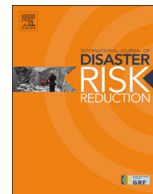




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International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdr

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

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ARTICLE INFO

Keywords:

Earthquakes
Preparedness
Beliefs
Concern
Actions
Gender

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, 2013¹) (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 2013³, 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 2013. 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.

<https://doi.org/10.1016/j.ijdr.2018.07.008>

Received 18 December 2017; Received in revised form 2 July 2018; Accepted 11 July 2018

Available online 11 July 2018

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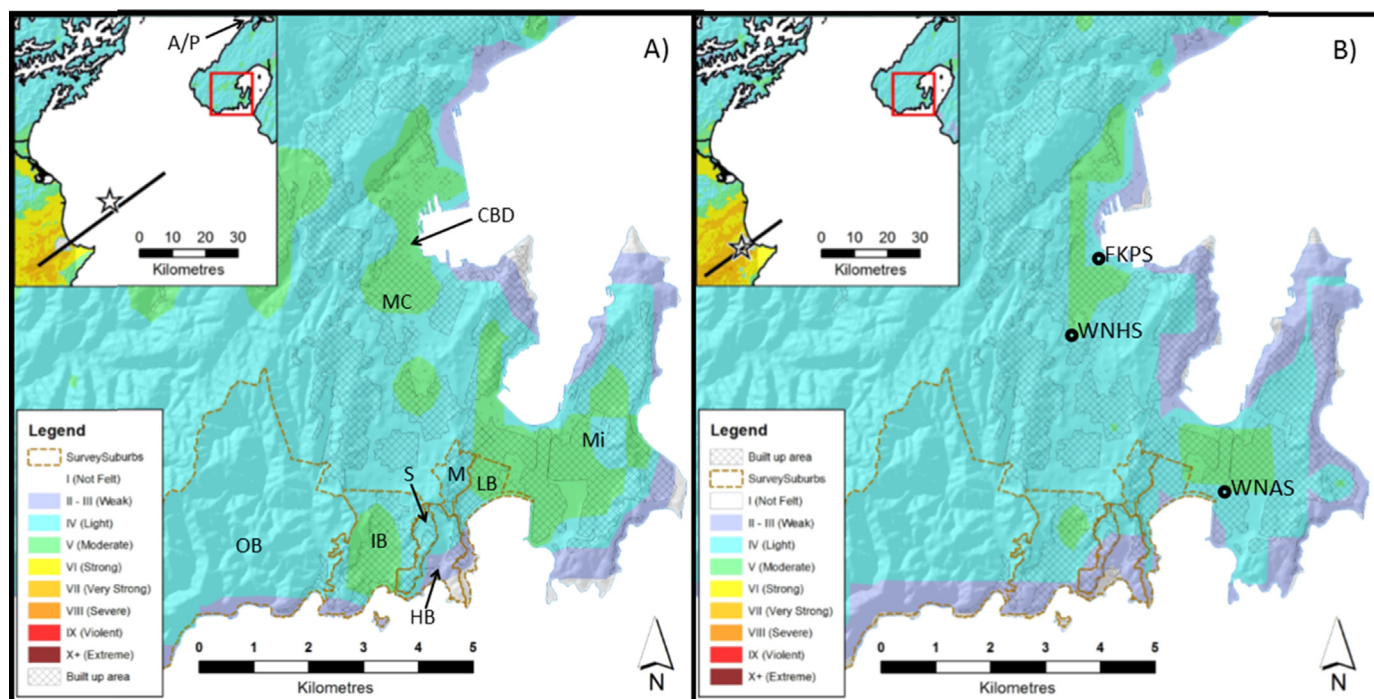


Fig. 1. : a) Earthquake epicentre of the first earthquake in the mainshock doublet, the M_w 6.5 Cook Strait event, and its position on the London Hills Fault in between the North and South Islands of New Zealand; b) the epicentre of the second earthquake, the M_w 6.6 Lake Grassmere event, located on 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, 2013⁶; Otago Daily Times, 2013⁷). 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, 2013⁸). 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

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.

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

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