

# Earthquake perceptions, beliefs, and preparedness in the Canterbury Region: A comparison before, during and after the Canterbury Earthquake Sequence in Aotearoa New Zealand

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## Abstract

In Canterbury, New Zealand, earthquake risk and preparedness information has been provided for many years, including before, during and after the 2010-11 Canterbury Earthquake Sequence. Information has been modified over time, depending on the earthquake context, and public appetite for information given ongoing aftershocks. To inform future information provision, we investigated earthquake perceptions, beliefs and preparedness from 2009-2021, drawing from previous questionnaire surveys of Canterbury residents in 2009 and 2013, and a new survey conducted in 2021. A comparison of these surveys suggests that earthquake experience has influenced a long-term, persistent, impact on perceptions and beliefs in ways that likely encourage more preparedness, except where damage was severe, and the benefit of preparedness was not obvious (e.g. property damage). In terms of future information, more focus might now need to be given in Canterbury to promote the benefits of property preparedness, to ensure people undertake structural and non-structural preparedness actions.

**Keywords:** Earthquakes, Canterbury, Christchurch, perceptions, beliefs, preparedness.

# 1 Introduction

Aotearoa New Zealand (NZ) is subject to regular earthquake activity. In the past thirteen years, several large earthquakes have impacted urban and provincial areas, including the 4 September 2010 Mw 7.1 Darfield earthquake in Canterbury Region, followed by the 22 February 2011 Mw 6.2 earthquake (comprising the 2010-11 Canterbury Earthquake Sequence, CES; Quigley et al., 2016). Both earthquakes caused damage to Christchurch city and nearby towns, with the 22 February earthquake causing severe liquefaction, building collapse and 185 deaths (Kaiser et al., 2012; Potter et al., 2015). In 2016, the Mw 7.8 Kaikōura earthquake also impacted the Canterbury Region (Kaiser et al., 2017). While the Kaikōura earthquake was felt by Christchurch residents, damage and disruption was predominantly focussed in northern Canterbury and the Upper South Island (e.g. Kaikōura) and Lower North Island (e.g. Wellington) (Stevenson et al., 2017). Consequently, earthquake impacts experienced in New Zealand in the last thirteen years have been substantial, particularly for those located in the Canterbury Region.

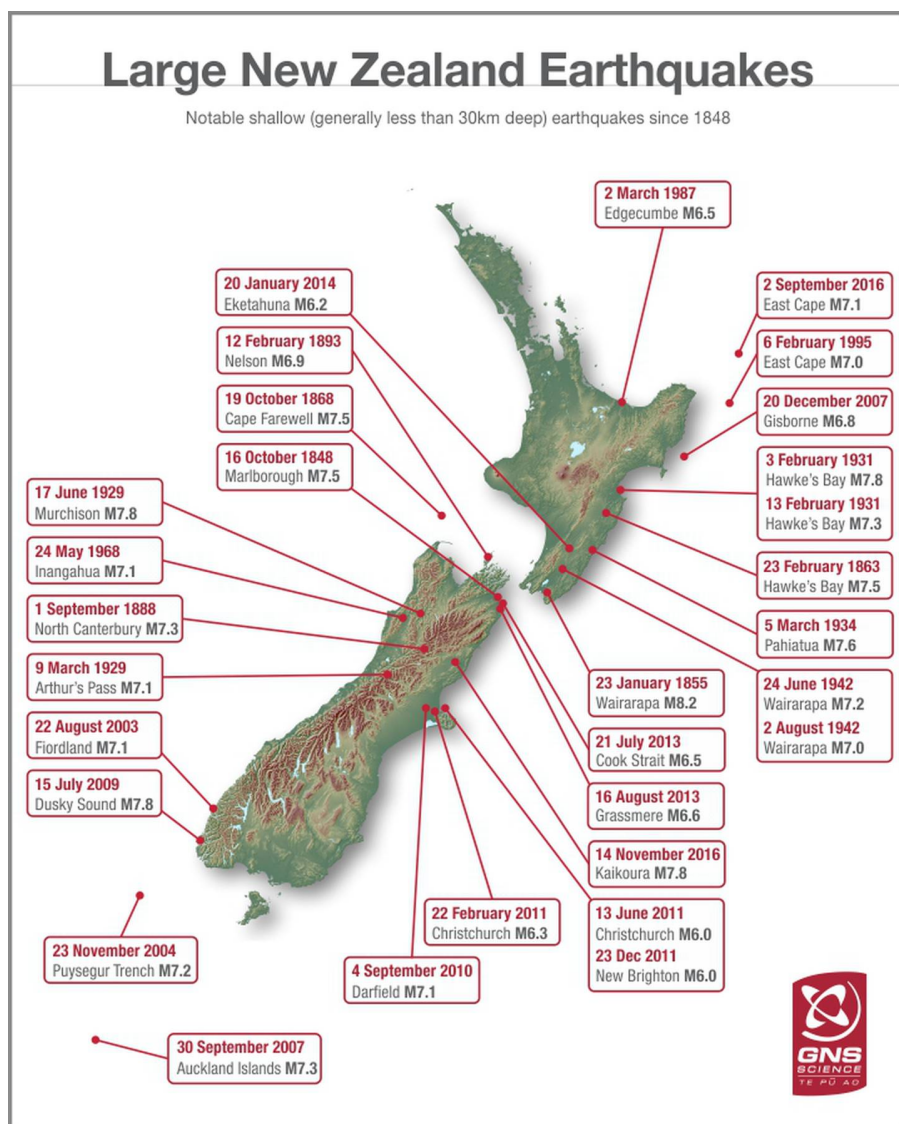


Figure 1. Large New Zealand earthquakes, showing the location of the Darfield, Christchurch and Kaikōura earthquakes (GNS Science, nd).

## *1.2 Reducing earthquake impacts: preparedness*

Earthquake impacts can be reduced by employing appropriate land-use planning techniques, earthquake engineering, and preparedness measures (also known as 'readiness' in the New Zealand context) (Becker et al., 2022). Preparedness is often a key method of reducing risk, especially where there is existing built environment. Earthquake preparedness constitutes a range of activities, including survival, structural, and community preparedness (Becker et al., 2022), and is often focussed on the residential household context. Survival preparedness typically includes actions such as collecting items required for survival such as food, water, medication and essential equipment. Structural preparedness involves undertaking mitigation actions such as securing the foundations to a house, securing chimneys, or securing loose items so they do not move in an earthquake. Community preparedness can vary – it might include planning for an emergency, gathering together community-based preparedness items or developing the relationships necessary for an effective response in an earthquake. Another type of emerging preparedness is psychological preparedness (Paton, 2019).

Given the existing built environment in Canterbury, survival, structural, and community preparedness was actively promoted in the Canterbury Region before the 2010-11 Canterbury Earthquake Sequence via an array of local and national informational resources (McBride, 2017). Over time, preparedness continued to be promoted - throughout the CES and in the years following - but with information modified as necessary depending on the public's appetite, given experiences of ongoing aftershocks. Active preparedness programmes continue to this day, but these are largely generic, and the question remains as to whether adjustment of these programmes is required given Canterbury's experience of large earthquakes over the last decade or so.

## *1.3 Factors influencing preparedness*

A number of factors influence preparedness, some directly, and others indirectly within the overall preparedness process. Additionally depending on the type of preparedness (e.g. survival versus structural preparedness), influencing factors might vary. For example, it is considered much easier and cheaper to store a bottle of water which might be perceived to have multi-hazard benefits (e.g. can be used for flooding or a water outage), whereas retrofitting a house is costlier, more complicated and might be seen as earthquake-specific rather than having multiple benefits. Community Engagement Theory (Paton, 2019) seeks to identify and explain the direct and indirect influences on household preparedness from individual through to societal influences (Figure 2). For this paper we focus on individual level perceptions and beliefs related to earthquakes known to influence preparedness, including general earthquake beliefs, beliefs about earthquake threat, and positive outcome expectancy (i.e. that preparing for earthquakes is beneficial). We consider how these beliefs might have contributed to motivating survival and structural preparedness in Canterbury from 2009-2021. Key questions we consider include: -

- Do people hold helpful beliefs about earthquakes and preparedness, and have these changed over time?
- Do people hold beliefs about the benefits of preparing for earthquakes (positive outcome expectancy) and have these changed over time?
- Are people better prepared, and if so, in what ways?
- How might we need to adjust future earthquake information?

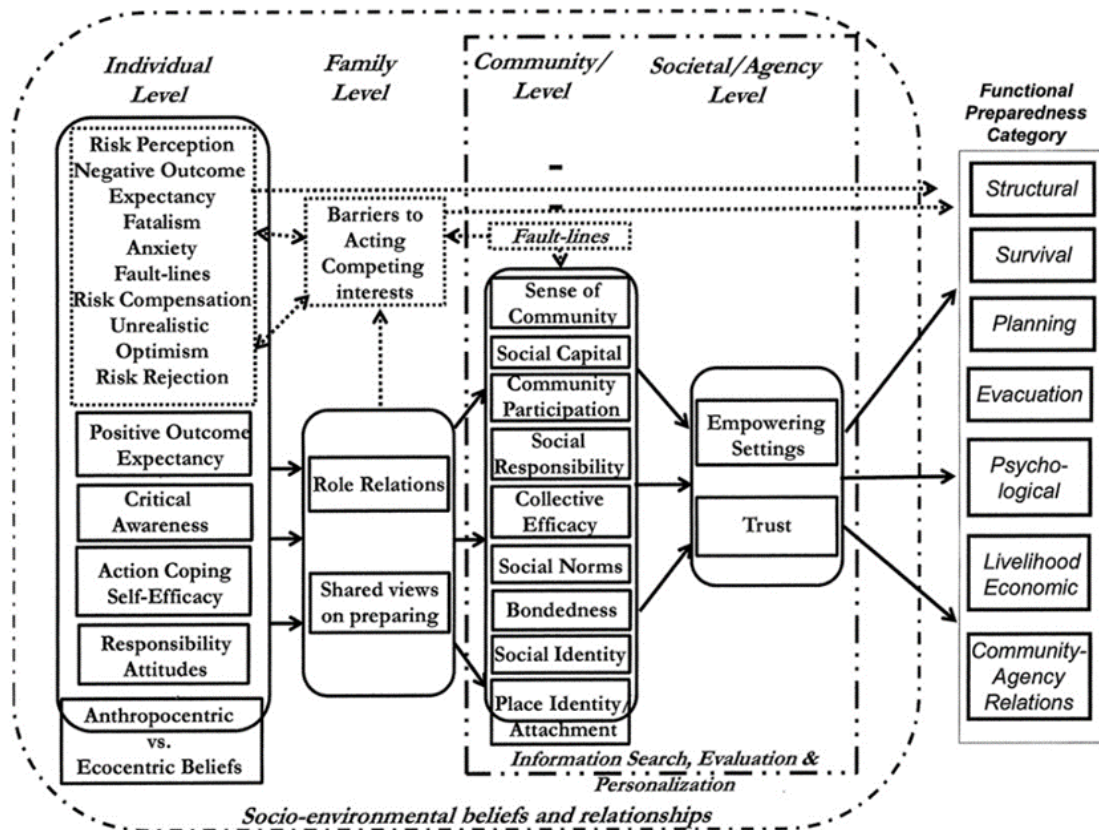


Figure 2. Community Engagement Theory, highlighting the various influences on preparedness (Paton, 2019).

## 2 Methods

To understand the evolution of earthquake perceptions, beliefs and preparedness over time, and identify future potential information needs for Canterbury, we compared household preparedness surveys conducted in 2009 (pre-CES, Becker, 2010) and 2013 (post-CES, Paton et al., 2016), with a new survey undertaken with residents in 2021 (10 years post-CES).

The 2021 survey was kept as similar as possible to that used in 2013 to allow for comparison, however, there were some minor changes, which meant not all questions were included in all surveys or included in exactly the same way. This paper reports on survey items which could be descriptively compared across at least two time points. The surveys asked a number of questions, not all of which are reported here. However, we do focus on the following questions for this paper: demographics; earthquake experience; sources of emergency preparation information; general beliefs about earthquakes; perceptions of earthquake threat; positive outcome expectancy and preparedness (predominantly survival and structural preparedness).

Mean scores and frequencies for all three surveys (where possible) are presented and discussed descriptively. Differences are not tested statistically; carrying out so many comparisons would greatly inflate the error rate. To account for the lack of statistical testing, where possible we discuss differences in terms of apparent patterns or trends rather than focusing on specific items except where the differences are considerable enough to have confidence that they would likely be statistically significant.

## 2.1 Participants

For the 2021 survey, we recruited participants by sending postcards to the 3,000 addresses used in the 2013 survey. The postcards included a short information statement about the project and a link to a Qualtrics survey page. The survey response rate was approximately 9%. After exclusions, we ended up with a useable sample of 237 participants. Because we were not able to link individual participants responses between the surveys (or confirm that participants had responded to both the 2013 and 2021 surveys), this research is quasi-longitudinal. That is, we used the same sampling method from the same population to compare descriptively, rather than inferentially, over time. This does mean that some of the specific differences may be influenced by, or an artefact of, differences in the samples. However, given the sample sizes and sampling method, overall trends should be robust.

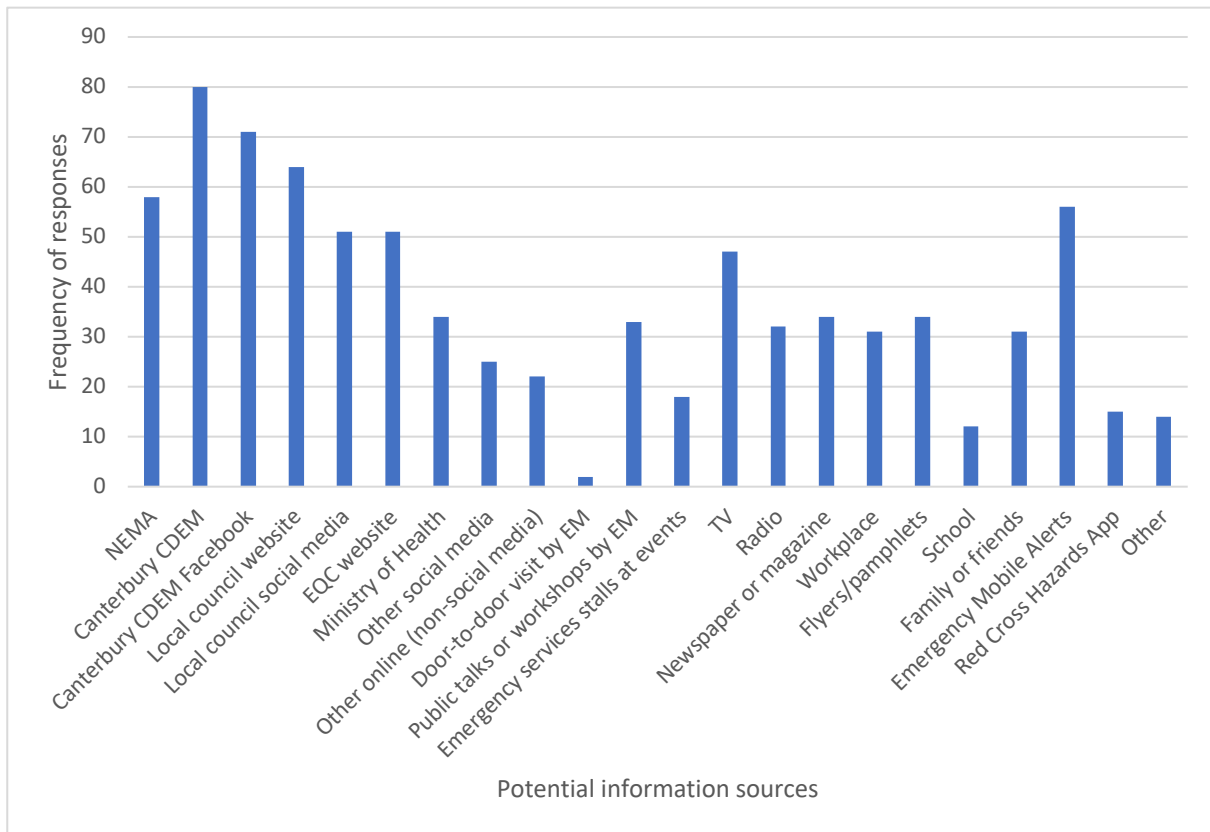
There was a large variation in the length of time people had lived in the Canterbury region from 0.5 to 79 years ( $M = 27.8$  years). Most (94.9%) had experienced at least one earthquake, with only 12 participants (5.06%) not experiencing any. Over half of participants had experienced the 2010 Darfield earthquake (54.4%), the 2011 Christchurch earthquake (58.7%), ongoing aftershocks during or following the 2010-2011 CES (62.0%), and/or the 2016 Kaikōura earthquake (46.4%). The majority of participants were women (68.02%; 30.81% were men and 1.16% were non-binary). Ages ranged from 18 to 81, with a mean of 52.50 years old. The vast majority of participants identified as being a New Zealander (78.53%) or European (7.34%); only 3.39% identified as Māori. Most (79.55%) owned their residence.

When comparing with the surveys in 2009 and 2013, it should be noted that full demographic information was not collected in 2013; however, some descriptive comparisons can be made. Slightly more of the participants in 2009 (88.13%) and 2013 (88.03%) owned their residence. Gender distribution was more even in the 2009 survey (49.1% male) but the modal age was higher (60 to 64 years). Identification with particular ethnicities cannot be compared easily due to changes in wording, but as with the 2021 survey, a majority of 2009 participants identified as New Zealand European (88.6%) and Māori were underrepresented compared to the national population (3.1%).

## 3 Results

### 3.1 Information sources

We asked participants in the 2021 survey whether they had sought information on how to prepare for emergencies. Just over two thirds (67.7%) of participants in the survey stated that they had sought information about how to prepare for emergencies. More people got information from their local emergency management group than from national sources such as the National Emergency Management Agency (NEMA) (Figure 1). Both social media and traditional media (including TV and radio as well as print media) were commonly cited sources of information, as well as warnings such as Emergency Mobile Alerts (which are less relevant in a preparedness context). Consequently, a mix of local and national information, across a range of channels is important for people accessing information about preparedness.



*Figure 3. Reported information sources for preparing for emergencies, such as earthquakes for 2021. NEMA = National Emergency Management Agency. CDEM = Civil Defence and Emergency Management. EQC = Earthquake Commission (now called Toka Tū Ake EQC). EM = Emergency Management.*

### *3.2 Beliefs*

In relation to our first question, “Do people hold helpful beliefs about earthquakes and preparedness, and have these changed over time?”, we found that in general there was a presence and increase in “helpful” beliefs (i.e., those that correlate positively with preparation actions, in contrast to detrimental beliefs which negatively correlate with preparation) over time, that should motivate preparedness. In general, participants were more likely to disagree with beliefs which are expected to hinder preparedness (Table 1) and agreed that earthquakes could pose a threat to their safety, daily life, and property (Table 2). Lower agreement with the beliefs in Table 1 is considered beneficial given that these beliefs can reduce people’s likelihood to prepare (McClure et al. 2007; Spittal et al., 2005). On the other hand, higher scores in Table 2 represent people’s perceptions that the earthquake threat is higher, whereby greater risk perception is typically considered more helpful in motivating preparedness. It should be noted, however, that risk perception is a complex variable and has been found to not always directly link with preparedness (e.g., Solberg et al., 2010).

Differences in beliefs between 2009 and 2013 mostly either persisted or widened (i.e., the difference between 2009 and 2021 was larger than the difference between 2009 and 2013), suggesting that earthquake experience influenced a long-term, persistent impact on both detrimental beliefs and risk perception. In both cases, the changes over time should theoretically be in the direction of encouraging more preparedness. If people see the threat of an earthquake as higher, and they more strongly disagree with beliefs such as that the likelihood of a major earthquake has been exaggerated, they should be more likely to prepare.

*Table 1. Agreement with general earthquake beliefs, where lower scores indicate less agreement.*

Statement	Year		
	2009	2013	2021
There may be earthquakes, but they won't be that bad	2.61	2.26	1.92
The location of the earthquakes will be far away from here and have little impact on us	2.43	1.92	1.73
The likelihood that major earthquakes will occur here has been greatly exaggerated	2.33	1.84	1.73
I have been fine during the earthquakes we have had and I will be fine in the next one too	2.76	2.71	2.75
Earthquakes are too destructive to bother preparing for	1.88	1.77	1.69
A serious earthquake is unlikely to occur during my lifetime	2.28	1.73	1.75
Preparing for earthquakes is inconvenient	2.42	2.19	2.28
It is difficult to prepare for earthquakes	2.79	2.60	2.45

*Note. Figures in Table are mean sample scores on scales from 1 (Strongly disagree) to 5 (Strongly agree), such that higher values indicate stronger agreement with the statement.*

*Table 2. Agreement with statements about the threat that earthquakes pose to different domains.*

Statement	Year		
	2009	2013	2021
Personal safety	3.94	4.29	4.22
Daily life	3.93	4.40	4.29
Property	4.03	4.40	4.37

*Note. Figures in Table are mean sample scores on scales from 1 (Strongly disagree) to 5 (Strongly agree), such that higher values indicate stronger agreement with the statement.*

### *3.3 Positive outcome expectancy*

In relation to our second question, “Do people hold beliefs about the benefits of preparing for earthquakes (positive outcome expectancy) and have these changed over time?” we found mixed results depending on the context. First, the Canterbury earthquakes appear to have made people think that preparing is less beneficial for reducing the amount of damage to their home, as the mean for this item has declined over time (Table 3). This change between the 2009 and 2013 survey is possibly due to the widespread damage to residential properties in the area caused by the September 2010 and February 2011 earthquakes. Such devastation may possibly have led people to believe that no amount of preparation could have helped reduce damage to their property, as demonstrated in the increased risk perceptions after the earthquakes (Table 2). It is notable, also, that the mean has stayed almost the same 10 years after the latter event, meaning that the belief that preparing will not reduce damage to homes has persisted in the long-term.

In contrast, the perception that preparing can benefit everyday life increased following the earthquakes and appears to have persisted over time. That is, people are more likely to think that preparing for earthquakes will help them in their day-to-day life even 10 years after the main CES events. Changes to perceptions that preparation can potentially improve property value has improved, but not to the same extent. Finally, and also particularly of note, is the

modest increase in agreement that preparing would help to deal with earthquake-related disruptions.

*Table 3. Agreement that preparing for earthquakes will have various benefits.*

Statement	Year		
	2009	2013	2021
Reduce damage to my home	3.20	2.87	2.88
Improve my everyday living conditions	2.75	3.18	3.29
Improve the value of my property	2.73	2.85	2.81
Improve my ability to deal with disruptions to family/community life following an earthquake	3.89	4.08	4.08

*Note. Figures in Table are mean sample scores on scales from 1 (Strongly disagree) to 5 (Strongly agree), such that higher values indicate stronger agreement with the statement.*

### *3.4 Intended and actual preparedness*

In answering the question, “Are people better prepared, and if so, in what ways?”, we need to revisit the survey data on preparedness over time. In 2009, before the Canterbury earthquakes, only 30.6% of residents believed they were prepared or very prepared for a future earthquake. In the 2021 survey we asked whether people had increased their preparedness since the initiation of the CES. Approximately two-thirds of participants (65.78%) said they either prepared or updated their preparedness during the Canterbury Earthquake Sequence (2010 to 2011). A majority (57.22%) suggested they had undertaken some earthquake preparation in the 3 to 5 years following the CES (2012 to 2016). A similar, but slightly larger, percentage (59.34%) increased their preparedness in the 6+ years since the CES (2017 to 2021). This stabilisation in preparedness actions could possibly be due to the November 2016 Kaikōura earthquake which was widely felt throughout the region, although further evidence is needed to support this suggestion.

Table 4 shows the different types of survival and structural preparedness actions we asked participants about in 2013 and 2021, according to what they had done, may do or will not do. Data for 2009 is not shown in the table because the actions asked about in that survey were framed slightly differently. Table 3 highlights that survival actions were typically more commonly undertaken than structural actions. The most commonly taken actions were those which are useful when power is lost regardless of reason, such as having an alternative cooking source and a battery torch. Generally, fewer participants in the 2021 survey reported that they had undertaken each preparation action than in 2013, showing a slight decline in preparedness actions overall. This finding seems to contradict those above whereby a majority of participants reported having increased their preparedness in the years following the CES. It is possible that in 2021 more people had taken a few actions but fewer had taken many actions than in 2013. It is also likely that these findings show the important difference in perceived preparedness and actual preparedness (and the benefit of assessing both).

The percentage of participants who had retrofitted non-structural elements of their home did not change between the 2013 and 2021 surveys, but the proportion of people who said they may do this action was considerably higher in 2021 (33.33%) than in 2013 (18.30%). This difference may align with a decrease between 2013 and 2021 in the percentage of participants who were confident that their home was safe and secure (84.6% down to 59.24%) and an increase in the proportion who sought information about previous earthquake damage and



other hazards before living or building in the area in which they currently reside (23.6% up to 43.61%).

As highlighted above, because the list of preparedness actions changed between the 2009 and 2013 surveys, it was not possible to compare all items across 2009, 2013 and 2021. However, for those that were comparable, for all but two of the actions, preparation levels were lower in 2009 than both 2013 and 2021. This pattern suggests that preparation increased after the earthquakes, and has since decreased slightly, but largely remains above pre-earthquake levels.

*Table 4. Frequency of completed preparedness actions in 2013 and 2021.*

	2013			2021		
	Have done	May do	Will not do	Have done	May do	Will not do
<b>Survival</b>						
I have at least three litres of water (in containers) per person, per day for three days	76.3	18.2	5.50	62.0	33.0	5.00
I have set aside three days or more worth of food, for all my family, that is specifically for an emergency	78.9	15.2	5.90	58.7	33.01	8.25
I have a supply of essential medicines for illness or allergies	80.1	16.2	3.80	81.0	17.5	1.50
I have a working battery torch (or solar/dynamo equivalent)	97.6	1.70	0.70	88.9	8.70	2.42
I have spare batteries for equipment I might need to use	86.7	10.6	2.70	81.5	15.6	2.93
I have purchased or put together a first aid kit	86.0	10.5	3.50	86.5	12.0	1.44
I have access to an alternative cooking source for cooking or boiling water (e.g. gas barbeque)	91.8	5.50	2.70	85.2	11.3	3.45
Each family member has an emergency get away kit in case we have to evacuate quickly	28.4	51.6	20.1	24.1	59.0	16.9
I have additional supplies at work and/or in my car in case I am away from home when an earthquake hits or I cannot get to my home supplies	33.9	47.0	19.1	26.3	56.8	16.8
I check the contents/operation of my emergency supplies at least every six months	64.1	30.8	5.1	42.9	42.9	14.3
I have a household emergency plan	64.5	29.0	6.60	52.9	36.8	10.4
<b>Structural</b>						
I have ensured that moveable items are stored safely in cupboards secured with latches (i.e. Heavy items down low, water bowls not over electrical equipment)	62.0	30.7	7.30	52.0	36.0	12.0
I have secured items in my house (e.g. furniture, hot water cylinder)	76.4	17.4	6.30	65.3	26.4	8.29
I have retrofitted the non-structural elements of my house to increase its earthquake resistance (e.g. knocked down or strengthened a chimney, upgraded pipes)	50.5	18.3	31.2	49.2	33.3	17.5
I have retrofitted the structural elements of my house (e.g., foundations) to increase earthquake resistance	-	-	-	26.2	30.0	43.9
I am confident my home is as safe and secure as it can be	84.6	12.2	3.10	59.2	38.0	2.72

When comparing the 2009 survey, with that of 2013 and 2021, the percentage who had a first aid kit (82.9%) and a battery torch (83.4%) was lower in 2009; and the percentage who had stored water (40.7%), made an emergency plan (27.2%), had spare batteries (58.9%), and checked the contents of their emergency supplies at least every six months (18.2%) were much lower in 2009. These particular items may have been useful during people's earthquake

experiences, and therefore participants can see the benefits of having these items in future. The percentage who had a supply of essential medicines (78.0%) was about the same as the 2013 and 2021 surveys, suggesting that people in Canterbury may not have struggled with accessing essential medicine during the earthquakes. Fewer people had an alternative cooking method in 2009 (85.3%) than in 2013, but rates were similar to the 2021 survey. This change, from 85% to 92% to 85% suggests a shorter-term influence of earthquake experience than is suggested by the other items for which there is data across all three surveys.

## 4 Conclusions

To understand the evolution of earthquake perceptions, beliefs and preparedness over time, and support future information provision, we drew from surveys of Canterbury residents in 2009, 2013 and 2021. Findings show that preparation increased after the CES, and has since decreased, but largely remains above pre-earthquake levels. In terms of perceptions and beliefs, residents agreed that earthquakes could pose a threat to their safety, daily life, and property, with these beliefs showing stronger trends over time. These beliefs are important for helping motivate preparedness. People also were more likely to think that preparing for earthquakes was beneficial for daily life after the earthquakes, with this belief persisting 10 years after the main CES. Benefit was seen for survival preparedness (likely used regularly during the CES), with this still a key part of people's preparedness. However, participants saw less benefit of preparing for reducing damage in their home in 2021 compared to 2009. This perception was virtually identical to 2013, suggesting that there may have been an impact of the CES on potential damage reduction which has persisted for the 10 years since the earthquakes. It might be that the significant amount of building damage in the 2010 and 2011 earthquakes reduced people's belief that this damage can be prevented. This is supported, in part, by reduced numbers of people undertaking structural preparedness in 2021, although other drivers (such as a potentially lower objective hazard as the earthquake sequence ended) may also be responsible for this trend. In comparing the surveys over time, then, we find that earthquake experience likely influenced a long-term, persistent, impact on perceptions and beliefs in ways that should theoretically encourage more preparedness, with some notable exceptions such as the one discussed above. This has implications for our final question, "How might we need to adjust future earthquake information?". It is apparent that while a continuing focus on survival preparedness is important, more focus might also now need to be given in Canterbury to provide information that promotes the benefits of property preparedness to develop positive outcome expectancy, and to support people in taking structural preparedness actions in future.

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