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Motivations to prepare after the 2013 Cook Strait Earthquake, N.Z.

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ABSTRACT

We investigated responses to the 2013 Cook Strait earthquake sequence, New Zealand. This included two foreshocks (M5.7 and M5.8) and a mainshock doublet pair: M6.5 Cook Strait (CS) earthquake on 21st July and M6.6 Lake Grassmere (LG) earthquake on Friday 16th August. We examined relationships between preparedness, experience and beliefs during the earthquakes, as well as concern and subsequent preparedness actions. Results indicate that earthquake characteristics (e.g., time, location) influence the types of preparedness actions. While there was a reduction in new actions from the first mainshock doublet earthquake (CS) to the second (LG), there were a large number of participants who reviewed or revisited their prior actions, related to their beliefs about impacts, in a form of problem-focused targeted action. Females took more actions than did males, and had a higher rate of immediate aftershock concern. For all participants, concern was greater after the CS earthquake than after the full earthquake sequence, supporting the findings of McClure et al. (2016) that there is a limited window after an event to maximise the opportunity for effective preparedness initiatives. Findings additionally suggest that such post-earthquake preparedness initiatives should consider the impacts that elicited the highest rate of concern in an event, and should tailor messages towards them. While this earthquake sequence resulted in low levels of impact and damage, it presents interesting findings regarding how disruption (in lieu of major damage) influences earthquake preparedness actions, which is particularly important to understand in highly active regions often exposed to smaller impact events.

1. Introduction

In 2013, the Wellington region of New Zealand (NZ) experienced a series of earthquakes that presented a unique opportunity to investigate how repeated earthquakes over a short period of time affect earthquake preparedness actions and perceptions about earthquake likelihood (see [56]). This sequence commenced with two small earthquakes which we term 'foreshocks' herein, of M5.7 and M5.8 respectively, felt at 9:06 a.m. Friday 19th July (FM) and 7:17 a.m. Sunday 21st July (SM). Then at 5:09 p.m. on Sunday 21st July, a strong M6.5 earthquake occurred at a depth of 16 km, approximately 51 km from Wellington (GeoNet, 2013[1]) (Fig. 1a). This earthquake, named 'The Cook Strait earthquake' (CS) was the first of a mainshock 'doublet' of similarly-sized earthquakes felt widely throughout both the North and South Islands of NZ. The second event, named the 'Lake Grassmere' (LG) earthquake, occurred at 2:31 p.m. on Friday 16th August, with a M6.6 event at a depth of 8 km and was centred 77 km from central Wellington.[2] Both earthquakes occurred at sea in the Cook Strait (Fig. 1b), on a previously unknown extension of the London Hills Fault.

While no lives were lost in these earthquake events, they caused NZ $30 million of insured earthquake damage to residential properties (EQC 2013[3]; particularly around Seddon, Marlborough). In the

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[1] M 6.5 Cook Strait Sun, Jul 21 2013. Retrieved from: https://www.geonet.org.nz/earthquake/2013p543824 last Accessed 2nd July 2018.
[2] M 6.6 Lake Grassmere Fri, Aug 16 201. Retrieved from: https://www.geonet.org.nz/earthquake/story/2013p613797 last Accessed 2nd July 2018.
[3] EQC. (21 Nov 2013). Update on Cook Strait Earthquake Claims. Retrieved from: http://www.eqc.govt.nz/news/update-on-cook-strait-earthquakes-claims; last Accessed 2nd July 2018.

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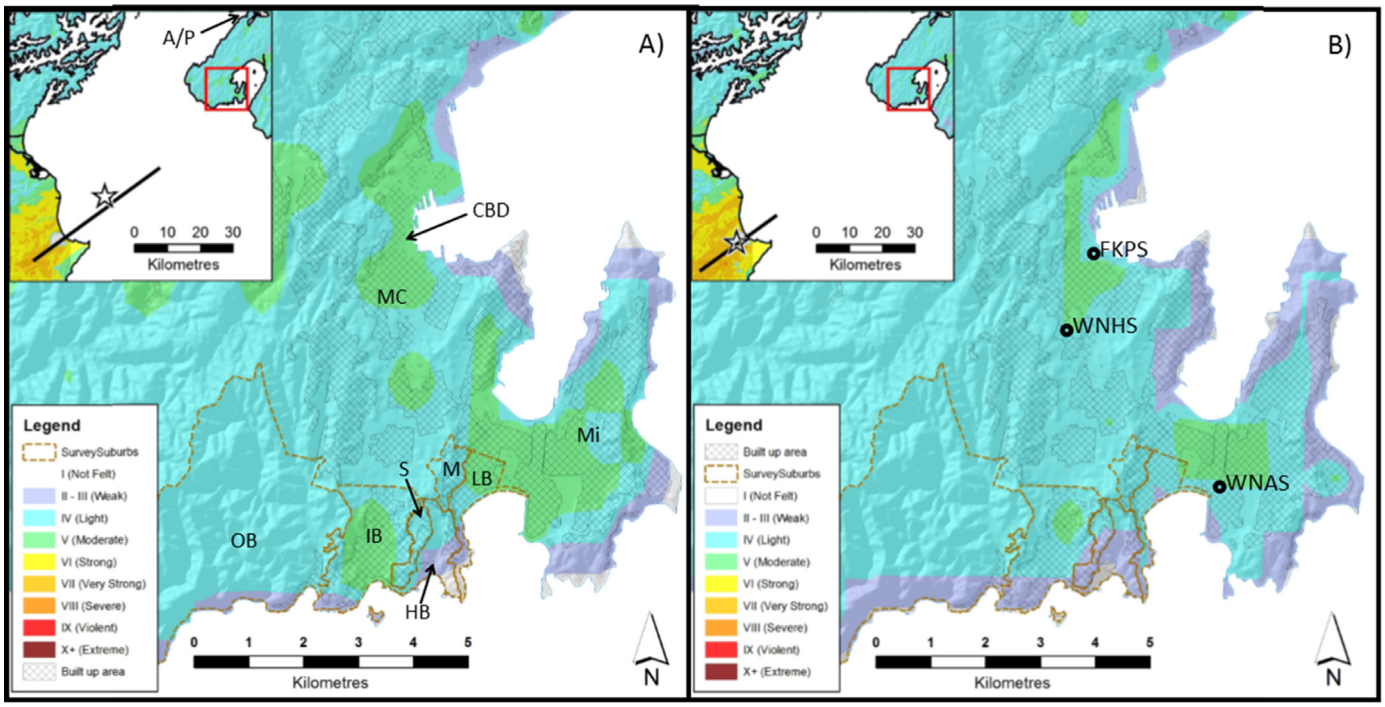

Fig. 1. : a) Earthquake epicentre of the first earthquake in the mainshock doublet, the M_W 6.5 Cook Strait event, and its position on the London Hills Fault in between the North and South Islands of New Zealand; **b)** the epicentre of the second earthquake, the M_W 6.6 Lake Grassmere event, located on the same fault on the South Island. For both, the Modified Mercalli Intensity (MMI) shake map is displayed. In addition, the boundaries of suburbs surveyed in this study and location of suburbs referred to in the text are given on (A): OB = Owhiro Bay; IB = Island Bay; HB = Houghton Bay; S = Southgate; M = Melrose; LB = Lyall Bay; Mi = Miramar; MC = Mount Cook; CBD = Central Business District; A = Aotea; P = Pukerua Bay. Strong motion stations are indicated on (B): FKPS = Frank Kitt's Park, WNHS = Wellington High School, WNAS = Wellington International Airport (from [35]).

Wellington region, significant damage occurred to a number of buildings during the CS earthquake, resulting in large portions of the CBD being temporarily closed and train services halted (Stuff, 2013a,[4,5]; Radio New Zealand, 2013[6]; Otago Daily Times, 2013[7]). Following the LG earthquake, many CBD workers left early due to train services being cancelled and workplaces being shut. This resulted in overloading of bus services, traffic gridlock on major roads out of Wellington, reports of people walking along the highway to return home, and police encouraging motorists to provide rides for stranded commuters (Taranaki Daily News, 2013[8]). Others elected to stay overnight in Wellington with friends, or to seek entertainment in pubs and restaurants until the gridlock had reduced.

We define the first M5.7 and 5.8 earthquakes in this sequence as the first and second foreshocks, and consider the CS earthquake as the first of the mainshock doublet, and the LG earthquake as the second. Such an earthquake sequence presented a unique opportunity to investigate the relationships between a) earthquake experiences and tsunami expectations (reported in [35]), b) earthquake preparedness (reported here), as well as c) aftershock communications and d) earthquake experiences and immediate actions (both reported in [17]). A survey was conducted in October 2013 with participants from six coastal suburbs of Southern Wellington, to investigate these issues (Fig. 1). These suburbs were chosen as they had areas that could be subject to tsunami inundation, and three of the suburbs (Island Bay, Owhiro Bay and Houghton Bay) had received a high degree of public education during the consultation and development of 'tsunami blue lines' painted on roads in 2011 and 2012 to delineate the start of the 'tsunami safe zone' (Wellington Emergency Management Office [88]). These three suburbs presented an interesting comparison group to those suburbs that will be part of future consultation on blue lines, and for residents outside of the tsunami zone (as reported in [35]). These investigations were included in a single postal survey questionnaire, to prevent over-surveying of the resident population, as experienced by communities after the 2011 Christchurch earthquake. In this study, we focussed on examining relationships between earthquake preparedness, experience and beliefs during the earthquakes, and concern about aftershocks and future earthquakes. We explored questions including: How did people's preparedness actions change with each earthquake in the sequence? How did the timing and characteristics of the two earthquakes in the mainshock doublet, the first being on a Sunday evening and the second on a Friday afternoon, influence the type of actions taken? How did participants' levels of concern relate to any actions they took? We next discuss the literature on preparedness motivations, to set the context for these investigations.

1.1. Preparedness motivations

There is an extensive literature on what motivates an individual, family, community or organisation to prepare for an earthquake or other natural hazard (e.g. [83,52,89]). Becker et al. [8] identified

[4] Stuff (22 July 2013). Rail lines reopen as inspections continue. Retrieved from: http://www.stuff.co.nz/dominion-post/news/8946467/Rail-lines-reopen-as-inspections-continue; last Accessed 2nd July 2018.

[5] Stuff (23 July 2013). Quake rattles Kapiti District. http://www.stuff.co.nz/dominion-post/news/local-papers/kapiti-observer/8947669/Quake-rattles-Kapiti-district; last Accessed 2nd July 2018.

[6] Radio New Zealand (21 July 2013). Damage after severe quake hits central NZ. https://www.radionz.co.nz/news/national/215023/damage-after-severe-quake-hits-central-nz; last Accessed 2nd July 2018.

[7] Otago Daily Times (22 July 2013). Wellington CBD off limits after quake. Retrieved from: https://www.odt.co.nz/news/national/wellington-cbd-limits-after-quake; last Accessed 2nd July 2018.

[8] Taranaki Daily News (17th August 2013). Quake-rattled residents flee after tremors. Retrieved from: http://www.stuff.co.nz/taranaki-daily-news/news/9054859/Quake-rattled-residents-flee-after-tremors; last Accessed 2nd July 2018.

several key factors that influence preparedness and resilience-building actions including individual, community and institutional factors. At the individual level, *self-efficacy* (an individual's belief that their actions can control an event outcome), *outcome expectancy* (the belief that an action will mitigate a threat), *critical awareness* (whether the hazard is seen as important enough to think about), *action coping* (problem-focussed coping mechanisms), *planning* (including detailed action plans) and personal *responsibility*, all influence people's intentions to prepare. Considering community factors, *community participation* helps people find new information, learn skills, be involved in solving problems, and provides the context for risk beliefs and decisions; *articulating problems* helps people define problems that might arise; emergent community *leadership* adds legitimacy, provides liaison with government agencies and business; *collective efficacy* expresses the belief that a community can collectively control the outcome; *social responsibility* increases motivation to prepare; and *place attachment* reflects individuals' emotional investment in their community which increases motivation to act. For institutional indicators, *community empowerment* (the degree to which citizens master their own affairs and deal with issues and opportunities using their own resources) and *trust* (in individuals and agencies) both influence actions. All these factors have interdependencies [8], and influence each other within a resilience building system.

In this investigation, we were particularly interested in the relationship between personal and family experiences, and the actions taken. As stated by Eiser et al. [27] the ways people act on interpretations of risks are "shaped by their own experience, personal feelings and values, cultural beliefs and interpersonal and societal dynamics". In their review of the effect of past hazard experience on responses to warnings, Sharma and Patt [77] note that there has been a discrepancy as to what constitutes 'experience'; with personal experience referring to anything from witnessing a major event to suffering substantial losses, with variants as to how the severity of the impact (scale, scope, size) are considered, or not. However, few studies consider the role of multiple, or nested experiences, focusing instead on one 'type' of experience, such as impacts (whether an individual experiences a single hazard). For many studies of experience and communication relating to natural hazards, the focus has been in the context of false alarms, with a binary hit or miss concept defining whether an experience negatively or positively influences warning compliance [27,4].

The role of experience on actions has been explored through a number of lenses. This includes the effect of an experience upon risk perception [22,29,66,73,8], consistently finding that direct experience heightened threat knowledge and risk perception, but vicarious experience sometimes did [51] and other times did not [66]. Becker et al. [9] identified that experience influences the preparedness process in seven distinct ways: prompting thinking; raising awareness; helping understanding of consequences; developing beliefs; developing preparedness; influencing emotions and feelings; and prompting community interaction. Other research has examined the role of experience on future compliance to warnings [44,54,60,77] and the issue of false alarms [4], including the effect this has on official decisions [20,71] and the construction of forecasts and communications [15]. Further studies have examined the role of experience on relationships between scientists and the public [21,3,40], and the role of experience in preparedness [37]. There is a large body of literature on experience and its impact upon warning interpretation [60]. Furthermore, there is extensive literature on risk communication in general (not hazard specific) that incorporates elements of experience and how that relates to trust and learning [12,13,33,62]. Morgan et al. [62] highlight that the past experience of a hazard influences an individual's mental model of the risk, which in turn influences the factors discussed above that motivate preparedness.

In the context of climate change adaptation, Grothmann and Patt [37] highlight that the degree to which past experience influences protective behaviour depends upon the severity of past damage, stating that 'risk experience appraisal' plays an essential role in motivating actions. This model links 'risk perception' to the probability and severity of a hypothetical threat in the future, and 'risk experience appraisal' to the severity of a past risk experience. The risk experience appraisal is assumed to impact optimistic bias, resulting in a higher risk perception because an individual's uncertainty has been reduced by their experience. However, as noted in [41], past experience can also decrease risk perception. Responses to uncertainty include a complacency to only expect the experienced, making people insensitive to changing risks, via normalisation bias [61] and promoting unrealistic optimism [16,43,78,84]. Haynes et al. [41] found at Montserrat volcano, that people had to witness events before they fully appreciated consequences and impacts, and that this experience can both give people a false sense of security as well as motivate actions. As reviewed by Becker et al. [8], previous experience also impacts concern and anxiety [22,42,75,79], as well as actual preparedness (e.g., [30,52,63]).

As reviewed by Paton and McClure [67], perception of invulnerability to a hazard is reduced by personal experience [36,43], but sometimes only for a limited time [16]. Perceptions of future impacts of an event also differ between unaffected and affected individuals [80] with the former overestimating 'the importance of casualties and destruction of houses and landscape' (p. 773) compared to the latter. Meanwhile the affected considered emotional aspects such as uncertainty and insecurity to be the most negative impact. Subsequent research by Halpern-Felsher et al. [39] and Paton et al. [66], shows that if people experience only mild impacts from a hazard event, they are likely to discount future risk from that hazard more so than those who experience serious impacts (Paton and McClure [67], p. 81). This phenomenon, which Baker [1] labelled'false experience' appears to result from people confusing the event's *magnitude*, which is widely publicized in the news media, with its local *intensity* as indicated by the minor impacts they observe in their neighbourhood.

In the earthquake sequence considered in this study, we are considering multiple 'experience events' rather than a singular event. As noted by McClure et al. [56], there is limited literature on how multiple hazard events affect risk judgments and preparation [1,23,74,81,86,87]. In particular, two studies found that community evacuation rates remained equally high over multiple hurricane threats within the same season [1,23]. Russell et al. [74] found that risk perception increased through time from the 1987 Whittier Narrows earthquake, Los Angeles to the 1989 Loma Prieta earthquake, San Francisco. This increase related to an increase in mitigation actions, especially for areas that experienced the greatest impacts. Weinstein et al. [87] found that optimistic risk judgments were affected by a series of tornadoes, decreasing in the highest impact areas. McClure et al. [56], considering the same 2013 Cook Strait earthquake sequence we consider here, found that participants in Christchurch, Wellington, and Palmerston North reported the earthquake risk to be more real, plausible, and important after the earthquake sequence, which resulted in higher preparations in Wellington and Christchurch, and suggests a valuable window for agencies to enhance preparedness in their communities. McClure et al. [56] highlight that their preparedness had been enhanced by the previous occurrence of the 2010–2011 Christchurch earthquake sequence, and that this range of findings is in contrast to Silver and Wortman [81] who identified an increase in helplessness after two negative events (see also [55]).

1.2. Demographics and preparedness motivations

A wide range of studies have explored how demographic variables such as gender, income, homeownership and education, etc., influence risk perception, disaster preparedness, and disaster actions (for reviews, see [1,44,49]). Out of all the demographic variables gender is found most consistently to influence preparedness. For example, Dooley et al. [22] found that females had greater concern, and those who were concerned were more likely to prepare. Bateman and Edwards [5]

found that females were more likely to evacuate for hurricanes and have a heightened perception of risk. In addition, they suggest the socially constructed gender differences in care-giving roles shape women's risk perception and actions, much as *responsibility for others* has been shown to motivate preparedness for disasters ([59,6,7]; see Section 1.1). This type of family decision making is also influenced by the degree of collective family support [38]. However, Lindell and Prater [51] found that females reported higher levels of risk perception but not higher levels of hazard adjustment or preparedness action to mitigate their risk.

Olofsson and Rashid [64] propose a 'white male effect' phenomena (see review in [70,65,72], and [82]), where the privileged demographic position of 'white males' makes them perceive lower levels of risk compared to other ethnicities and women. Palmer [65] attributes this to their life experiences leading them to a greater belief that final event outcomes will be satisfactory. Similarly, Senkbeil et al. [76] identify significant differences in tornado hazard risk perception, preparedness and response times between three ethnic and racial groups (white, African American, Hispanic/Latino), after controlling for age, education, and experience. As discussed by Blake et al. [10], preparedness intentions may be limited due to financial constraints, lack of social capital and social connections, and a lack of capacity and support. Thus, minority groups and marginalised individuals may be "disadvantaged in preparedness practices because they lack the necessary resources to prepare" (p. 283). Social vulnerability, socio-economic status and lack of social capital thus create barriers to people's ability and resources to prepare, even if they recognise the need to ([2]; Bolin [11]; [31,32,90,28]). Higher levels of education have also been identified as a factor that influences the understanding of risks and motivations to act ([19]; Senkbeil et al. [76]), and is closely related to socio-economic status and income level.

However, the literature presents a wide range of conflicting results as to how significantly these demographic variables influence perceptions and actions. Through a statistical meta-analysis of 49 studies into real and hypothetical hurricane warnings, Huang et al. [44] found that demographic variables have much weaker effects on evacuations than other predictors such as observations of environmental conditions, social cues, and expectation of personal impact. Similar weak and inconsistent effects for demographic variables were found in Lindell's [49] review of mitigation and preparedness actions for a broader range of hazards. To summarise, a number of research studies have identified that demographic variables such as socio-economic status and gender can be statistically significant predictors of psychological variables, preparedness motivations, long-term hazard adjustments, and disaster responses but the results tend to be weak and inconsistent. Thus, further research is needed to determine if the effect of demographic variables on preparedness is either completely or nearly completely mediated by variables such as perceptions of the hazard and alternative protective actions. Resolving this question will require more researchers to report the entire matrix of correlations among demographic variables, psychological variables, and hazard adjustments [48] and to test mediation models [69]. In addition, more systematic meta-analyses such as Huang et al. [44] are needed to determine whether these findings are supported by assessments of effect sizes across a wide range of studies.

2. Method

2.1. Materials/procedure

The survey questionnaire included items from studies of immediate behavioural response and emotional reactions to the 2011 Christchurch, New Zealand, and 2011 Great East Japan earthquakes [53], earthquake preparations [57,58], aftershock communications [24–26], new questions exploring levels of concern after each earthquake, and potential damage and casualties due to tsunami and tsunami evacuation response [35]. Existing questionnaire items were utilised to enable further future comparison across international earthquake events.

We focus here on the questions listed in Appendix A, which considered all four earthquakes in the sequence (the two foreshocks, followed by the mainshock doublet earthquakes CS and LG). Specifically, questions for the CS and LG earthquakes asked about the felt strength and duration, risk perceptions during each earthquake regarding damage and disruption (rated on a scale from Not at all/1 to Very great extent/5). Respondents were also asked what supplies and plans they had to hand at the time of each earthquake, the injuries and infrastructure damage they experienced, and whether they took any preparedness actions after the earthquake (including getting basic supplies and equipment, logistics/planning, and damage mitigation). Participants were then asked to think back to the days prior to the CS earthquake, and indicate whether they felt the earlier M5.7 foreshock on the morning of Friday 19th July and the M5.8 foreshock on the morning of Sunday 21st July, and if either of these foreshocks prompted them to also take any actions and if so, what (using the same categories as CS and LG).

To further explore factors that may influence preparedness, participants were then asked to consider the week following the CS earthquake (before the LG earthquake had occurred) and report their level of concern about a damaging aftershock or earthquake (on a scale of Less concerned/1 to More concerned/5). Finally, participants were asked to consider the future, and rate their level of concern about future aftershocks or earthquakes in the Wellington region. The survey questionnaire included twelve demographic items, and space for open-ended comments for participants to share their thoughts about the earthquakes and the questionnaire.

2.2. Participants

Participants were recruited via 600 survey questionnaires that were hand-delivered on 30th and 31st October 2013 to residential properties in six coastal south Wellington suburbs, also illustrated in Fig. 1. This survey was conducted in accordance with Massey University's ethical code regarding research with human participants. In each suburb, streets were chosen inside and outside the tsunami zone and survey questionnaires delivered to alternate houses on those streets. Questionnaires were re-sent by post to the 404 properties that had not responded by 5 December 2014, and responses were accepted until 10 January 2014. The number of questionnaires delivered was chosen based upon the resources available to implement this survey. The respondent for each household was requested to be the resident aged 18 years or older who most recently had a birthday.

In total there were 204 responses, corresponding to a response rate of 34%. Of these, the mean age of respondents was 49.6 years (SD 14.6), the majority were female (65%), NZ European (79%), employed (71%), had a household income of $50,000 or more (74%), owned their home (81%), and had a tertiary university education (66%). According to Statistics New Zealand data, the sample is close to the New Zealand population at large for the percentage of European ethnicity (79% vs 70% nationwide), but over-represents older residents (2014 Census Mean = 37.5 years), employed (71% vs 59% nationwide), females (65% vs. 51%), homeowners (81% vs. 47%), and those with higher education (66% vs. 26%) and income (74% vs. 24% earning $50,000 or more). See Table 1 for more details.

The first of the mainshock doublet earthquakes (CS) occurred on a Sunday evening, and thus, most (75%) respondents were located at home. Only 9% reported that they did not know where absent family members were, whereas 31% reported absent members who were known to be safe. In comparison, the second of doublet earthquakes (LG) occurred on a Friday afternoon, and thus, 41% of respondents indicated they were at work in the central suburbs, and only 34% were at home. A much higher 46% did not know where absent family

Table 1
Demographic statistics comparing sample statistics to those of the 2013 census for the survey area, Wellington Region and nation.
Source:Source of census data: [85], as reported in [35].

Question group	Question variable	Survey sample (%)	Survey meshblocks[a], 2013 census (%)	Wellington region, 2013 census (%)	National, 2013 census (%)
Ethnicity	NZ European	79	78	73	70
	Maori	6	8	12	14
	Samoan or Other Pacific Islander	2	6	8	7
	Chinese	1	10[b]	10[b]	11[b]
	Indian	1			
	Other	0	2	2	2
Gender	Male	35	49	48	49
	Female	65	51	52	51
Education level	Uni undergrad degree	46	20	24	20
	Uni postgrad degree	20	14	9	6
	Secondary school	16	34	37	38
	Trade or professional certificate or diploma	15	8	8	8
	No school qualifications	4	11	15	19
Employment	Employed	71	70	62	59
	Retired	14		29[c]	31[c]
	At-home parents	5	23[c]		
	Students	2			
	Unemployed	5	4	5	5
Household income	Less than NZ$ 20,000	10	6[d]	32	35
	NZ$ 20,000–29,000	10	6[d]	11[d]	12[d]
	$30,000–39,000	3	12[e]	10[d]	11[d]
	$40,000–49,000	4		8[d]	9[d]
	$50,000 or more	74	63	30	24
Home ownership	Owner	81	50	49	47
	Rent	9	46[f]	33[f]	33[f]

[a] Refers to the census meshblocks in which this survey was conducted. Some categories are distinct in the survey but part of wider category in census data as: .
[b] Asian.
[c] Not in the labour force.
[d] Corresponding thresholds in census data are: $20,000 or less; $20,001–$25,000 and $25,001–$30,000 (combined); $30,001–$35,000 and $35,001–$40,000 combined; $40,001–$50,000; and over $50,001 (multiple categories combined).
[e] $30,000–50,000.
[f] Not owned.

members were, and approximately the same number as CS (30%) reported absent members known to be safe.

2.3. Analyses

All data were analysed using IBM Statistical Package for the Social Sciences (SPSS) software.[9] We present the analysis of these questions, considering four main themes: 1) experiences and preparedness actions, 2) how beliefs, impacts and concern relate to preparedness actions, 3) perceptions of aftershock advice, 4) perceptions of future earthquake likelihoods.

3. Results

3.1. Experiences and preparedness actions

3.1.1. Preparedness actions

One hundred and seventy-two people reported that they were in the region for the CS earthquake which was the first of the mainshock doublet,175 for LS which was the second of the doublet, and 152 for both. Considering the two foreshock events, 137 and 131 people reported they felt the FM and SM earthquakes, respectively, and 113 felt both. The numbers of people who then took action in each of the four earthquakes, and the actions they took are shown in Table 2.

For the first foreshock (FM), a chi-square analysis shows that there was no association between feeling the earthquake(Y/N) and overall taking action to prepare for future earthquakes (χ^2 (1, N = 178) = 3.49, *ns*). However, there were weak but significant relationships between feeling the shaking and getting basic supplies, (χ^2 (1, N = 196) = 4.91, $p = 0.027$, $\varphi = -0.16$), getting basic equipment (χ^2 (1, N = 196) = 4.03, $p = 0.045$, $\varphi = -0.14$), and making damage mitigation (χ^2 (1, N = 196) = 4.24, $p = 0.039$, $\varphi = -0.15$), but not for reviewing logistics (χ^2 (1, N = 196) = 1.37, *ns*).

For the second foreshock (SM) we found a significant, but weak, relationship between feeling the shaking and taking a preparedness action (χ^2 (1, N = 161) = 6.87, $p = 0.009$, $\Phi = 0.21$) with 23% of those that felt the shaking stating they took action. For the sub-categories of actions, this relationship was reflected in basic supplies (χ^2 (1, N = 192) = 5.90, $p = 0.015$, $\varphi = -0.18$), basic equipment (χ^2 (1, N = 192) = 3.91, $p = 0.048$, $\varphi = -0.14$), and damage mitigation (χ^2 (1,N = 192) = 5.24, $p = 0.022$, $\varphi = -0.17$), but again not for reviewing logistics (χ^2 (1,N = 192) = 1.73, *ns*).

Comparing the number of people who took any one of the four actions following the CS and LG earthquakes, a related-samples McNemar's change test was run with continuity correction (asymptotic), considering all participants, showing that the number who took any of the actions was significantly higher after the first (CS) of the mainshock doublet (108, 53%) than after the second (LG) of the mainshock doublet (86, 42%; χ^2 (1, N = 205) = 6.30, $p = 0.012$).

We next compare participants' preparedness actions taken after the earthquake to what supplies or plans they stated they had to hand at the time of the two mainshock doublet earthquakes, illustrated in Table 3. For the CS earthquake, of the 57 people who got basic supplies after the earthquake, 25 did not already have water (44%), 16 did not have food

[9] http://www.ibm.com/analytics/us/en/technology/spss/; last Accessed 26th June 2018.

Table 2
The number of respondents who felt the earlier earthquakes and took action; and the number who were in the region for the CS and LG earthquakes and took action. N = 204. *A further 5 people took action in the CS earthquake and 6 in the LG earthquake, but these participants did not state whether they were in the region or not so are not included. Note that for the foreshock events (FM, SM) participants were asked if they felt the earthquake, but not explicitly whether they were in the region. For the mainshock events (CS, LG) participants were asked if they were present in the region, and then later asked to indicate the degree of shaking they felt (see Section 3.1.2, and Appendix A).*

	Friday 19th July (M5.7), FM		Sunday 21st July (M5.8), SM		Sunday 21st July (M6.5), CS		Friday 16th August (M6.6), LG	
Present in the region	n/a		n/a		172	84%	175	86%
Felt the earthquake	137	67%	131	64%	n/a		n/a	
Of those who felt the earthquake or were present in the region: *Percentages shown are relative to the number who felt the earthquake or were present in the region.*								
Took action	42	31%	30	23%	103	60%	80	46%
Got basic supplies	26	19%	22	17%	57	33%	31	18%
Got basic equipment	24	18%	18	14%	49	28%	23	13%
Reviewed logistics	18	13%	13	10%	39	23%	36	21%
Undertook damage mitigations	15	11%	16	12%	59	34%	41	23%

(28%) and 24 did not have an emergency kit (42%). Similarly, of the 39 people who reviewed logistics after the earthquake, 16 did not already have a household plan (41%) and 21 did not have a place to evacuate (54%). Finally, of the 49 who got basic equipment, 17 did not already have a battery radio (35%). This indicates that the CS earthquake prompted people to make new preparations that they did not have in place at the time the shaking occurred. However, interestingly it also shows that the earthquake prompted a large proportion of participants who had taken action prior to the earthquakes to either *review* or *enhance* their existing preparations. For example, of the 57 people who got basic supplies, while 25 did not already have water, 32 *did*, and while 16 did not have stored food, 41 *did*. Similarly, of the 39 who reviewed logistics, 16 did not already have a plan, but 23 *did*. Similar preparedness results were also found for the LG earthquake (Table 3).

For participants who stated they were *in the region for both earthquakes* (illustrated in Table 4; N = 152), a related-samples McNemar change test shows a difference in preparedness between the two events, χ^2 (1) = 9.88, p = 0.002, with a decrease from 83 participants taking any of the four actions after CS to 60 preparing after LG. This change included 47 people taking action in both, 56 not taking action in either, 36 people only taking action in the CS earthquake (and not in the following LG earthquake), and 13 people only taking action in the LG (and not in the earlier CS earthquake). Considering the individual preparedness actions, we find more people got basic supplies (e.g. food and water) after the CS versus the LG earthquake (χ^2 (1) = 9.76, p = 0.002), got basic equipment (χ^2 (1) = 14.67, $p < 0.0005$), and undertook damage mitigation (χ^2 (1) = 11.25, p = 0.001, exact not asymptotic). However, there is no difference between reviewing logistics (χ^2 (1) = 1.16, *ns*) after CS or LG, reflecting the smaller proportion who reviewed logistics only after CS and the higher number after LG (the discordant pair).

3.1.2. Felt shaking intensity and preparedness actions. Considering next the intensity of the CS and LG earthquakes, a Mann-Whitney U test shows a significant relationship between the level of shaking felt during the CS earthquake (N = 187) and being prompted to get basic equipment (U = 4.06, Z = 1.98, p = 0.048), review logistics (U = 3.80, Z = 2.92, p = 0.004), and take damage mitigation actions (U = 4.66, z = 2.701, p = 0.007), but not for getting basic supplies. However, for the LG earthquake there was a significant relationship only between felt shaking intensity and reviewing logistics (U = 3.95, Z = 3.80, $p < 0.0005$, N = 191). Moreover, a Wilcoxon signed rank test shows that for individuals who experienced both earthquakes, there was no difference in perceived shaking intensity (Z = 1.02, *ns*, N = 174). Considering shaking duration, a Wilcoxon signed rank test finds the participants rating the LG earthquake as significantly longer than the CS earthquake (Z = 2.36, p = 0.018, N = 164, asymptotic not exact).

Table 3
Comparing people's preparedness actions after the earthquake with items and plans they had in place at the time of the earthquake. Numbers represent the people who took that action who **did not** have the related item or plan in place at the time of the earthquake (e.g. got basic supplies after earthquake, did not have 3 days water at time of earthquake).

Cook Strait earthquake (CS)					
People who did not have	**And then took any action (N = 103)**		**And then took a specific action**		**Action details**
3 days water	36	35%	25	44%	Got basic supplies
3 days food	28	27%	16	28%	(N = 57)
EM kit	38	37%	24	42%	
Battery radio	33	32%	17	35%	Got basic equipment (N = 49)
Household plan	59	57%	16	41%	Reviewed logistics
Place to evacuate	62	60%	21	54%	(N = 39)
Lake Grassmere Earthquake (LG)					
People who did not have	**And then took any action (N = 80)**		**And then took a specific action**		**Action details**
3 days water	28	35%	11	36%	Got basic supplies
3 days food	31	39%	13	42%	(N = 31)
EM kit	34	43%	18	**58%**	
Battery radio	38	48%	9	39%	Got basic equipment (N = 23)
Household plan	46	**58%**	12	33%	Reviewed logistics
Place to evacuate	39	49%	13	36%	(N = 36)

Table 4
Actions taken by participants who were in the region for *both* earthquakes. (N = 152).

Action	Took action in CS		Took action in LG		Didn't prepare in either		Prepared in both		Prepared only after first (CS)		Prepared only after second (LG)	
Any of the four actions	83	55%	60	39%	56	37%	47	31%	36	24%	13	9%
Got basic supplies	48	32%	27	18%	94	62%	17	11%	31	20%	10	7%
Got basic equipment	42	28%	19	13%	105	69%	14	9%	28	18%	5	3%
Review logistics	37	24%	30	20%	103	68%	18	12%	19	13%	12	8%
Damage mitigation	52	34%	36	24%	98	64%	34	22%	18	12%	2	1%

3.2. Beliefs, impacts, and concern

3.2.1. Beliefs during earthquake shaking and preparedness actions

Table 5 shows nearly all participants reported low levels of belief during the CS earthquake that the building they were in or their home would be damaged, and low levels of belief that they or their family would be injured or that there would be disruption to their job. However, participants reported a higher belief that there would be disruption to electrical, telephone, or service interruption compared to these other beliefs (vs. building damaged: $t(148) = -6.21$, $p < 0.0005$; vs. home damaged: $t(154) = -6.04$, $p < 0.0005$; vs. family injured $t(153) = -6.64$, $p < 0.0005$; vs. job disruption: $t(146) = -5.86$, $p < 0.0005$).

Nearly all participants reported low levels of belief during the LG earthquake that the building they were in or their home would be damaged, or their family would be injured (Table 5). However, participants reported higher relative belief that there would be disruption to their job (vs. building damaged: $t(155) = -4.61$, $p < 0.0005$; vs. home damaged: $t(154) = -6.07$, $p < 0.0005$; vs. family injured: $t(156) = -5.05$, $p < 0.0005$), and higher beliefs that there would be disruption to electrical, telephone or service interruption (vs. building damaged: $t(160) = -5.51$, $p < 0.0005$; vs. home damaged: $t(160) = -8.41$, $p < 0.0005$; vs. family injured: $t(161) = -7.56$, $p < 0.0005$). However there is no significant difference between beliefs about job disruption vs. electrical, telephone or service interruption. Interestingly, for LG, participants who were not at home had higher beliefs that the building they were in would be damaged than their home would be damaged, $t(159) = 3.54$, $p < 0.005$. These results indicate that the greatest belief during CS, when the majority of people were at home with their families, was that there would be service and communication interruption. However, during LG, when the majority of people were away from home, their greatest belief was that there would be disruption to their job, disruption to communications, and that the building they were in would be more damaged than their home.

Considering only those respondents present for both earthquakes, paired *t*-tests indicate higher beliefs for the LG earthquake than CS that the building they were in would be damaged, that family members would be injured, and that their job would be disrupted (see Table 5). Given that LG occurred on a Friday work afternoon, whereas CS was on a Sunday evening, this implies that participants felt their homes were safer than workplaces and schools, that they were more concerned about injury to their family members when apart from them during a work day, and that they believed an earthquake during their work day would have more impact to their job than one on a weekend evening.

Considering how these beliefs compare to preparedness actions after CS, people who believed the building they were in would be damaged, and those who believed injuries would occur to family members were significantly more likely to get basic equipment (for brevity reported in Table 6). In addition, people who expected job disruption were significantly more likely to have reviewed their logistics and taken any of the four actions. For the LG earthquake, people who had higher levels of any of the five risk perceptions were more likely to review their logistics (for brevity reported in Table 7). In addition, those who expected higher levels of electrical telephone and/or service interruption were also significantly more likely to review logistics, take damage mitigation, and take any action. Finally, those who scored a higher belief about injuries to members of the family were significantly more likely to take any of the four preparedness actions. These results indicate that reviewing logistics related more to impact beliefs for the second earthquake (LG) than for the first (CS) one. In addition, electricity, telephone and/or service interruption beliefs influenced actions more for LG compared to CS. This could again be attributed to the second (LG) earthquake occurring on a Friday afternoon, impacting communication and travel plans for individuals and families (see Section 1).

3.2.2. Impacts from the earthquakes

For the CS earthquake, five of the impact variables had such a low incidence that it was not possible to examine how they related to preparedness. Specifically, only two people (1.2%) reported household injuries, three (1.4%) participants reported electricity interruption, eight reported internet interruption, four reported satellite or cable TV access interruption, and 11 reported telephone interruption. However, there was variation in damage: 142 people (78%) reported no damage to their home, 37 (20.3%) reported slight damage, and three reported moderate damage, and no one reported severe damage.

The LG earthquake also produced low levels of physical impacts. Only three people (1.8%) reported household injuries, four (2.1%) reported electricity interruption, one (0.5%) reported water interruption, three (1.4%) reported internet interruption, two (1.0%) reported

Table 5
The difference in belief scores between CS and LG, where participants reported how much they believed each of the following during the earthquake shaking: Scaled from 1 (not at all) to 5 (very great extent).

Beliefs	CS Considering all responses			LG Considering all responses			Comparing via paired *t*-tests (considering only those who experienced both earthquakes)		
	Mean	SD	Skew	Mean	SD	Skew	Mean diff	(SD diff)	Test result
Building participant in would be damaged	1.89	0.99	0.86	2.14	1.19	0.71	0.29	0.92	$t(142) = -3.71$, $p < 0.0005$,
Home damaged	1.97	0.95	0.68	1.91	0.98	0.88	0.03	0.73	NS
Family injured	1.89	1.00	1.08	2.02	1.09	0.88	0.18	0.84	$t(142) = -2.60$, $p = 0.010$
Job disruption	1.95	1.23	1.24	2.57	1.42	0.38	0.54	1.15	$t(134) = -5.46$, $p < 0.0005$
Electrical, telephone, service interruption	2.49	1.13	0.30	2.67	1.20	0.33	0.16	1.02	NS

Table 6
The relationships between beliefs and preparedness actions for the first (CS) earthquake, where participants indicated how much they believed each of the following during the earthquake shaking: Scaled from 1 (not at all) to 5 (very great extent). This independent samples t- test examined whether there was a difference between the belief scores for those who prepared and those who did not (for each action). *using equal variances not assumed test statistic.

Belief	Action	Belief score for those who took action (Y) or not (N) (mean and SD shown)		Mean Diff (& SD)	T test statistic
		Y	N		
Building participant in would be damaged	**Basic equipment**	2.13 ± 0.97	1.79 ± 0.99,	0.344 ± 0.17	$t(157) = -1.98$, $p = 0.049$
Family injured	**Basic equipment**	2.17 ± 0.94	1.76 ± 0.98	0.433 ± 0.17	$t(157) = -2.53$, $p = 0.012$
Job disruption	**Review logistics**	2.47 ± 1.44	1.78 ± 1.11	0.695 ± 0.26	$t^*(49) = -2.65$, $p = 0.011$
Job disruption	**Any action**	2.18 ± 1.34	1.60 ± 0.96	0.582 ± 0.19	$t^*(146) = -3.08$, $p = 0.002$

satellite or cable TV interruption, and seven (3.4%) reported telephone interruption. However, this earthquake also produced variation in damage; 147 (79.9%) people indicated there was no damage to their home, 36 (19.6%) reported slight damage, and one (0.5%) reported moderate damage.

3.2.3. Immediate aftershock concern after CS

Concern about a damaging aftershock or earthquake in the Wellington region during the week following the CS earthquake (termed '*immediate aftershock concern*') was fairly high (M = 4.16, SD = 0.87, N = 199; Fig. 2). Those who had higher concern were more likely to take any of the four preparedness actions after the earthquake (see Table 8). They were also more likely to believe that the building they were in and their home would be damaged, there would be family injuries, and there would be disruption to their jobs and infrastructure (Table 9).

3.2.4. Future concern after both earthquakes

Participants showed fairly high levels of concern (M = 3.84, SD = 0.93, N = 203, Fig. 2) about a damaging earthquake or aftershock in the region after the mainshock doublet earthquake sequence (termed '*future concern*'), with 63% reporting an increase in concern about future events. However, this was significantly lower than the levels of '*immediate aftershock concern*' after the first of the mainshock doublet (CS) earthquakes, $t(197) = 4.19$, $p < 0.0005$, mean difference: 0.318 ± 1.069. People who had higher levels of concern had higher rates of all preparedness actions after LG, but only 'reviewed logistics' was statistically significant (Table 10). Considering the beliefs experienced in the LG earthquake and levels of future concern (Table 9), there are also positive correlations between risk perceptions during the LG earthquake (building and home damage, family injuries, and job and infrastructure interruption) and future concern.

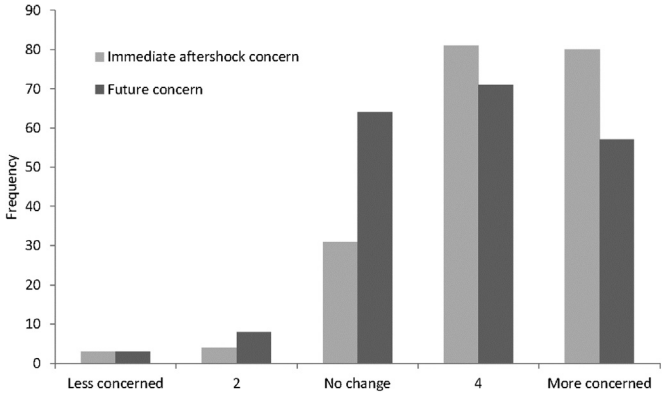

Fig. 2. : People's concern about a damaging aftershock or earthquake in the Wellington region during the week following the Cook Strait earthquake ('immediate aftershock concern'), and people's concern about a damaging aftershock since both earthquakes ('future concern'), assessed on a scale from 1 (Less concerned) to 5 (More concerned), with the midpoint of 3 representing 'No Change' in levels of concern (See Appendix A, question 12).

3.2.5. The relationships between demographics, actions, and concern

Considering the relationships between demographics and actions, females took more preparedness actions than males after the first (CS) mainshock doublet for: taking any of the four actions (χ^2 (1) = 4.40, $p = 0.036$, $\phi = 0.15$), getting basic supplies (χ^2 (1) = 5.38, $p = 0.020$, $\phi = 0.16$), and getting basic equipment (χ^2 (1) = 5.16, $p = 0.023$, $\phi = 0.16$). There was no difference between genders for reviewing logistics or damage mitigation. For the second (LG) mainshock doublet,

Table 7
The relationships between beliefs and preparedness actions for the second (LG) earthquake, where participants indicated how much they believed each of the following during the earthquake shaking: Scaled from 1 (not at all) to 5 (very great extent). This independent samples t- test examined whether there was a difference between the belief scores for those who prepared or not (for each action). *using equal variances not assumed test statistic.

Belief	Action	Belief score for those that took action (Y) or not (N) (mean and SD shown)		Mean Diff (& SD)	T test statistic
		Y	N		
Building participant in would be damaged	**Review logistics**	2.67 ± 1.15	2.00 ± 1.16	0.67 ± 2.18	$t(168) = -3.06$, $p = 0.003$
Home damaged	**Review logistics**	2.28 ± 1.16	1.81 ± 0.91	0.47 ± 0.18	$t(164) = 2.58$, $p = 0.011$
Family injured	**Review logistics**	2.72 ± 1.32	1.83 ± 0.94	0.89 ± 2.35	$t^*(45.11) = -3.79$, $p < 0.0005$,
Job disruption	**Review logistics**	3.19 ± 1.41	2.39 ± 1.37	0.80 ± 0.26	$t(159) = -3.07$, $p = 0.003$
Electrical, telephone, service interruption	**Review logistics**	3.29 ± 1.25	2.51 ± 1.14	0.77 ± 0.22	$t(164) = -3.50$, $p = 0.001$
Electrical, telephone, service interruption	**Damage mitigation**	3.00 ± 1.38	2.56 ± 1.12	0.44 ± 0.21	$t(164) = -2.05$, $p = 0.042$,
Family injured	**Any action**	2.26 ± 1.20	1.82 ± 0.95	0.44 ± 0.17	$t^*(146.07) = -2.58$, $p = 0.011$,
Electrical, telephone, service interruption	**Any action**	2.90 ± 1.23	2.48 ± 1.14	0.42 ± 0.19	$t(164) = -2.28$, $p = 0.024$

Table 8
The relationship between levels of immediate aftershock concern and actions taken for the first (CS) mainshock doublet, via independent samples *t*-tests. Immediate aftershock concern was assessed on a scale from 1 (Less concerned) to 5 (More concerned), with the midpoint value of 3 representing 'No Change' (see Appendix A, question 11).

Action	Concern score for those that took action (Y) or not (N) (mean and SD shown)		Mean Diff (& SD)	T test statistic
	Y	N		
Any of the four actions	4.32 ± 0.81,	3.97 ± =0.90	0.37 ± 0.12	$t(197) = -2.95$, $p = 0.004$
Got basic supplies	4.36 ± 0.85	4.08 ± 0.86	0.28 ± 0.13	$t(197) = -2.12$, $p = 0.035$
Got basic equipment	4.63 ± 0.53	4.00 ± 0.90	0.63 ± 0.13	$t(197) = -4.69$, $p < 0.0005$
Review logistics	4.51 ± 0.68	4.07 ± 0.89	0.44 ± 0.15	$t(197) = -2.97$, $p = 0.003$
Damage mitigation	4.47 ± 0.75	4.03 ± 0.88	0.44 ± 0.13	$t(197) = -3.35$, $p = 0.001$

females reviewed logistics more than males (χ^2 (1) = 6.80, $p = 0.009$, $\phi = 0.18$) and took more damage mitigation actions (χ^2 (1) = 5.01, $p = 0.025$, $\phi = 0.16$). There was no difference between genders for taking any of the four actions, getting basic supplies, or getting basic equipment. No significant difference was found between the genders for actions taken after either of the earlier foreshock events.

For the second (LG) mainshock doublet, there was a significant association between education and taking any of the four actions (χ^2 (2) = 11.23, $p = 0.004$, $\phi = 0.24$), as well as education and getting basic supplies (χ^2 (2) = 7.23, $p = 0.027$, $\phi = 0.19$). A greater proportion of people with a trade or university qualification took action compared to those with secondary or no qualifications. For example, for any action 52% of those with a trade qualification and 46% of those with a university qualification took action, compared to 18% with no or secondary qualifications. However, education was not significantly related to action for the foreshock events, nor the first (CS) mainshock doublet. Ethnicity was also not significantly related to actions for any of the four earthquakes in the sequence.

Finally, there was a significant association between age and getting basic supplies (Fishers, $p = 0.002$), getting basic equipment (Fishers, $p = 0.003$) and damage mitigation (Fishers, $p = 0.021$) after the first (CS) mainshock doublet, with more actions taken by adults aged less than 55 than by older adults aged 55 and above. No association was found between age and actions after the foreshocks, nor for the second (LG) mainshock doublet.

To assess how demographics relate to concern, the concern rating was divided into two categories, 'less concerned or no change' (ratings 1–3, N = 68), and more concerned (rating 4–5, N = 120). A chi-square test shows a significant association between gender and *immediate aftershock concern*, with females reporting higher concern (χ^2 (1, N = 188) = 12.84, $p < 0.0005$, $\varphi = 0.26$). However, there was no association between gender and *future concern* about earthquakes, (χ^2 (1) = 2.01, *ns*). Education and ethnicity are not significantly related to either immediate aftershock or future concern. There was, however, a significant association between age and *immediate aftershock concern* (Fisher's $p = 0.004$), with lower levels of concern for older adults aged 55 and above than for those aged less than 55. No significant associations were found for other age group categorisations. No association was found between age and future earthquake concern after the earthquake sequence.

4. Discussion

The study results indicate that specific earthquake characteristics (e.g., timing in terms of daytime versus evening, participant location relative to family and home) influence the types of preparedness actions taken after an earthquake.

In terms of the specific preparedness actions taken after the CS and LG earthquakes in the mainshock doublet, with participants present for both earthquakes, the number of people who got basic supplies, got basic equipment, or undertook damage mitigation, decreased from the first (CS) earthquake to the second (LG) earthquake (Section 3.1). The McNemar test indicates that this difference was mainly due to people who prepared after CS then choosing not to also prepare after LG, perhaps due to believing they had taken sufficient actions after the first (CS) earthquake. However, there are a few who only took action after the second (LG) earthquake.

Considering the 'reviewing logistics' action there was no significant difference in reviewing logistics between CS and LG for those participants present in both earthquakes, reflecting the smaller proportion who reviewed logistics only after CS and the higher number who took that action after LG (the discordant pair). 'Reviewing logistics' becomes increasingly frequent after the second (LG) earthquake compared to both the first (CS) earthquake and the two earlier foreshocks, and thus reviewing logistics represents a greater proportion of the actions taken after LG than in CS. As presented in Section 3.1.2, for participants present in both of the mainshock doublet earthquakes, 19 of 36 who took action only after the CS earthquake took logistics action, compared to 12 of the 13 people who only took action after LG. Thus, a greater proportion of all actions taken after LG involved reviewing logistics. This suggests that 'reviewing logistics' was the action most strongly influenced by the characteristics of the earthquakes.

Table 9
Correlations between a) the beliefs reported in the first (CS) mainshock doublet earthquake and immediate aftershock concern; and b) beliefs reported in the second (LG) mainshock doublet and future earthquake concern since the earthquakes. Pearson's correlation coefficients are shown.

Beliefs in CS	Immediate aftershock concern after CS	Beliefs in LG	Future earthquake concern
beliefs during the CS earthquake shaking vs. concern for aftershocks and future earthquakes		**beliefs during the LG earthquake shaking vs. concern for future earthquakes**	
Building damaged	rho = 0.33, $p < 0.0005$, N = 158, moderate	**Building damaged**	rho = 0.27, $p < 0.0005$, N = 169, small
Home damaged	rho = 0.30, $p < 0.0005$, N = 162, moderate	**Home damaged**	rho = 0.29, $p < 0.0005$, N = 166, small
Family injured	rho = 0.37, $p < 0.0005$, N = 158, moderate	**Family injured**	rho = 0.32, $p < 0.0005$, N = 167, moderate
Job disruption	rho = 0.18, $p = 0.028$, N = 147, small	**Job disruption**	rho = 0.19, $p = 0.016$, N = 161, small
Electrical, telephone, service interruption	rho = 0.28, $p < 0.0005$, N = 158, small	**Electrical, telephone, service interruption**	rho = 0.37, $p < 0.0005$, N = 166, moderate

Table 10
Levels of future earthquake concern for those people who took specific actions and those who did not after the second (LG) mainshock doublet. Concern was assessed on a scale from 1 (Less concerned) to 5 (More concerned).

Action	Future concern score for those that took action (Y) or not (N) (mean and SD shown)		Mean Diff (& SD)	Independent samples T test statistic
	Y	N		
Any of the four actions	3.92 ± 0.91	3.79 ± 0.95	0.13 ± 0.132	NS
Got basic supplies	3.85 ± 0.94	3.84 ± 0.93	0.01 ± 0.18	NS
Got basic equipment	4.08 ± 0.88	3.81 ± 0.94	0.27 ± 0.20	NS
Review logistics	4.13 ± 0.91	3.78 ± 0.93	0.36 ± 0.17	$t(201) = -2.14$, $p = 0.033$
Damage mitigation	3.93 ± 0.89	3.82 ± 0.94	0.12 ± 0.16	NS

This finding can be understood by considering the different times of each earthquake. As discussed in Section 1, the first (CS) earthquake occurred on a Sunday evening when most people reported family members were with them. However, the second (LG) earthquake occurred on a Friday work afternoon when most people were separated from family, and there was disruption to people's ability to travel home. It seems reasonable that these travel impacts resulted in more reviewing of logistics after LG. This is supported by the findings regarding people's beliefs (Section 3.2.1). Considering beliefs within CS, the greatest belief was that there would be service and communications interruption. Within LG, the greatest beliefs were that there would be disruption to their job, disruption to communications, and that the building they were in would be more damaged than their home. Comparing between events, participants reported higher beliefs in the LG earthquake compared to CS; that the building they were in would be damaged, that family members would be injured, and that their job would be disrupted. So for the second (LG) earthquake, reviewing logistics was influenced more by these impact beliefs than for the first (CS) earthquake. In addition, it demonstrates that participants felt safer at home than at workplaces, and were more concerned about injury to family members when apart from them during their work day.

The free text responses provided by participants further exemplify how the different household contexts prompted different types of actions (such as reviewing logistics), and the effect that telecommunication interruptions and being separated from family members had on these actions:

- *"From 16th August – Very unnerving to be away from my local area and home. Always conscious of having good walking shoes with me at all times. Keep shoes by the bed at night. Scary driving through town to get home"*
- *"I was more concerned for my household members after Friday 16th August because I couldn't contact them"*
- *"I was surprised at how different the experience can be depending on where you are when it happens"*
- *"I was surprised how jammed the telephones were after the 2nd quake – I didn't like it!"*

Notably there was also a relationship between shaking and taking action after CS, but for LG this relationship was only seen for reviewing logistics, most likely reflecting the outstanding action to be taken after LG. However, this may also reflect the higher degree of shaking felt by office workers in tall buildings in the CBD during the LG earthquake, who would also have been more impacted by poor logistics plans that failed to adequately provide for being away from home; this should be explored further in future research. As stated by two participants, the different characteristics and vulnerabilities of the CBD buildings, compared to homes, were made more meaningful by the second (LG) earthquake:

- *"Having my husband work in the CBD, I'm 100% worried and fearful for his life, should a seriously big one strike when he is at work"*
- *"The Friday 16 August series of earthquakes were considerably scarier. Especially on the 7th Floor of our building. Though [workplace] is very new and coped with the earthquake really well. I must get my chimney removed and piles looked at in my house"*

Considering preparedness actions in general, while a number of participants who took actions had no previous preparedness items or plans at the time of the earthquakes, the majority of those who took action already had some of these items or plans in place (see Table 3). A larger proportion of participants were prompted by the earthquakes to review or enhance their existing preparations, than those who were prompted to take entirely new preparedness actions. Russell et al. [74] found that experiencing earthquakes increased preparedness, especially for individuals that had the greatest impacts on their life, as represented by their earthquake damage experiences and their level of fear during shaking. The present findings show that a) repeated earthquakes mostly encouraged a review of preparedness which then resulted in an increase in existing preparedness actions, rather than initiation of new ones; and that b) the type of existing preparedness actions that were increased depended upon the context of the earthquake. The initiation of some actions was lower after LG (perhaps because they had been completed after the previous CS earthquake), while some actions were higher because they were recognised as a new need in the second LG earthquake due to beliefs about impacts in that event. This can be considered a form of problem-focussed coping [8], a target action to directly address a noticed problem for future earthquakes. It may be motivated by a reduction in optimistic bias regarding a specific impact experienced in an event [43], or by changes in risk perception due to risk experience appraisal [37].

Our results also indicate that *immediate aftershock concern* after the first (CS) earthquake, and *future earthquake concern* after the mainshock doublet sequence, related to actions. There were higher ratings of immediate aftershock concern for those who took action after CS than those who did not, and higher ratings of future earthquake concern for those who reviewed logistics after LG. This supports findings that direct experience heightens threat knowledge and risk perception [66], and that experience can impact concern and anxiety [22,42,79], and thus preparedness actions [30,51].

Participants rated *immediate aftershock concern* higher than their *future earthquake concern*. This may reflect their understanding that aftershocks usually decrease in frequency over time. However, given we asked them about their concern about future *earthquakes* and not only *aftershocks*; it may also reflect the decreasing importance of experience with time since a hazard event. Burger and Palmer [16] found that people's sense of invulnerability to a hazard decreased after an event, but only for few months. Thus, participants' concern in the week after the first (CS) earthquake about future aftershocks may have been higher due to the immediacy of the event. However, participants reported their future earthquake concern when the survey was conducted in October 2013, which was a few months after the second LG earthquake (August). Thus any direct experience-related effects on risk perception and concern may have declined to usual levels by then. This again suggests a limited window for risk preparedness messaging after an event (see also [56]). In addition, the lower levels of *future earthquake concern*

relative to *immediate aftershock concern* may reflect a normalisation bias [61] and thus unrealistic optimism [16,43,46,84] due to the fact the earthquakes in the mainshock doublet had relatively low impacts. This low impact, termed a "false experience" by Baker [1], could have thus reduced participants' future risk perceptions and concern about earthquakes.

Those who reviewed logistics actions after LG rated *future earthquake concern* higher than those who did not. These participants may reflect a specific group who had direct impacts that heightened their concern about the logistics enough to prompt them to act by reviewing logistics. The specific impacts of that earthquake may have changed their mental models [62] of the risk and impacts of future earthquakes, and thus prompted these actions.

Our study finds that females took more actions than men, after both CS and LG, with a focus on getting basic supplies and equipment after CS and a focus on logistics and damage mitigation after LG. However, there was no difference between genders for either of the smaller foreshock events. Interestingly, females also reported higher *immediate aftershock concern* after CS, but not for future earthquake concern after the mainshock doublet sequence. The difference between which actions were taken by females between the CS and LG events may relate to the specific concerns that were raised within each event, and further research should explore the relationships between gender and specific concerns and actions (see also Section 1.2).

Finally, we find older adults reported lower levels of *immediate aftershock concern* after CS, and also took less actions after CS. However, these associations are not seen for *future earthquake concern* and actions after LG, and future research should explore how specific concerns relate to actions in different age categories.

4.1. Limitations and future research

There were some limitations to this study. The sample was not exactly representative of all demographic categories. In particular, while the sample was close to the NZ population for ethnicity (79% European vs. 70% nationwide), it particularly over-represents education (66% vs. 26%), homeownership (81% vs. 47%), and income (74% vs. 24%) (see Table 1 and Section 2.2). Thus, the sample represents a disproportionally educated and affluent group of participants, which may bias our results towards increased levels of risk perception and ability and resources to prepare and take actions (see Section 1.2). However, over representation of some demographic categories contributes to bias in other variables such as risk perception and preparedness action only to the degree that the latter variables are correlated with demographic variables, but such correlations are low in this sample, as well as more generally [14,49,50,53]. While our 34% response rate was not particularly low, we note reports by Curtin et al. [18], Keeter et al. [47], and Lindell and Perry [50] that indicate low response rates do not appear to bias central tendency estimates such as means and proportions, and Lindell and Perry [50] presented psychometric reasons for believing low response rates are unlikely to affect correlations.

Other limitations include the fact that the individuals who answered the survey questionnaire were reporting upon their individual perceptions, concerns, and beliefs, but the actions they took may have actually represented their household or family's actions rather than just their own actions, affecting the relationships explored (see [45]). The effect or influence of other household members upon an individual's or family's actions could be considered in future surveys. In addition, participants may have been influenced by hindsight bias regarding their recollection of their beliefs and concerns during and after the earthquakes, and their inclination to view the earthquakes as having been more predictable and more probable after it has occurred [34]. Finally, response bias may have arisen due to the 'social desirability bias' [68] whereby respondents may have reported what they thought investigators wanted to hear, to appear more compliant with social norms and more favourable to the researchers.

5. Conclusions

The analysis of this earthquake sequence demonstrates how individual earthquake characteristics (primarily time of day and whether it was a work day or not) and location of participants with respect to their home and family, influence the subsequent preparedness actions taken after the earthquake. Unlike other studies, we find that overall preparedness actions actually decreased after the repeated earthquakes as people considered themselves prepared 'enough'. However, analysis of the proportion of individual actions between events highlights that while some actions decreased (equipment, supplies, damage mitigation), some actually increased (reviewing logistics). We suggest this is due to the different experiences of each earthquake, and the role played by being away from family members and concern about family injuries, job disruption, and service interruption.

Further, our results highlight that while there was a reduction in *new* actions from CS and LG, there were a large number of participants who reviewed or revisited their prior actions, assessing and evaluating their specific needs. This can be considered a form of problem-focused coping, a targeted action to a noticed problem, or a reduction in optimistic bias regarding a specific impact due to their direct experience. This evaluation of needs may have been driven primarily by concern, as both immediate aftershock concern and future earthquake concern were found to increase actions. However, immediate aftershock concern was greater than future earthquake concern, perhaps due to the reduction of the influence of direct experience on risk perception with time, or alternatively due to an unrealistic optimistic bias due to normalisation. This supports existing research [56] which highlights that to maximise the potential benefits of an earthquake's influence on preparedness actions, there is actually a limited window after an event for preparedness initiatives and action messaging to have an effect. In addition, our findings suggest that such messaging should focus on aspects and impacts that were unique to that event, as people are in a state where they may be more receptive to action messaging related to the particular impact that elicited the highest rates of concern (in this case logistics planning after LG). However, this type of targeted messaging must be done with care, so as to not result in a relative reduction in preparedness for the impacts not experienced in that event. In contrast, these findings could alternatively suggest that targeted action messaging should focus on those impacts *not* experienced in the earthquake, under the assumption that people will already be preparing for the impacts they experienced most severely or that elicited the highest rates of concern. Future research should thus investigate the merits and efficacy of different types of targeted preparedness initiatives and messaging after earthquake events.

Finally, while this earthquake sequence resulted in low levels of impacts and damage, it was still important to analyse as it provided interesting findings regarding how disruption (in lieu of major damage) influences earthquake preparedness actions. It demonstrates the importance of studying *both* low impact and high impact earthquake events, as the former can help inform our understanding of how frequent low magnitude events influence preparedness ahead of a significant event. This is particularly important for highly active seismic areas, such as Wellington, N.Z.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ijdrr.2018.07.008.

References

[1] E.J. Baker, Hurricane evacuation behavior, Int. J. Mass Emerg. Disasters 9 (2) (1991) 287–310.
[2] L.R. Baker, L.A. Cormier, Disasters and Vulnerable Population: Evidence-based Practice for Helping Professions, Springer Publishing Company, New York, 2015.
[3] J. Barclay, K. Haynes, T.O.M. Mitchell, C. Solana, R. Teeuw, A. Darnell, S.H. Crosweller, et al., Framing volcanic risk communication within disaster risk reduction: finding ways for the social and physical sciences to work together, Geol. Soc., Lond. Spec. Publ. 305 (1) (2008) 163–177, https://doi.org/10.1144/SP305.14.
[4] L.R. Barnes, E.C. Gruntfest, M.H. Hayden, D.M. Schultz, C. Benight, False alarms and close calls: a conceptual model of warning accuracy, Weather Forecast. 22 (5) (2007) 1140–1147, https://doi.org/10.1175/WAF1031.1.
[5] J.M. Bateman, B. Edwards, Gender and evacuation: a closer look at why women are more likely to evacuate for hurricanes, Nat. Hazards Rev. 3 (3) (2002) 107–117, https://doi.org/10.1061/(ASCE)1527-6988(2002)3:3(107).
[6] J.S. Becker, D. Paton, D.M. Johnston, K.R. Ronan, A model of household preparedness for earthquakes: how individuals make meaning of earthquake information and how this influences preparedness, Nat. Hazards 64 (1) (2012) 107–137, https://doi.org/10.1007/s11069-012-0238-x.
[7] J.S. Becker, D. Paton, D.M. Johnston, K. Ronan, "Societal influences on earthquake information meaning-making and household preparedness", Int. J. Mass Emerg. Disasters 32 (2) (2014) 317–352.
[8] J.S. Becker, D.M. Johnston, D. Paton, Communication of risk: a community resilience perspective. 2015/55. GNS Science Report. Lower Hutt, New Zealand, 2015.
[9] J.S. Becker, D. Paton, D.M. Johnston, K.R. Ronan, J. McClure, The role of prior experience in informing and motivating earthquake preparedness, Int. J. Disaster Risk Reduct. 22 (2017) 179–193, https://doi.org/10.1016/j.ijdrr.2017.03.006.
[10] D. Blake, J. Marlowe, D. Johnston, Get Prepared: discourse for the privileged?" International journal of disaster risk reduction 25: 283-288.bolin B. 2007 "Race, class, ethnicity, and disaster vulnerability, in: H. Rodríguez, E.L. Quarantelli, R.R. Dynes (Eds.), Handbook of Disaster Research. Handbooks of Sociology and Social Research, Springer, New York, NY, 2017.
[11] B. Bolin, Race, class, ethnicity, and disaster vulnerability, in: H. Rodriguez, E.L. Quarantelli, R.R. Dynes (Eds.), Handbook of Disaster Research, Springer Science, New York, NY, 2007, pp. 113–129.
[12] A. Bostrom, Future risk communication, Futures 35 (6) (2003) 553–573 〈http://www.sciencedirect.com/science/article/B6V65-47X1WC0-2/2/96fc4a07bc1b7dfd4c04573af4fa035c〉.
[13] A. Bostrom, R.E. Löfstedt, Communicating risk: wireless and hardwired, Risk Anal.: Off. Publ. Soc. Risk Anal. 23 (2) (2003) 241–248 〈http://www.ncbi.nlm.nih.gov/pubmed/12731809〉.
[14] L. B. Bourque, L. A. Russell, and J. D. Goltz. "Human Behavior during and Immediately after the Earthquake." In The Loma Prieta, California, Earthquake of October 17, 1989: Public Response, edited by Patricia A Bolton, B3–22. Professional Paper 1553-B. Washington, D.C., USA: U.S. Geological Survey.1993. (pubs.usgs.gov/pp/pp1553/pp1553b/).
[15] K. Broad, A. Leiserowitz, J. Weinkle, M. Steketee, Misinterpretations of the 'cone of uncertainty' in Florida during the 2004 hurricane Season, Bull. Am. Meteorol. Soc. 88 (5) (2007) 651, https://doi.org/10.1175/BAMS-88-5-651.
[16] J.M. Burger, M.L. Palmer, Changes in and generalization of unrealistic optimism following experiences with stressful events: reactions to the 1989 California earthquake, Personal. Social. Psychol. Bull. 18 (1) (1992) 39–43, https://doi.org/10.1177/0146167292181006.
[17] M. Coomer, E.E.H. Doyle, D.M. Johnston, J.S. Becker, S.A. Fraser, S. Johal, G.S. Leonard, S.H. Potter, John McClure, K.C. Wright, Cook Strait Earthquakes: survey on reactions of Wellington residents to the Cook Strait earthquake sequence. 2014/41. GNS Science Report. Lower Hutt, New Zealand, 2014.
[18] R. Curtin, S. Presser, E. Singer, The effects of response rate changes on the index of consumer sentiment, Public Opin. Q. 64 (4) (2000) 413–428, https://doi.org/10.1086/318638.
[19] S.L. Cutter, B.J. Boruff, W.L. Sand hirley, Social vulnerability to environmental hazards, Social. Sci. Q. 84 (2) (2003) 242–261.
[20] R.L. Dillon, C.H. Tinsley, Near-miss events, risk messages, and decision making, Environ. Syst. Decis. 36 (1) (2016) 34–44, https://doi.org/10.1007/s10669-015-9578-x.
[21] A. Donovan, C. Oppenheimer, Science, policy and place in volcanic Disasters: insights from Montserrat, Environ. Sci. Policy 39 (2013) 1–12, https://doi.org/10.1016/j.envsci.2013.08.009.
[22] R. Dooley, S. Catalano, S. Mishra, D. Serxner, Earthquake preparedness: predictors in a community survey, J. Appl. Social. Psychol. 22 (6) (1992) 451–470, https://doi.org/10.1111/j.1559-1816.1992.tb00984.x.
[23] K. Dow, S.L. Cutter, Crying wolf: repeat responses to hurricane evacuation orders, Coast. Manag. 26 (1998) 237–252.
[24] E.E.H. Doyle, J. McClure, D.M. Johnston, D. Paton, Communicating likelihoods and probabilities in forecasts of volcanic eruptions, J. Volcanol. Geotherm. Res. 272 (January) (2014) 1–15, https://doi.org/10.1016/j.jvolgeores.2013.12.006 (Elsevier B.V.).
[25] E.E.H. Doyle, J. McClure, D. Paton, D.M. Johnston, Uncertainty and decision making: volcanic crisis scenarios, Int. J. Disaster Risk Reduct. 10 (2014) 75–101, https://doi.org/10.1016/j.ijdrr.2014.07.006.
[26] E.E.H. Doyle, D.M. Johnston, J. McClure, D. Paton, The communication of uncertain scientific advice during natural hazard events, N.Z. J. Psychol. 40 (4) (2011) 39–50.
[27] J.R. Eiser, A. Bostrom, I. Burton, D.M. Johnston, J. McClure, D. Paton, J. van der Pligt, M.P. White, Risk interpretation and action: a conceptual framework for responses to natural hazards, Int. J. Disaster Risk Reduct. 1 (2012) 5–16, https://doi.org/10.1016/j.ijdrr.2012.05.002.
[28] E. Enarson, A. Fothergill, L. Peek, Gender and disaster: foundations and Directions, in: H. Rodríguez, E.L. Quarantelli, R.R. Dynes (Eds.), Handbook of Disaster Research. Handbooks of Sociology and Social Research, Springer, New York, NY, 2007.
[29] C. Eriksen, N. Gill, Bushfire and everyday life: examining the awareness-action 'gap' in changing rural landscapes, Geoforum 41 (5) (2010) 814–825, https://doi.org/10.1016/j.geoforum.2010.05.004.
[30] J.E. Farley, Earthquake Fears, Predictions, and Preparations in Mid-America, Southern Illinois University Press, Southern Illinois, 1998.
[31] P. Farmer, Pathologies of Power: Health, Human Rights, and the New War on the Poor, University of California Press, Berkeley, CA, 2003.
[32] K. Finnis. Creating a Resilient New Zealand: Can Public Education and Community Development Campaigns Create Prepared Communities? An Examination of Preparedness Motivation Strategies, 2004. Retrieved from 〈〈http://www.civildefence.govt.nz/assets/Uploads/publications/finnis-creating-a-resilient-new-zealand.pdf〉〉 (Assessed 20th June 2018).
[33] B. Fischhoff, Risk perception and communication unplugged: twenty years of process, Risk Anal.: Off. Publ. Soc. Risk Anal. 15 (2) (1995) 137–145 〈http://www.ncbi.nlm.nih.gov/pubmed/7597253〉.
[34] B. Fischhoff, R. Beyth, I knew it would happen remembered probabilities of once-future things, Organ. Behav. Human. Perform. 13 (1975) 1–16.
[35] S.A. Fraser, E.E.H. Doyle, K.C. Wright, S.H. Potter, J. McClure, D.M. Johnston, G.S. Leonard, M.A. Coomer, J.S. Becker, S. Johal, Tsunami response behaviour during and following two local-source earthquakes in Wellington, New Zealand, Int. J. Disaster Risk Reduct. 16 (2016) 123–133, https://doi.org/10.1016/j.ijdrr.2016.02.008.
[36] L. Greening, S.J. Dollinger, Illusions (and shattered illusions) of invulnerability: adolescents in natural disaster, J. Trauma. Stress 5 (1) (1992) 63–75, https://doi.org/10.1007/BF00976811.
[37] T. Grothmann, A. Patt, Adaptive capacity and human cognition: the process of individual adaptation to climate change, Glob. Environ. Change 15 (3) (2005) 199–213, https://doi.org/10.1016/j.gloenvcha.2005.01.002.
[38] Hm Goodman, A. Cottrell, Responding to a fire threat: gender roles: dependency and responsibility, in: D. Paton, F. Tedim (Eds.), Wildfire and Community: Facilitating Preparedness and Resilience, Charles C Thomas, Springfield, IL, 2012, pp. 281–299.
[39] B.L. Halpern-Felsher, S.G. Millstein, J.M. Ellen, N.E. Adler, J.M. Tschann, M. Biehl, The role of behavioral experience in judging risks, Health Psychol. 20 (2) (2001) 120–126, https://doi.org/10.1037/0278-6133.20.2.120.
[40] K. Haynes, J. Barclay, N. Pidgeon, The issue of trust and its influence on risk communication during a volcanic crisis, Bull. Volcanol. 70 (5) (2007) 605–621, https://doi.org/10.1007/s00445-007-0156-z.
[41] K. Haynes, J. Barclay, N. Pidgeon, Whose reality counts? Factors affecting the perception of volcanic risk, J. Volcanol. Geotherm. Res. 172 (3–4) (2008) 259–272, https://doi.org/10.1016/j.jvolgeores.2007.12.012.
[42] K. Heller, D.B. Alexander, M. Gatz, B.G. Knight, T. Rose, Social and personal factors as predictors of earthquake preparation: the role of support provision, network discussion, negative affect, age, and education, J. Appl. Social. Psychol. 35 (2) (2005) 399–422, https://doi.org/10.1111/j.1559-1816.2005.tb02127.x.
[43] M. Helweg-Larsen, The lack of optimistic biases in response to the 1994 Northridge earthquake: the role of personal experience, Basic Appl. Social. Psychol. 21 (2) (1999) 119–129, https://doi.org/10.1207/S15324834BA210204.
[44] S.-K. Huang, M.K. Lindell, C.S. Prater, Who leaves and who stays? A review and statistical meta-analysis of hurricane evacuation studies, Environ. Behav. 48 (2016) 991–1029, https://doi.org/10.1177/0013916515578485.
[45] L.S. Hung, Married couples' decision-making about household natural hazard preparedness: a case study of hurricane hazards in Sarasota County, Florida, Nat. Hazards 87 (2) (2017) 1057–1081, https://doi.org/10.1007/s11069-017-2809-3.
[46] D.M. Johnston, D. Paton, B.F. Houghton, Volcanic hazard management: promoting integration and communication, in: J. Ingleton (Ed.), Natural Disaster Management, United Nations (IDNDR), Coventry, 1999, pp. 243–245.
[47] S. Keeter, C. Miller, A. Kohut, R.M. Groves, S. Presser, Consequences of reducing nonresponse in a national telephone survey, Public Opin. Q. 64 (2) (2000) 125–148, https://doi.org/10.1086/317759.
[48] M.K. Lindell, Response to environmental disasters, in: S. Clayton (Ed.), Handbook of

Environmental and Conservation Psychology, Oxford University Press, New York, 2012, pp. 391–413.
[49] M.K. Lindell, North American cities at risk: household responses to environmental hazards, in: T. Rossetto, H. Joffe, J. Adams (Eds.), Cities at Risk: Living with Perils in the 21st Century, Springer, Dordrecht, The Netherlands, 2013, pp. 109–130.
[50] M.K. Lindell, R.W. Perry, Household adjustment to earthquake hazard: a review of research, Environ. Behav. 32 (4) (2000) 461–501, https://doi.org/10.1177/00139160021972621.
[51] M.K. Lindell, C.S. Prater, Household adoption of seismic hazard adjustments in two states, Int. J. Mass Emerg. Disasters 18 (2) (2000) 317–338.
[52] M.K. Lindell, C.S. Prater, Risk area resident' perceptions and adoption of seismic hazard adjustments, J. Appl. Social. Psychol. 32 (11) (2002) 2377–2392.
[53] M.K. Lindell, C.S. Prater, H.C. Wu, S.-K. Huang, D.M. Johnston, J.S. Becker, H. Shiroshita, Immediate behavioural responses to earthquakes in Christchurch, New Zealand, and Hitachi, Japan, Disasters 40 (1) (2016) 85–111, https://doi.org/10.1111/disa.12133.
[54] B. Mackie, Warning fatigue–myth or misunderstanding: insights from the Australian bushfires, Can. Risk Hazards Netw. 5 (1) (2013) 51–55.
[55] J. McClure, The social parameter of 'learned' helplessness: its recognition and implications, J. Personal. Social. Psychol. 48 (6) (1985) 1534–1539.
[56] J. McClure, L. Henrich, D. Johnston, E.E.H. Doyle, Are two earthquakes better than one? How earthquakes in two different regions affect risk judgments and preparation in three locations, Int. J. Disaster Risk Reduct. 16 (2016) 192–199, https://doi.org/10.1016/j.ijdrr.2016.03.003.
[57] J. McClure, E. Johnston, L. Henrich, T.L. Milfont, J. Becker, When a hazard occurs where it is not expected: risk judgments about different regions after the Christchurch Earthquakes, Nat. Hazards 75 (1) (2015) 635–652, https://doi.org/10.1007/s11069-014-1338-6.
[58] J. McClure, J. White, C.G. Sibley, Framing effects on preparation intentions: distinguishing actions and outcomes, Disaster Prev. Manag. 18 (2) (2009) 187–199, https://doi.org/10.1108/09653560910953252.
[59] D. McIvor, D. Paton, D.M. Johnston, Modelling community preparation for natural hazards: understanding hazard cognitions, J. Pac. Rim Psychol.3 2 (2009) 39–46.
[60] D.S. Mileti, R. Bandy, L.B. Bourque, A. Johnson, M. Kano, L. Peek, J. Sutton, M. Wood. Annotated Bibliography for Public Risk Communication on Warnings for Public Protextive Actions Response and Public Education. Report (last (Accessed 1 May 2014). Natural Hazards Centre, University of Colorado at Boulder. 〈http://www.colorado.edu/hazards/publications/informer/infrmr2/pubhazbibann.pdf〉.
[61] D. Mileti, P.W. O'Brien, Warnings during disaster: normalizing communicate risk, Social. Probl. 39 (1) (1992) 40–51, https://doi.org/10.1525/sp.1992.39.1.03x0062j.
[62] M. Morgan, B. Granger, A. Fischhoff, Bostrom, C.J. Altman, Risk Communication: A Mental Models Approach, Cambridge University Press, London, 2001.
[63] J.P. Mulilis, T.S. Duval, The PrE model of coping and tornado preparedness–moderating effects of responsibility, J. Appl. Social. Psychol. 27 (1997) 1750–1766, https://doi.org/10.1111/j.1559-1816.1997.tb01623.x.
[64] A. Olofsson, S. Rashid, The white (males) effect and risk perception: can equality make a difference? Risk Anal. 31 (6) (2011) 1016–1032.
[65] C. Palmer, Risk perception: another look at the 'white male' effect, Health, Risk Soc. 5 (1) (2003) 71–83.
[66] D. Paton, D.M. Johnston, M.S. Bebbington, Chin-Diew Lai, B.F. Houghton, Direct and Vicarious experiences of volcanic hazards: implications for risk perception and adjustment adoption, Aust. J. Emerg. Manag. Summer (2001) 58–63.
[67] D. Paton, J. McClure, Preparing for Disaster: Building Household and Community Capacity, Charles C Thomas Pub Ltd, Springfield, Illinois, USA, 2013.
[68] D. Phillips, K. Clancy, Some effects of 'social desirability' in survey studies, Am. J. Sociol. 77 (5) (1972) 921–940.
[69] K.J. Preacher, Advances in mediation analysis: a survey and synthesis of new developments, Annu. Rev. Psychol. 66 (2015) 825–852.
[70] U. Ranke, Natural Disaster Risk Management. Geosciences and Social Responsibility, Springer Publishing Company, New York, 2016.
[71] E. Regnier, Public evacuation decisions and hurricane track uncertainty, Manag. Sci. 54 (1) (2008) 16–28, https://doi.org/10.1287/mnsc.1070.0764.
[72] L. Rivers, J. Arvai, P. Slovic, Beyond a simple case of Black and White: searching for the white male effect in the African-American community, Risk Anal. 30 (1) (2010) 65–77.
[73] K.R. Ronan, D. Paton, D.M. Johnston, B.F. Houghton, Managing Societal Uncertainty in Volcanic Hazards: A Multidisciplinary Approach, Disaster Prev. Manag. Int. J. 9 (2000) 339–349.
[74] L.A. Russell, J.D. Goltz, L.B. Bourque, Preparedness and hazard mitigation actions before and after two earthquakes, Environ. Behav. 27 (6) (1995) 744–770, https://doi.org/10.1177/0013916595276002.
[75] A. Rustemli, A.N. Karanci, Correlates of earthquake cognitions and preparedness behavior in a victimized population, J. Social. Psychol. 139 (1) (1999) 91–101, https://doi.org/10.1086/250095.
[76] J.C. Senkbeil, D.A. Scott, P. Guinazu-Walker, M. Rockman, Ethnic and racial differences in tornado hazard perception, preparedness, and shelter lead time in Tuscaloosa, Prof. Geogr. 66 (4) (2014) 610–620.
[77] U. Sharma, A. Patt, Disaster warning response: the effects of different types of personal experience, Nat. Hazards 60 (2) (2011) 409–423, https://doi.org/10.1007/s11069-011-0023-2.
[78] J.A. Shepperd, W.M.P. Klein, E.A. Waters, N.D. Weinstein, Taking stock of unrealistic optimism, Perspect. Psychol. Sci.: A J. Assoc. Psychol. Sci. 8 (4) (2013) 395–411, https://doi.org/10.1177/1745691613485247.
[79] J.M. Siegel, K.I. Shoaf, A.A. Afifi, L.B. Bourque, Surviving two disasters: does reaction to the first predict response to the second? Environ. Behav. 35 (5) (2003) 637–654, https://doi.org/10.1177/0013916503254754.
[80] M. Siegrist, H. Gutscher, Natural hazards and motivation for mitigation behavior: people cannot predict the affect evoked by a severe flood, Risk Anal. 28 (3) (2008) 771–778, https://doi.org/10.1111/j.1539-6924.2008.01049.x.
[81] R.L. Silver, C.B. Wortman, Coping with undersirable life events, in: J. Garber, M.E.P. Seligman (Eds.), Human Helplessness, Acadmic Press, New York City, USA, 1980, pp. 279–375.
[82] P. Slovic, Trust, emotion, sex, politics and science–surveying the risk assessment battlefield, Risk Anal. 19 (4) (1999) 689–701.
[83] C. Solberg, T. Rossetto, H. Joffe, The social psychology of seismic hazard adjustment: re-evaluating the international literature, Nat. Hazards Earth Syst. Sci. 10 (8) (2010) 1663–1677, https://doi.org/10.5194/nhess-10-1663-2010.
[84] M.J. Spittal, J. Mcclure, R.J. Siegert, F.H. Walkey, Optimistic bias in relation to preparedness for earthquakes, Australas. J. Disaster Trauma Stud. 2005–1 (2005) 1–13 〈http://www.massey.ac.nz/~trauma/issues/2005-1/spittal.htm〉.
[85] Statistics New Zealand. 2013 Census Tables about a Place: Wellington Region., 2014. Available at: 〈http://archive.stats.govt.nz/Census/2013-census/data-tables/tables-about-a-place.aspx?Request_value=24467&reportid=14&tabname=〉 last Accessed 2nd July 2018.
[86] W.K. Viscusi, R.J. Zeckhauser, National survey evidence on disasters and relief: risk beliefs, self-interest, and compassion, J. Risk Uncertain. 33 (1–2) (2006) 13–36, https://doi.org/10.1007/s11166-006-0169-6.
[87] N.D. Weinstein, J.E. Lyon, A.J. Rothman, C.L. Cuite, Changes in perceived vulnerability following natural disaster, J. Social. Clin. Psychol. 19 (3) (2000) 372–395, https://doi.org/10.1521/jscp.2000.19.3.372.
[88] Wellington Regional Emergency Management Office, What to do if you Feel a Long or Strong Earthquake, Wellington, New Zealand, 2014. Available at: 〈http://www.getprepared.org.nz/tsunami/what-to-do〉.
[89] D.J. Whitney, M.K. Lindell, H.D. Nguyen, Earthquake beliefs and adoption of seismic hazard adjustments, Risk Anal. 24 (1) (2004) 87–102.
[90] B. Wisner, P. Blaikie, T. Cannon, I. Davis, At Risk: Natural Hazards, People's Vulnerability and Disasters, Routledge, New York, NY, 2004.