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Evaluation of the ShakeOut earthquake drill and use of protective actions in Aotearoa New Zealand

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ABSTRACT

Many earthquake injuries in Aotearoa New Zealand result from people falling or being struck by flying objects during shaking. Since 2012, the ShakeOut earthquake (and now tsunami) drill has aimed to teach the protective actions "Drop, cover, and hold" to reduce harm from earthquakes. This paper reports findings from evaluations of the 2012 and 2015 nationwide ShakeOut drills. Most previous evaluations tend to focus on describing participation rates and challenges with running the drill; in contrast, we summarize previous findings from this study that those who participated in the drill are more likely to report the correct actions to take both when inside and outside and are more likely to have used "Drop, cover, and hold" in a real earthquake. Further, we found that most participants who did not use "Drop, cover, and hold" in actual earthquake shaking justified their inaction by saying that the earthquake was too short or too weak. This misconception regarding the purpose of "Drop, cover, and hold" – which should be employed as soon as shaking starts so that people are safe when the shaking becomes strong enough to cause harm – has important ramifications for how protective actions are taught to communities in Aotearoa New Zealand.

1 INTRODUCTION

1.1 Earthquake injuries in Aotearoa New Zealand

Compared to countries with similar seismicity, Aotearoa New Zealand (NZ) has experienced relatively few earthquake fatalities, with the majority from building damage or collapse in the 1931 Hawke's Bay and 2011 Canterbury earthquakes; only 13 fatalities have occurred due to causes such as falling or being struck by objects which could be reduced by the use of protective actions (Abeling et al., 2020). However, rates of earthquake injury are much higher than the fatality rate; between 2010 and 2014 alone around 15,000 people were injured during earthquakes (Basharati et al., 2020). In an analysis of risk factors during the 2016 Kaikōura earthquake, Horspool and colleagues (2020) identified that 91% of injuries occurred during shaking; these injuries were caused by people falling (37%), other actions (44%), and object strikes (8%).

Similar patterns of injury cause were identified in the 2011 Canterbury earthquake, yet few people undertook preventive actions to reduce their chance of injury (Johnston et al., 2014; Lambie et al., 2017).

It is clearly important, therefore, to teach protective actions such as "Drop, cover, and hold" (DCH) which is widely encouraged particularly in countries with comparatively high building standards. Such efforts should avoid prescribing to the knowledge deficit model (Simis et al., 2016) where it is presumed that people do not act in a certain way only because they do not know to, and that continuing to provide this information will lead to the desired behaviour. People need to perceive risk from a hazard and know what they can do to protect themselves in order to act, but typically these factors alone do not predict preparedness behaviours such as learning protective actions (Ballantyne et al., 2000; Solberg et al., 2010). Information about what to do ought to be combined with information about *why* to act (McClure, 2017; Paton et al., 2017); this should be more explicit than providing risk information and assuming that people will infer that the recommended behaviours will reduce that risk. Presenting risk information alone in this way can lead to fatalism (the belief that events such as earthquakes are too destructive for their impacts to be mitigated; Ballantyne et al., 2000). Further, these behaviours should not just be taught but also practiced (Ronan & Johnston, 2005), with practice as groups likely to lead to higher uptake and a better outcome as encouraging collective efforts has been shown to increase disaster preparedness (Paton et al., 2017).

Drills to teach emergency response behaviour have been used in countries like the United States (US) for at least 60 years (Johnson et al., 2014). Disaster education programs have been shown to reduce fear and make risk perceptions more realistic (in the context of earthquakes; Ronan et al., 2008), improve response knowledge (Perry, 2004), increase actions to reduce disaster risk (Witvorapong et al., 2015), and contribute to decreases in injuries and fatalities (in the context of fires in US schools; Johnson et al., 2014). One widely used drill to teach protective actions during earthquake shaking is the ShakeOut drill.

1.2 ShakeOut earthquake (and tsunami) drill

1.2.1 History

The ShakeOut earthquake drill was developed in California, an area of the US with high seismicity, as part of a hypothetical earthquake scenario designed to help planning and preparedness. The first drill in 2008 had over five million registered participants; since then, ShakeOut has been conducted in many areas of the US to become the country's largest ever earthquake drill (Adams et al., 2017; Becker, 2009).

1.2.2 Use in Aotearoa New Zealand

The first instance of the ShakeOut earthquake drill happening outside of the US was on the West Coast of NZ in 2009 (Orchiston et al., 2013). Since then, ShakeOut drills have been run nationally in 2012, 2015, 2018, 2019, and 2020 with up to 1.3 million participants (Vinnell et al., 2020). In 2018, the National Emergency Management Agency (NEMA) began to include a tsunami hīkoi (walk) as part of the drill for those in tsunami risk zones. The website for registering also provides information about why DCH is useful and other preparedness actions. Many participants undertake ShakeOut with their school or workplace; injuries in non-residential buildings such as schools and workplaces were nearly three times more likely in the 2016 Kaikōura earthquake (Horspool et al., 2020), although this pattern is not found in all recent NZ earthquakes (Basharati et al., 2020).

1.2.3 Findings from previous research

Thorough evaluations of disaster drills, including ShakeOut, are uncommon (Becker, 2009; Dufty, 2009; Johnston et al., 2014; Tipler et al., 2016). Existing evaluations of ShakeOut often focus on challenges with conducting the drill (e.g., Johnson et al., 2014; Orchiston et al., 2013) and knowledge of DCH. These evaluations tend to find improved but not perfect knowledge of DCH. Given the unpredictability of earthquakes, it is difficult to empirically establish whether participation in the ShakeOut earthquake drill

leads to higher use of DCH during actual earthquake shaking, as well as why people do *not* use DCH. Participants in the 2012 and 2015 NZ ShakeOut drills commonly reported that they did not practice DCH during the drill due to embarrassment (McBride et al., 2019); while it is likely that embarrassment is still relevant to the lack of use of DCH in actual earthquake shaking, it is also likely that other reasons are prominent.

1.3 Study Aims

This study used a quantitative survey to provide preliminary answers to the following questions (among others which are not reported here):

1. Are those who participated in the ShakeOut earthquake drills in NZ in 2012 and 2015 more likely to have used DCH in actual earthquakes than people who did not participate?
2. Why do people who have participated in ShakeOut *not* use DCH in earthquakes?

2 METHOD

2.1 Design

This study used a quasi-experimental design where participants were split into two groups, those who participated in the 2012 or 2015 ShakeOut and those who did not, based on the participants' own decisions. Such a design has more potential confounds than a true experiment where the researcher randomly assigns participants to groups but has the benefit of higher efficiency which means more participants can be involved and therefore more statistical power attained. Participants responded to this survey approximately one year after the drill so their decision to participate in ShakeOut was unlikely to be affected by an assumption that they would participate in this survey in the future. Further method detail for this study is reported in Vinnell et al. (2020).

2.2 Materials

The survey included questions assessing knowledge and behaviour specific to DCH as well as to earthquake preparedness more generally. Of relevance to this paper, participants were asked:

- What to do during an earthquake while indoors;
- What to do during an earthquake while outdoors;
- If they had used DCH in a real earthquake since the time of the drill; and
- If they had felt an earthquake but *not* used DCH, why they had not done so.

2.3 Procedure

Participants in the survey following the 2012 ShakeOut drill were recruited via email using the information provided during registration. Participants in the survey following the 2015 drill were recruited via distribution of paper surveys to randomly selected households. As the former method led to an overrepresentation of drill participants and the latter method to an overrepresentation of non-participants, the two datasets were combined to improve statistical power.

2.4 Participants

Because the recruitment process could not specifically target only people 18 years or older, a question at the start of the survey screened out any potential respondents under this age requirement in a conservative approach to informed consent for participation; the host institution considers anyone under the age of 16 as children in regards to study ethics. Of the 1,709 responses across both surveys, 199 were removed due to the participant being under 18 years of age, not reporting if they did or did not participate in ShakeOut, or

participating in both the 2012 and 2015 drills. In the final combined dataset, 68% had participated in either the 2012 or 2015 ShakeOut drill while 32% had participated in neither. Participants were relatively geographically spread across urban centres in particular with 25% from Auckland, 20% from Wellington, and 19% from Otago, with the remainder from other areas of the country.

Confidentiality of responses was assured across all surveys and all data collection was performed in accordance with Massey University's Code of Ethical Conduct for Research, Teaching, and Evaluations Involving Human Participants.

3 RESULTS AND DISCUSSION

3.1 Knowledge of DCH

As reported in Vinnell et al. (2020), a larger proportion of those who participated in the ShakeOut drill (compared to those who did not participate) knew the correct actions to take when inside (66% vs. 21%) and when outside (19% vs. 4%). The proportion of drill participants who knew to use DCH when inside is lower than desirable but such a pronounced difference a year after the drill suggests a strong benefit of ShakeOut. The difference in accurate knowledge when outside also supports the benefit of ShakeOut but strongly suggests that more communication around what to do when outside, and perhaps encouragement to conduct ShakeOut outside, would be useful.

3.2 Use of DCH

Also as expected, Vinnell et al. (2020) found that a larger proportion of ShakeOut participants had used DCH in actual earthquakes than non-participants (63% vs 20%). While the proportions of correct knowledge and use are similar, and those who know to use DCH when inside are statistically more likely to have used DCH in a real earthquake, $\chi^2(1) = 38.49$, $p < .001$, the correlation between knowledge and use is only weak to moderate in strength, $\Phi = .22$. Of the 422 participants who had used DCH in a real earthquake, 117 did not report the correct actions (i.e., DCH) when asked earlier in the survey what they should do during an earthquake when inside.

There are several reasons why people might not know to use DCH but reported that they used DCH in an actual earthquake. First, participants may be demonstrating a social desirability bias where they give the answer which they think would be approved by their social group or a researcher expectancy bias where they give the answer which they think is expected by the researcher. The framing of the question "Have you undertaken the actions drop, cover and hold during a real earthquake…") does potentially imply that these actions are the desirable ones. Such issues are however difficult to avoid in survey design. Secondly, this discrepancy could stem from a memory error as the question assessing knowledge was towards the start of the survey and the question about use was later; it is possible that the question "What should you do when you feel an earthquake" is not a sufficiently strong cue for some participants to recall DCH while the question about use may be strong enough for participants to recall their behaviour during an earthquake. Thirdly, it is possible that these participants were not alone when they experienced earthquakes and followed social cues of others around them using DCH. Finally, while unlikely, it is possible that these participants used DCH instinctively but do not believe that it is the correct reaction to an earthquake.

3.3 Reasons for not using DCH

One hundred and eighty-four participants reported that in the time between participating in ShakeOut and the survey they had experienced at least one earthquake but did not use DCH in any or all of them. Of these participants, 39 either did not feel the earthquake or did not realise at the time that an earthquake was occurring. The majority ($n = 114$; 62%) did not use DCH because they felt it was unnecessary; nearly all

(102) of these participants said the earthquake was too weak or too short to bother using DCH. These responses suggest that participants wait until shaking gets "strong" before taking protective actions; however, by the time shaking is strong enough for self-protection to be necessary it may be too strong to drop safely or damage and injury might have already occurred.

Future research could explore in more depth than was possible in this study why people wait to protect themselves. It is feasible that people do not take earthquake risk seriously enough until the shaking meets their personal threshold for "strong" or that that people are concerned about being perceived as over-reacting when shaking is only weak; the main reason for people not practising DCH in ShakeOut drills in NZ is embarrassment (McBride et al., 2019). Messaging around DCH should encourage people not to wait for weak shaking to get stronger before taking protective actions and work to engender positive social norms to reduce embarrassment.

The next-most common reason for not using DCH is prioritizing other actions such as looking after children and other actions likely intended to protect the individual including going outside, standing in doorways, or following building procedures. Some of these actions are likely influenced by conflicting messaging. For example, official advice to stand in doorways has historically been given in NZ, while other countries with less stringent or less earthquake-focused building codes do encourage immediate exit of buildings; such behaviours are also often depicted in films and TV. Some research has demonstrated that disaster films have a strong influence on beliefs about human behaviour during disasters (Quarantelli, 1980); this should be further explored in the NZ context.

Other behaviours such as moving to protect dependants represent understandable reactions to an earthquake. Given the large number of injuries which occur as a result of people undertaking non-protective actions (e.g., 44% in the 2016 Kaikōura earthquake; Horspool et al., 2020), ShakeOut drills should be continued in schools so that guardians such as parents and teachers are less compelled to move to protect children. A further option is to develop and provide specific advice for people with dependants, balancing the instinct and necessity to protect vulnerable others as well as the need to protect oneself.

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