e.g., % of people who feel they belong to their community).

WREMO plays an important role, not only as an oversight and implementation body, but as a boundary organisation that can translate best-practice research into meaningful action. Their capacity as a boundary organisation is enacted through their coordinating role for councils in the region and through their networks in the research community, where they have long-term ongoing engagement through joint platforms such as the International Research on Disaster Risk's International Centre of Excellence in Community Resilience (ICoE: CR). WREMO also has a substantial presence in communities through programmes implemented as emergency management and community resilience practitioners such as the tsunami blue lines project (Leonard et al., 2008), establishing a network of community emergency hubs, and distributing water storage tanks to private citizens (WREMO, 2018a).

The exercise described here was an attempt to operationalise resilience measurement for the Wellington Region of Aotearoa New Zealand (NZ). In this paper, we begin with a brief background of resilience theory, the challenges of operationalising resilience measurement, and the goals of the researchers and needs of the practitioners involved with the current study. We then outline the co-creation process undertaken to develop resilience indicators for the WREMO Group Plan and detail the results of this process. Finally, we consider future steps and provide insight into the key learnings of this multi-stage process.

Resilience Theory and Considerations for Operationalising Resilience Measurement

Over the years, theories of resilience have developed across many fields, and the way community resilience is defined often changes to fit the context in which the concept is being applied and interpreted (Kwok, Paton, Becker, Hudson-Doyle, & Johnson, 2018). Resilience relates to the capacity to persist and the ability to adapt or transform in the face of changes in the environment, whether these are gradual or abrupt (Folke, 2006; Paton et al., 2006). Resilience can be measured at many levels; the current study focuses on community resilience, taking a holistic, multi-capital approach to consider all aspects of society. Adaptation in this context is reliant on a variety of aspects including ensuring that the built environment is resistant to the effects of hazards, planning and resourcing to facilitate successful response and recovery, and the beliefs, capabilities, and capacities of society to undertake effective action in the face of adversity (Paton & Johnston, 2017). As a result of its multidimensional nature, there is significant variation in how resilience is operationalised through measurement (Kwok, Doyle, Becker, Johnston, & Paton, 2016).

Operationalisation is the process of strictly defining a concept into measurable factors. Until an abstract concept is operationalised, it is not possible to tell whether the "thing" is absent or present, in what circumstances it occurs, or the importance it has (Payne & Payne, 2004). Although the theory of community resilience continues to evolve, there is growing consensus among hazard scholars that the first step towards developing community resilience is understanding how it can be operationalised and measured (Aldunce, Beilin, Howden, & Handmer, 2015; Asadzadeh, Kötter, Salehi, & Birkmann, 2017; Cutter, 2016; Parsons & Thoms, 2018; Peterson, Salmon, Goode, & Gallina, 2014). Therefore, measuring resilience can be considered an essential translational step from theory to action, as it can guide decision-makers and other end-users towards holistic actions that cultivate and maintain resilience (Asadzadeh et al., 2017; Keck & Sakdapolrak, 2013).

Operationalising resilience through clear definition of its characteristics in order to produce a standardised output (e.g., a quantitative "resilience score") allows observers to establish a common baseline and language to facilitate mutual learning and exchange across places, institutions, and people (Stevenson, Kay, Bowie, Ivory, & Vargo, 2018). Both qualitative and quantitative measures can be used to operationalise resilience, and there have been several comprehensive reviews of different approaches to measuring resilience (e.g., Becarri, 2016; Ostadtaghizadeh, Ardalan, Paton, Javvari, & Khankeh, 2015; Sharifi, 2016; Winderl, 2014). These reviews note that composite indicators have often been employed to operationalise the concept of resilience across a number of contexts (e.g., Cutter, Burton, & Emrich, 2010; Hughes & Bushell, 2013; Peterson et al., 2014). Indicators are valued for their relative simplicity and ability to facilitate communication and engagement across various stakeholder groups (Booysen, 2002; Saltelli, 2007). To allow for non-experts to engage with resilience measurement, and to allow for such facilitation of communication and engagement, a quantitative approach to the current study was used and composite indicator building is part of the approach to resilience operationalisation pursued in this study.

Operationalising Resilience Measurement: Joining "Top-down" and "Bottom-up" Models

Operationalising resilience measurement through composite indicator building requires a series of steps starting with defining the term resilience for the context and system of interest, determining the measurement focus, and selecting measurable indicators (Asadzadeh et al., 2017). Appropriate data must then be accessed and assessed and the index calculated (e.g., data transformed, standardised, normalised, weighted, and aggregated; Asadzadeh et al., 2017).

There are two general techniques for deriving indicators: top-down (also referred to as non-participatory and nomothetic) and bottom-up (also referred to as participatory and idiographic; Asadzadeh et al., 2017; Cutter, 2016). Nomothetic refers to the more generalised nature of top-down comparisons, which tend to be designed for comparing across places or varying units of analysis. Idiographic, or bottom-up measures, are so called as they tend to be locally generated and customised to a place (Cutter, 2016; Pfefferbaum, Pffeferbaum, Nitiéma, Houston, & Van Horn, 2015).

Top-down models tend to be based on an overarching theory or set of government-level priorities. Items selected for assessment and intervention are derived from deductive reasoning as elements that will shift a system towards or away from the overarching resilience construct (Butler et al., 2015). These models usually rely on quantitative, secondary data that has been collected at the regional, national, or international level for another purpose (such as the national census). They are useful in their ability to standardise measurement across time and place and to track trends. However, the selection of indicators to include in top-down measurement is often influenced by data availability, particularly as primary data collection is frequently cost-prohibitive. As a result, it can be difficult to ensure that included data is representative of the community being measured and this may create a disconnect between the outputs and interpretations of the measure and the values of the people living in the community (Gaillard & Mercer, 2013; Sharifi, 2016).

Bottom-up models solicit stakeholder input through participatory approaches to generate measures of resilience and indicators are linked to the needs and goals of the community (Kwok et al., 2018; Sharifi, 2016). Bottom-up approaches relying on community participation, however, are time and resource intensive and it can be difficult to achieve representation of all relevant groups (Kwok et al., 2018). Additionally, the variability of the community generated indicators means that scaling measures and facilitating comparisons and co-learning between different places is not often possible (Cutter, 2016).

Top-down and bottom-up approaches can be integrated to generate insights that are scalable, generalisable, relevant, and applicable by the communities applying the measures to guide actions (Sharifi, 2016). The purpose of the study described in the remainder of this paper is to capture the process of an integration between top-down and bottom-up methods, to ensure that the specific and relevant needs of the community are considered alongside top-down measurement. Although there is a multitude of literature on the development of indicators of resilience (e.g., Burton, 2014; Cutter et al., 2010), few studies have focused on indicators of resilience relevant to a NZ context (e.g., Huggins, Peace, Hill, Johnston, & Muñiz, 2015; Kwok et al., 2018). The following co-creative approach to resilience indicator selection through enduring engagement of practitioners, researchers, and community stakeholders aimed to achieve a more holistic operationalisation of resilience measurement in NZ, allowing better understanding and monitoring of resilience to support the country's national and international policy commitments.

Project Context

The following sections describe the initial stages of a process to integrate two resilience assessment approaches. The paper focuses on a co-creative collaboration process occurring between May and October 2018. This process, however, built on existing programmes of work, which we briefly review as part of the project context.

Co-creation Partners

Four primary co-creation partner groups were involved in this project. These partners included researchers associated with the Resilience to Nature's Challenges (RNC) National Science Challenge (Trajectories Toolbox and Cultural and Economic Resilience Toolboxes) and the Joint Centre for Disaster Research (JCDR), practitioners from WREMO, and community stakeholder groups engaged by WREMO[1]. This collaboration was facilitated through the ICoE:CR networks.

Top-down Context: International and National Priority Setting

Top-down indicator selection was informed by NZ's national and international resilience strategies, the National Disaster Resilience Strategy (NDRS) and the Sendai Framework, as well as international peer-reviewed literature exploring resilience theory and practice across numerous contexts (e.g., Burton, 2014; Cutter et al., 2010; Folke, 2006).

The NDRS is built around six community capitals of resilience (see Figure 1). These are: social resilience, cultural resilience, economic resilience, resilience of the built environment, resilience of the natural environment, and governance of risk and resilience. Underpinning these capitals are five environments through which resilience is enacted: homes, families and whānau; businesses and organisations; communities and hapū; cities, districts, and regions; and government institutions.

The Sendai Framework articulates measurable DRR targets against which all participating countries are expected to report annually. The NDRS refers to a formal reporting process that will accompany the forthcoming strategy reported biennially by the Ministry of Civil Defence and Emergency Management (MCDEM), which will include "progress on goals and objectives, progress on resilience, and progress on [reducing] impacts," (MCDEM, 2019, p. 32). The NDRS also notes that "Progress towards the desired outcomes and interim outcomes will be measured against a series of indicators, including a resilience index developed as part of the National Science Challenge: Resilience to Nature's Challenges" (MCDEM, 2019, p. 36).

The RNC is a national research programme funded by NZ's central government to conduct research that will contribute to the country's resilience to natural hazards. Researchers contributing to the RNC are developing tools to help measure resilience, including the New Zealand Resilience Index (NZRI), a composite indicator developed to provide a simple, high-level baseline measurement of community disaster resilience across the country. The NZRI is designed to facilitate consistent comparisons between place-based communities in NZ, assessed through the lens of six community capitals. These capitals are drawn from international research (Stevenson et al., 2018). For more on the NZRI's conceptual development and indicator selection see Stevenson et al. (2018), Stevenson, Kay, Bowie, and Ivory (2019), and Kay, Stevenson, Bowie, Ivory, and Vargo (2019).

Figure 1. The six capitals and five environments of the National Disaster Resilience Strategy (NDRS; Ministry of Civil Defence and Emergency Management, 2019).

1 WREMO conducted all direct stakeholder engagement as part of their Group Plan development and as part of the development and implementation of their community-based initiatives. The researchers referred to in this paper did not directly engage with community stakeholders as part of the indicator selection process described in this paper.

Bottom-up Context

The bottom-up community participatory processes referred to here have been led by WREMO or result from collaborative projects with researchers engaging community stakeholders, rather than emerging at a grass-roots level from the communities themselves. Through the networks facilitated by the ICoE:CR, researchers and practitioners conducted several projects to enhance knowledge transfer among citizens, researchers, and practitioners (e.g., Doyle et al., 2015; Orchiston et al., 2016), including working with community stakeholder groups to generate potential social resilience indicators for the Wellington region (Kwok et al., 2016). WREMO works closely with researchers and communities on joint projects, many of which have been facilitated by the ICoE:CR (ICoE:CR, 2014; WREMO, 2018b). They also engage community-based stakeholders more formally as part of strategy and planning protocols.

WREMO is required to provide a Civil Defence Emergency Management (CDEM) Group Plan as mandated by the Civil Defence and Emergency Management Act 2002. This plan is a strategic document that guides the group for five years following implementation. Its purpose is to "enable the effective and efficient management of significant hazards and risks for which a coordinated approach will be required" (Wellington Region CDEM Group, 2013, p. 2).

During the development of the Group Plan for 2019-2024, WREMO conducted extensive engagement with stakeholders in the Wellington Region CDEM Group, which comprises the nine councils as well as emergency response agencies and lifelines utilities. Initial engagement and scoping for the Group Plan was accomplished by a review of plans and capabilities in reduction, readiness, response, and recovery. The work was reviewed by the Coordinating Executives Group (CEG) and their sub-committee (SubCEG) and expanded via 14 individual stakeholder workshops, with separate workshop sessions for each of the nine Territorial Authorities, lifeline utilities, planners and hazard analysts, welfare agencies, emergency response agencies, and WREMO staff. The final outputs of these workshops were then collated and organised by WREMO and vetted through a Joint Committee.

Drawing on input from stakeholder consultation, WREMO developed a draft vision statement and a series of outcomes and related outputs that could be achieved through the implementation of the plan. The vision statement as of June 2018 was to build "A Resilient Community: Ready, Connected, Capable". These attributes are further defined as follows:

Ready: All stakeholders are able to respond quickly and effectively to change and adversity by being well-informed and able to make good decisions.

Connected: All stakeholders are in touch with (relevant) others and able to support each other in times of need.

Capable: All stakeholders take practical steps to reduce their level of risk, are ready for change and adversity, can respond effectively to change and adversity, and recover quickly after a disruptive event.

The outcomes and outputs of the draft Group Plan map onto the four phases of emergency management (Reduction, Readiness, Response, and Recovery) and are aligned to one of five "environments" identified in the NDRS (Figure 1). As of June 2018, WREMO had drafted 61 outcomes and 127 outputs against which they could assess the implementation of their Group Plan.

Initiating Indicator Co-creation

With the establishment of the draft vision, outcomes, and outputs, WREMO staff identified a need to develop a comprehensive yet manageable framework of indicators for tracking their progress. The indicators should not only measure the quality and completion of Group Plan outputs and outcomes, but should also reflect progress towards WREMO's vision of building a more resilient region. To advance the development of these indicators, WREMO initiated a collaborative work programme with researchers associated with the ICoE:CR and RNC. The programme is referred to here as the WREMO Resilience Indicators Programme (WRIP). The ultimate goal of WRIP is to effectively merge practice-derived indicators with research and theory-derived indicators in a way that is applicable to WREMO's Group Plan 2019 – 2024.

Methods

This section outlines the process taken to operationalise resilience measurement for WREMO's Group Plan. The co-creative process, summarised in Figure 2, began with a review of the relevant bottom-up and top-down approaches to resilience that would likely inform the development of indicators for WREMO.

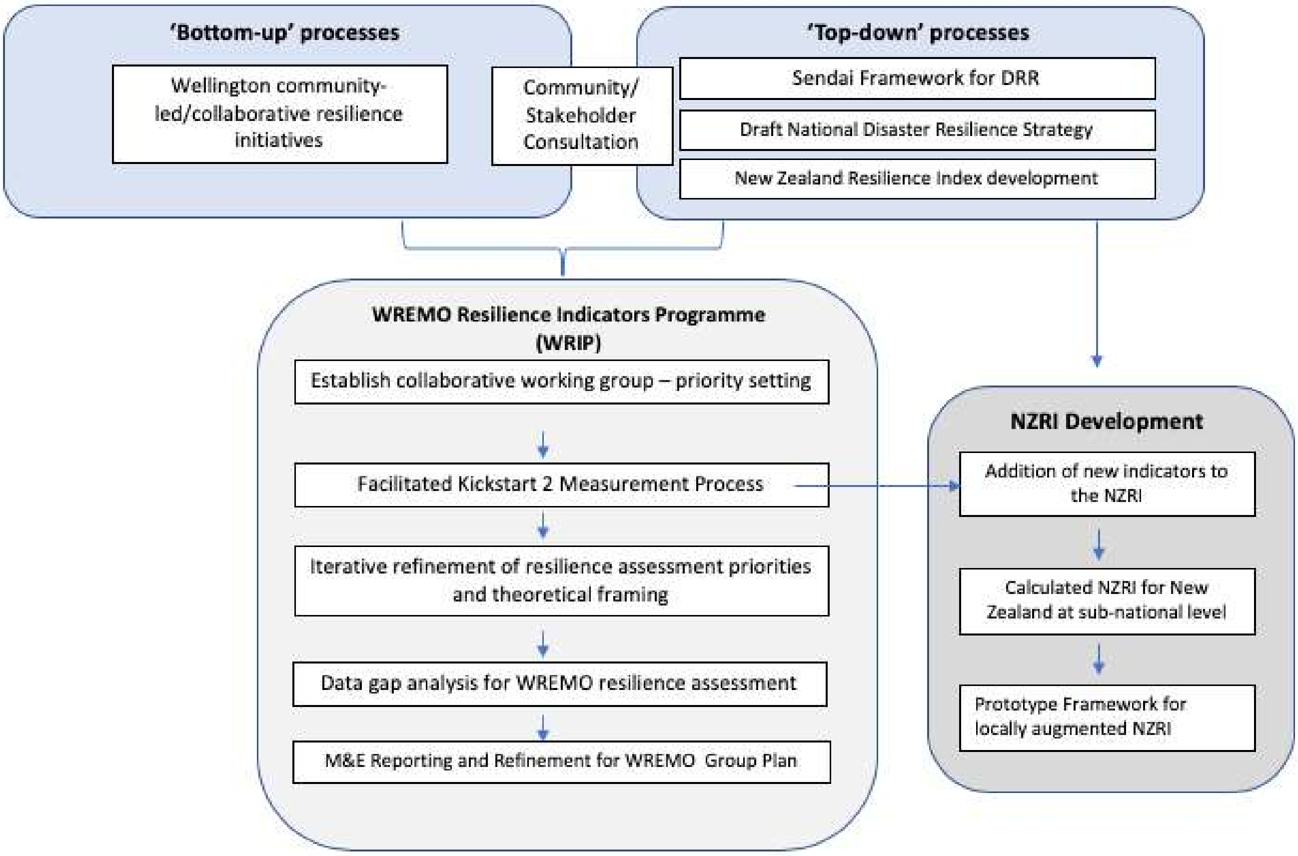

Figure 2. Resilience indicator framework for assessing resilience in Wellington, Aotearoa New Zealand.

Establishment of Working Group and Priority Setting

In April 2018, WREMO staff reached out to researchers through the ICoE:CR network to gain insights into the process of indicator selection that would meet the needs they saw emerging from the WREMO Group Plan development. Overall, there were 13 people directly involved in the WRIP working group; nine researchers and four WREMO staff members.

A series of brief scoping meetings were held in May 2018 to determine the nature of WREMO's needs and the kinds of input the researchers should provide. An initial action of the working group researchers was to conduct a review of possible indicators of DRR and resilience to act as a reference point for further conversation. The review incorporated bottom-up and top-down resilience assessment initiatives in Wellington (e.g., Kwok et al., 2018, and the Wellington Resilience Strategy; Wellington City Council, 2017) and indicators drawn from international literature (e.g., Burton, 2014; Orencio & Fuji, 2013; Pearson, Pearce, & Kingham, 2013; Pfefferbaum, Pfefferbaum, & Van Horn, 2011). A sub-working group of researchers compiled indicators drawn from the review into short reports.

In June 2018, all members of the working group met at the WREMO offices in Wellington for a collaborative workshop. The workshop had two key objectives. The first was to present an overview of the reviews conducted to date. Working group members presented the indicator summary reports and additional summaries of relevant portions of the Sendai Framework, NDRS, and NZRI. The second objective was to further refine the measurement priorities and approach that WREMO would pursue, drawing on the indicator summaries and assessing WREMO priorities against the objectives and targets identified in the Sendai Framework and the NDRS.

Kickstart 2 Measurement Workshop

The process of refining WREMO's assessment priorities was guided by the Kickstart 2 Measurement (K2M) tool, a heuristic process developed to guide people through complex conversations about resilience measurement (Stevenson et al., 2018). Two members of the working group conducted this portion of the workshop with WREMO and the rest of the working group as participants. The K2M tool progresses users through several steps to refine an approach to resilience assessment and monitoring. This includes defining a purpose, determining focus areas, specifying desired outcomes, selecting and prioritising indicators, and linking to data.

Each member of the working group was provided with a list containing the resilience concepts and indicators identified in the above DRR indicator review, comprising both bottom-up and top-down derived indicators. The indicators were categorised into the six community capitals of resilience underpinning the NDRS (Figure 1). The group considered one capital at a time and, working alone, were asked to select three indicators that they believed were likely to have the greatest impact on resilience outcomes in the region. Members of the group were encouraged to consider any indicators that may be missing from the list, and to include these in their selections. Once all members had picked their indicators, the group reconvened to discuss the selections. All members were asked to identify to the group which indicators tthey had selected and their reasons for their selections. Each response was tallied to determine the indicators that received the most votes. No ties occurred in the number of votes, eliminating the need for a tie-breaker. This process was repeated for all six of the resilience capitals.

Iterative Refinement

Following the workshop, participants' votes and comments were aggregated. Thematic content analysis was used to derive 10 indicator categories out of the highest rated indicators by grouping similar concepts. This was refined through a series of discussions with the working group to examine how the indicators fit within the existing framework of the WREMO Group Plan.

Several additional meetings between the researchers who conducted the workshop and WREMO ensured that the indicator categories met the needs of the Group Plan. The results of this workshop, data gap analysis, monitoring and evaluation, and development of the NZRI are presented in the following sections.

Results

A total of 10 resilience indicator categories were developed from the indicator selections made by the working group. These categories are outlined in Table 1. Each category was linked to one or more of the five environments outlined in the forthcoming NDRS, the six capitals of resilience, and the WREMO vision statements of ready, connected, and capable. This demonstrated clear links from each of the categories to community stakeholder needs outlined by WREMO for the Group Plan[2].

Data Gap Analysis for Wellington

Suitable metrics (i.e., ways to measure each indicator within the indicator categories) and data that correspond with the 10 indicator categories will be identified and refined in future work. For each category, researchers have identified several measurable indicators that will capture dimensions of resilience across the capitals and environments. A further gap analysis of the categories showed additional resilience concepts that were not captured adequately within these 10 concepts. Examples include: household economic health; hazard exposure of people, property, and livelihoods; and human capital components such as levels of education. However, these concepts are already captured in the NZRI, which will soon be calculated for the Wellington region.

There are many other concepts in the Group Plan that WREMO would like to measure but for which they currently do not have data (e.g., safety and robustness of residential and commercial buildings and facilitation of cross-community networking). To gain a better understanding of local nuances of the Wellington region, future work should explore existing publicly and privately-held datasets and the possibility of primary data collection that could be used to measure such additional concepts.

Monitoring and Evaluation Reporting and Refinement

Part of the purpose for pursuing the WRIP was to allow WREMO to assess whether the programmes and interventions initiated by them and their counterparts at local CDEM Groups influence resilience over time. Repeated measurement of indicators within each of the concepts derived from the current study will allow for tracking of resilience improvements. These efforts will need to be reviewed and refined as issues become apparent and better data become available.

Addition of New Indicators to the NZRI

The consultation with WREMO caused the working group members involved in the development of the NZRI to consider additional indicators that might be available

2 WREMO conducted all direct stakeholder engagement as part of their Group Plan development via workshops within their communities. Indicators needed to link to Group Plan concepts as a result.

Table 1
Definitions of WREMO Group Plan resilience indicator categories.

		Social	Economic	Infrastructure	Environmental	Cultural	Governance/ Institutional	Individ/Household	Businesses/Orgs	Communities	Cities, Districts, & the Region	Critical Infrastruc.	Ready	Connected	Capable
Category Name	**Definition**	**Resilience capital**						**Environment/s**					**Vision**		
DRR Engagement (Awareness and Information)	Encompasses awareness of hazard risk and access to information about hazards, DRR, and post-disaster recovery information. It also includes agency engagement with diverse communities, both across multiple communication platforms and in relevant different languages.														
DRR Action and Capacity	Assesses the degree to which all environments have reduced risks in their respective areas. This includes pre and post-disaster measures such as sheltering capacity.														
Adequacy of Planning and Land Management/ Hazard Exposure Reduction	Includes planning, zoning, and environmental management of the environment. It also includes reduction of hazard exposure, best practice planning, and efficacy measurement to avoid the creation of new hazards.														
Buildings are Built or Retrofitted to a High Standard	Measures the extent to which buildings are built or retrofitted to a high standard. This includes residential and commercial buildings, as well as public building resilience (e.g., schools and hospitals).														
Leadership Quality and Capacity	Encompasses the adequacy (e.g., diversity, accountability, and transparency) of leadership and representation, the degree of trust in governance, and council effectiveness. This also includes local NGOs, Community Based Organisations, and communities of interest's level of engagements with issues capable of supporting DRR and response, and the quality of agency-agency networks.														
Business and Organisational Resilience and Redundancy	Assesses business and organisational resilience and redundancy through effective business continuity planning. This component may include special indicators for rural or primary sector businesses and planning and resilience for infrastructure providers, hospitals, and education organisations. This additionally includes facility redundancy across the respective environments.														
Access to and Quality of Critical Services	Assesses access to and quality of critical services, including communications, electricity, water, and sewerage/sanitation.														
Social Capital	Includes bridging and linking capital, community connectiveness, and community and civic engagement.														
Human Health and Wellbeing	Assesses the health and wellbeing of the region across all environments. This component may include health capacity metrics as well as quality of life metrics.														
Cultural and Heritage Health	Encompasses access to and engagement in cultural activities. It also captures the value of the heritage in the region through the protection and perceived value of cultural and heritage assets.														

to capture CDEM efforts and capacity. It became clear through the engagement with the working group that DRR capacity and engagement should be included in our calculations of resilience. Indicators assessing these categories have subsequently been included in the draft index (indicated in Figure 2).

Discussion

Reflections from Blending Research and Practice

Practitioners charged with integrating scientific findings into community interventions and improvements while juggling various policy requirements and operational goals may neglect to include appropriate scientific information (Weichselgartner & Kasperson, 2010). Likewise, researchers may struggle to comprehend the views of the user when they are not involved in the operationalisation of their theory-driven concepts and neglect to include end user needs when conducting research (Weichselgartner & Kasperson, 2010). If researchers are not involved in the application of their findings, they may unintentionally disregard important practitioner experiences (Nevo & Slonim-Nevo, 2011). Therefore, it is important to recognise that as science informs practice, practice can equally inform science. This study is an example of scientific co-production of knowledge, a collaborative process between multiple stakeholders, to ensure knowledge is useful, useable, and used.

Limitations and Future Research

This study is a practical example of how science and practice can be combined to operationalise resilience measurement. The process of the current study evolved through a series of engagements initiated by WREMO and, as such, it could not be designed as an end-to-end process managed by the researchers. The project experienced significant time constraints, due both to the competing priorities of researchers who were volunteering their time and the time pressure of the WREMO Group Planning process. However, achieving rigour from a controlled environment in the real world is often unrealistic (Guba & Lincoln, 1981; Hood, Hopson, & Kirkhart, 2015) and the process undertaken reflected and adapted to the reality of the practice-theory interface.

Integrating research and practice will often be unlikely to follow an exact scientific process, meaning that researchers and practitioners need to navigate together under the constraints and parameters of a project. The process that was used in this study, and the indicators and framework that were developed, will need to be reviewed, refined, and validated over time. Going forward, the developers of the NZRI are continuing to explore options for including more local nuance. Building on the WRIP, they will assess locally available datasets and develop a process for these to be integrated into a regional version of the NZRI.

Concluding Thoughts and Lessons for Future Practitioner-Researcher Collaborations

As a boundary organisation, WREMO plays an important role not only as an oversight and implementation body, but in creating opportunities and incentives for engagement across scientific and policy domains and, in a practical sense, translating best-practice research into meaningful action on the ground (Beavan, 2015). The current study has benefited both researchers and practitioners in the operationalisation of resilience assessment in the Wellington Region. The development of the resilience indicators and metrics for the region through this co-creation exercise has provided WREMO with guidance on how to measure changes in resilience within place-based communities.

The combination of top-down and bottom-up derived approaches in this case study has shown the critical importance of a collaborative process for theory-informed practice and practice-informed theory for evaluating and monitoring community resilience. Moving forward, WREMO is in a position to further operationalise their vision of resilience and drive change to ensure that the region's citizens are capable of flexibility and change; or are, in other words, "ready, connected, and capable" of preparing for, responding to, and recovering from an emergency.

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