Surviving Earthquakes:

A study of preparedness advice and protective actions

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This thesis is submitted for the degree of Doctor of Philosophy

Ko Rūaumoko e ngunguru nei!

Hark to the rumble of the earthquake god![1]

Declaration:

I, Gillian Dacey, confirm that the work presented in this thesis is my own.

Where information has been derived from other sources, I confirm that this has been indicated in the thesis.

[1] from the Rūaumoko Haka – translation (Mahuika, 2012)

Abstract

Earthquake preparedness advice, including exercises, aims to reduce injury and increase survivability. However, the relationship between official advice, such as drop-cover-hold, and actions taken during an earthquake has been largely overlooked in previous research. The aim of this study has been to investigate the protective actions that people take during earthquakes, and the influence of preparedness advice, along with variables such as age and gender, on these actions.

Two surveys of earthquakes from New Zealand and Japan, and an analysis of earthquake preparedness advice from 67 countries, formed the basis of this study. This approach allowed for comparisons to be made between different earthquake events, using identical methodologies.

This research has shown that actions commonly taken include, to seek shelter, stand in a doorway, remain in the same place, or to attempt to leave a building. Not all reported actions are included in relevant official advice and, despite high levels of awareness of current guidance, this did not always translate into recommended actions being taken. Actions most frequently advised in official guidance were to 'avoid glass or loose and falling objects' and 'shelter under furniture' when indoors, and 'keep clear of buildings and tall structures' when outside.

The research concluded that behaviour during earthquakes is determined by the interaction of human and environmental factors in addition to the earthquake itself. The efficacy of earthquake advice in its current form was questioned and arguments were made for improving the communication of preparedness messages with more positive, action-orientated messaging. Additionally, messaging needs to address the requirements of a variety of groups in society. It is further suggested that disaster risk reduction experts acknowledge that people will not always behave as advised during an earthquake, and to incorporate this into their planning.

Impact statement

This research contributes to the understanding of the effectiveness of preparedness advice on injury and survivability for those affected by earthquakes. The research will be of interest to those involved in disaster risk reduction, including elected officials, government agents and those involved in public safety education generally. It will also be of interest to the academic community involved in understanding and developing the field of disaster risk reduction.

Findings from this research show the current limited effect of providing protective advice and suggest ways in which the advice can be enhanced or modified to have a greater impact and reach a larger number of those affected. Engaging with policy makers, therefore, to raise awareness of these opportunities can inform future policy and practice in this area. This in turn will produce a greater return from the resources invested in the production and dissemination of preparedness advice and any associated education programmes.

The findings of this research will be disseminated through journal publications and by communication to interested stakeholders, such as government disaster management authorities, international NGOs and local community groups. The research is relevant to all parts of the world affected by earthquakes, emphasising the need, as it does, to both tailor advice to the prevailing environment and to address the needs of a variety of vulnerable groups.

Focusing on an area of disaster preparedness that has only received limited attention from researchers, this research may also generate further discussion within the academic community. Among the possible influences of this work, from an academic perspective, is the argument for the use of more clearly defined variables when studying actions to ensure that findings are comparable across earthquakes and countries.

In more general terms, it is hoped that this research can contribute to the aim of reducing disaster mortality that was included as a principal goal of the 2015 Sendai Framework for Disaster Risk Reduction (UNISDR, 2015). This may be achieved through encouraging an improved understanding of actions taken during earthquakes and targeting preparedness advice for specific community and group needs.

In summary, this research will add to the understanding of behaviour during earthquakes, and this may lead to improvements in the appropriateness and effectiveness of earthquake preparedness advice and guidance programmes, and subsequently increase survival rates among those who are unfortunate enough to find themselves at risk from significant earthquakes.

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Friends and family have continued to support me during the course of my research, patiently listening and having faith in me to complete this research. In particular, I would like to thank my parents who supported me so effectively during the fieldwork in Christchurch.

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Chapter 1: Introduction

1.1. Introduction and context

Each year tens of thousands of earthquakes occur, with the majority detectable only by seismic instruments (IRIS, n.d.). However, it is well known that some earthquakes can cause considerable damage to infrastructure, and high levels of injury and death. In 2018 an estimated 4535 people globally died from earthquakes (USGS, n.d.-a.). Other recent major earthquakes include those that occurred in Haiti in 2010, Pakistan in 2005, and Iran in 2004. On average, about 16 earthquakes occur each year that are greater than moment magnitude (Mw) 7.0, meaning that they are large enough to cause significant damage to buildings.

It is widely recognised that with growing urbanisation of populations around the world societies are becoming increasingly vulnerable to natural hazards such as earthquakes (IFRC, 2020). Adding to this problem are factors such as displaced migrants and refugees, who, along with increasing numbers of low-income families, are forced to make their homes in vulnerable areas, perhaps where there is an increased risk of landslides, owing to a lack of available land. This means that marginalised people, frequently living in crowded and poorly constructed buildings, are further exposed to the risk posed by hazards such as earthquakes.

Changing patterns of urbanisation and rising population numbers in many locations are among the reasons why governments of many countries are increasingly seeking ways to protect their citizens from disasters (Department of Home Affairs, 2020; FDMA, n.d.; ECPHOA, 2021). In areas where there are particular vulnerabilities, such as to earthquakes, considerable resources are now devoted to preparing for these types of events in order to reduce their impact (FEMA, n.d.; NEMA, n.d.; IFRC, 2020)

Governments and national authorities are also being encouraged by agencies such as the United Nations to undertake disaster risk reduction activities to ensure the improved safety and wellbeing of citizens before, during and after a disaster. The Sendai Framework for Disaster Risk Reduction, signed in 2015 (UNISDR, 2015), called on signatory countries to develop a range of disaster risk reduction policies, plans and processes to mitigate the impact of disasters. Examples of these include strengthening building codes, installing tsunami early warning systems, developing community-based disaster response teams, and educating the public on activities that can help to make them less vulnerable to the effects of earthquakes.

Encouraging communities and individuals to undertake preparedness activities in advance of disasters in general has been shown to have beneficial outcomes (Shenhar *et al.*, 2015; Izadkhah & Hosseini, 2010; Mohadjer *et al.*, 2010; Tanaka, 2005; Doyle *et al.*, 2018). As part of their disaster risk reduction responsibilities, governments and national agencies now commonly issue advice about hazards relevant to

the country or area, along with appropriate guidance on preparedness activities and actions that can be taken before, during and after a disaster (FEMA, n.d.; NEMA, n.d.; American Red Cross, 2021). There is also an increasing body of research into how people prepare for and recover from disasters (Paton *et al.*, 2015; Gowan *et al*., 2015; Tang & Feng, 2018).

Each type of natural hazard has its own characteristics. One of the features of earthquakes, the focus of this research, is that they strike quickly and with little or no warning, meaning that after onset there is very little time in which to make potentially life-saving decisions and actions. This indicates that preparedness advice provided before earthquakes occur may have a significant role to play in reducing the impact of these events.

Currently many governments and other public bodies, as well as international non-governmental organisations (INGOs) make preparedness advice available to citizens that includes actions to undertake before, during and after an earthquake. Examples include avoiding injury by pre-securing heavy furniture, doing the 'drop-cover-hold' action during shaking, and instructions on how to treat the injured casualties afterwards.

However, in spite of the time, effort and resources given to earthquake preparedness advice and campaigns in vulnerable areas of the world, little is really known about what people actually do when an earthquake occurs, i.e. at the time of shaking (Shapira *et al.*, 2018; Yun & Hamada, 2012; Sunseri & Walton, 2005).

Since a person's choice of action may impact their chance of survival, it can therefore be argued that an increased understanding of how people behave at this time may help to save lives. Without this knowledge, it is difficult to assess the effectiveness of these programmes. Does preparedness advice and training do anything to change people's behaviour during an earthquake, and if so, does it improve their chances of surviving with or without injury?

Historical reports of earthquakes touch on the impact of human behaviour and actions during an earthquake (Slade, 1933; Franz & Norris, 1934), and comment on the need for further research to better understand the factors that influence survivability (Alexander & Magni, 2013; Yun & Hamada, 2012; Armenian *et al.*, 1992; Roces *et al.*, 1992). A review of these studies also finds that there is little mention of the influence of earthquake preparedness advice and guidance on the behaviour and actions of people during shaking.

Alexander (2012) and Sunseri and Walton (2005) have argued that the behaviour and actions of people during earthquakes and the effects of these actions on survival and injury rates has been little documented or acknowledged in general earthquake preparedness literature. Murakami and Durkin (1988) studied the actions taken while evacuating buildings. Other studies have focused on more general actions (Goltz & Bourque, 2017; Lindell *et al.*, 2016; Prati *et al*., 2012; Prati *et al.*, 2013; Santos-Reyes & Gouzeva, 2020).

However, there are no studies that have adequately considered the relationship between protective actions taken and the preparedness advice received by citizens prior to an earthquake. More specifically, several studies (Alexander, 2012; Yun and Hamada, 2012; Archea & Kobayashi, 1984; Paton & Johnston, 2001; Paton, 2003; Sunseri & Walton, 2005) suggest a potential gap in knowledge regarding the relevance of protective actions during earthquakes and the effect of earthquake preparedness information on survivability, in particular how people react to shaking in buildings and how best to inform and train them (Alexander, 2012).

One reason for this lack of research into people's behaviour during earthquakes may be because as engineering capabilities over the years have improved building resistance to earthquakes (Egbelakin *et al.*, 2011), so attention has been diverted from understanding how people behave during an earthquake. This is reflected in the observation of United Nations Office for Project Services (UNOPS) that there is a tendency to believe that "it is not earthquakes that kill people, but buildings" (UNOPS, 2013). Consequently, as buildings have become safer, there is a perception that behaviour becomes less important. However, as Horspool *et al.* (2020) have noted that while improvements to the building code in New Zealand have increased safety, large numbers of injuries still occur due to the actions of individuals.

The current situation, nonetheless, is that governments and other agencies continue to invest in preparedness advice and training with little understanding of either existing earthquake behaviour or the effectiveness of these campaigns on outcomes for citizens.

1.2. Understanding actions taken during earthquakes

This research attempts to explore the relationship between preparedness advice and human behaviour during earthquakes. This presents a variety of challenges, among which includes the question of how to define the various actions taken and to characterise the influences on those actions. With the paucity of research in this specific area identified above, this research is necessarily exploratory in nature, rather than building on a substantial body of previous knowledge. For this reason, the research does not attempt to test a specific hypothesis based upon an existing model or theory, but instead aims to provide a description and analysis of an existing situation derived from the data collected. To achieve this, the research has been guided by four key questions that are described in section 1.3 below.

This line of research is relevant with regard to improving survival from earthquakes, as understanding the actions people take, whether they follow the advised actions, or if they do something different, may be important in determining how people can improve their chances of survival. Previous research has not focused on the influence of preparedness advice on actions taken, yet this is key to understanding the effectiveness of earthquake preparedness advice and the public communication of earthquake safety messages.

Another challenge for earthquake research in general is that no two events are alike, and there are many factors to consider, such as earthquake variables (time, magnitude, depth), population demographics, building and structural characteristics, and the political, economic and social variations (Alexander, 2012). Research into a single earthquake event will produce a snapshot in time of people, the environment and other variables at the moment the earthquake strikes. This means that it is often difficult to extrapolate knowledge about one event to earthquake situations in general.

This research attempts to broaden the relevance of its findings by comparing two earthquakes of similar intensity in order to understand the effects of preparedness advice on actions in more than one setting. This of course presents its own set of challenges such as cultural differences, language barriers and variations in advice given to two different populations. Nonetheless this research seeks to understand the protective actions taken during earthquakes, and the effects of earthquake preparedness advice on these actions through the use of two field studies, one in Christchurch, New Zealand and the other in Sendai, Japan.

In addition to the field work, a document analysis of earthquake advice from countries around the world provides further insights into the current state of preparedness guidance. In particular, an attempt is made to identify common themes in the advice and to ask whether these are appropriate given the knowledge gained from the two field studies about actions taken during earthquakes.

1.3. Research aim and questions

As mentioned above, research into the protective actions people take during earthquakes, and in particular how these relate to preparedness advice, is limited. Given this lack of empirical research, the aim of this study can be described as follows:

> To investigate the protective actions that people take during earthquakes, and the effect of earthquake preparedness advice on these actions. The influence of variables such as age and gender will also be considered.

In addition to this main goal, a subsidiary aim has been to review the content of earthquake preparedness advice in countries around the world and explore its relationship to the actions taken during earthquakes.

In the context of this research, the term ‘earthquake preparedness advice’ refers to publicly available information issued by governments or national agencies that contains specific information and advice about the actions to take to before, during and after an earthquake. The term ‘protective action’ is defined as any behaviour taken by an individual to protect, save, or reduce harm to themselves during an earthquake.

1.3.1. Research questions

By understanding the protective actions people take it is possible to consider whether a relationship exists between the actions prescribed in national preparedness advice and the actual actions undertaken. Through analysing the actions taken from sample populations in New Zealand and Japan, it may be possible to understand how actions taken relate to the contents of earthquake preparedness advice, and thus the impact of that advice. Therefore, the focus of this research can be summarised through four key questions that support the aim and form the foundation to the study. Namely:

1. What protective actions do people take during earthquakes?

A core aspect of this research is to understand in general what people do during earthquakes, and specifically what protective actions, if any, they take. Answering this question involved utilising two field studies to identify the actions taken during two large earthquakes. Specifically, samples from selected populations were surveyed by questionnaires that focused on a number of protective actions including seeking shelter under furniture, drop-cover-hold, standing in a doorway, and going outside.

As well as identifying the protective actions taken, the surveys also explored which actions people believed were the most appropriate or inappropriate to take during an earthquake. This element of the research was intended to provide insight into whether people's behaviours were in line with their beliefs.

2. What influences the actions taken during earthquakes?

Having identified the protective actions taken during earthquakes, the survey explored influences on these actions. The factors studied in this research include the variables of age, gender, feelings, previous experience of exercises and drills, attitudes to drop-cover-hold, and awareness of earthquake preparedness advice. Demographic factors were included as previous research suggests that these may have an influence on the actions taken (Lindell *et al.*, 2016; Goltz & Bourque, 2017), and inclusion of exercises and drop-cover-hold reflects common preparedness advice and activities.

3. What are the consequences of the actions taken?

A logical next step in this research is to explore the consequences of taking protective actions. The focus is on immediate outcomes such as whether the person is injured or not, and whether they are trapped as a result of their actions during the earthquake. This proposes a measurable outcome of survival, for example, whether a relationship exists between injury and the actions taken. In the case of this research, only survivors comprise the sample groups and therefore nothing can be said about the actions of those who were killed.

4. What actions are recommended in earthquake preparedness advice?

Finally, many governments and national authorities globally issue advice on what to do during earthquakes, however there is no commonly accepted set of guidelines, and advice varies between countries. A further

aspect of this research has been to look at the nature of this advice in general and, in the context of the field studies, explore its relevance and appropriateness in view of what has been learnt about actual behaviour during earthquakes.

1.4. Significance of the research

This research will contribute to the study of earthquake preparedness through the advancement of knowledge in the area of protective actions taken during earthquakes and the relevance of earthquake preparedness advice. This is an area of research that has received little attention when compared to the field of disaster studies in general.

The value of this research is enhanced by the inclusion of two comparable field studies from separate earthquake events which arguably extends the validity of the findings beyond that of a single event. As many studies look at specific risk patterns and outcomes for single events in one country, the outcomes cannot easily be generalised to all earthquakes (Ramirez & Peek-Asa, 2005). This comparative study of earthquakes in two countries will go some way to ensuring the results are applicable to a wider audience.

An intended outcome at a theoretical level is to advance knowledge of earthquake preparedness advice through identifying and understanding the protective actions that people take. A second outcome, at a practical level, aims to identify the reasons behind the protective actions taken and implications for disaster managers developing future advice. This research may also contribute to the ongoing discussion about what constitutes best practice in terms of advice given to those vulnerable to the effects of earthquakes.

1.5. Overview of the thesis

This thesis contains eight chapters arranged into three parts. The first part, chapters 1, 2 and 3, focuses on the introduction and background to the research problem, along with relevant literature. The literature review in Chapter 2 considers relevant studies in the two key areas relating to the research topic, protective actions and earthquake preparedness advice. This review highlights a number of earthquakes where people's protective actions have been studied, but shows that little research relates these actions to the preparedness advice available. The literature tends to focus instead on actions to take before and after an earthquake, with less attention being given to actions at the time of shaking. Chapter 3 introduces the two field studies and the desk review of emergency preparedness documents, providing a background and context for the two earthquakes and earthquake preparedness advice in New Zealand and Japan.

The second part of this thesis, chapters 4 and 5, focuses on the empirical aspects of the research, namely the methodology and the results. Chapter 4 outlines the methodology used for the field studies and document analysis, including the research design, ethical considerations, development of the survey and supporting

documents, as well as the sampling and data analysis process. Limitations and constraints associated with the research are also considered here. This chapter also provides the context and background to the field studies for Sendai and Christchurch with information on the earthquakes and relevant earthquake preparedness advice for each location. A description of the collection and analysis of global earthquake preparedness advice documents is also included. Contained in Chapter 5 are the results of the field studies and document analysis along with appropriate data analysis and some basic interpretation of the results.

The third and final part of this thesis considers the implications of the results, placing them in the context of existing research and exploring the issues raised in terms of the areas of interest identified for future research. Chapter 6 focuses on the findings from the case studies where the protective actions taken in both Christchurch and Sendai are discussed, along with the reasons given for those actions, and other influences such as age, gender and feelings. This chapter also looks at the consequences of taking protective actions, in particular whether the person is injured or trapped as a result of the earthquake. Chapter 7 considers the impact of advice given and whether protective actions are influenced by factors such as attitudes to drop-cover-hold, participation in exercises or drills, and an awareness of official guidance on earthquake preparedness. The review of national earthquake preparedness advice is also discussed, and a number of observations are made regarding the actions contained in the advice, including issues regarding specific situations and community groups. The final chapter, chapter 8, draws together the outcomes from the research and points to a way forward for future research and furthering knowledge in the area of protective actions.

Finally, supporting documents are contained in the appendices, including the questionnaires for the field surveys. This makes the survey instrument available for others to scrutinise, use and build on. This approach enables other researchers to replicate the study, something that has been highlighted as a key component in furthering disaster research (Bird, 2009).

In summary, this research gathers evidence in a field where there are currently few studies, and still less that contain analysis of more than one earthquake. This first chapter has introduced the research and provided a background to the topic. It then considered the provision of preparedness advice, highlighting areas where there are gaps in research around how this advice might influence the protective actions taken by people during earthquakes. From this, the aim and key areas of interest that underpin and provide direction to the research were described.

Chapter 2: Earthquake Literature: Preparedness advice and protective actions

History records many hundreds of destructive earthquake events that have killed thousands and destroyed vast amounts of property. For this reason, it is perhaps surprising that only relatively recently have governments and authorities directed significant resources into preparing and providing guidance about what to do during earthquakes. Reducing the impact of these devastating events has become the focus of governments and disaster managers around the world. This can be seen through activities such as the introduction of more stringent building standards, providing citizens with sufficient information to help them prepare for earthquakes, and enhancing ways to respond and recover from such events. This literature review focuses on research and information that relates to earthquake preparedness advice programmes and the protective actions taken by people during earthquakes.

For the purposes of this research, earthquake preparedness advice refers to information issued by governments and their agencies about the actions that citizens can undertake before, during and after an earthquake. This is a narrower definition than the general concept of preparedness used by the United Nations Office for Disaster Risk Reduction (UNISDR, 2009) as 'the knowledge and capacities developed….to effectively anticipate, respond to, and recover from, the impacts of….hazard events or conditions'.

This section reviews the literature surrounding official advice, including the measures used to educate the public about personal preparedness and preventive actions that can be taken to reduce and mitigate the impact of earthquakes, particularly during the tremor. Consideration is also given to both historic and more recent earthquakes, using eye-witness accounts and research respectively, to provide a foundation for understanding the actions that people take during shaking.

This review begins by considering the background to preparedness advice, and then considers the evidence for its effectiveness. Methods of risk communication and the value of exercises and drills are also considered, as these also form an important part of earthquake preparedness strategies.

2.1. The history, context and theory of earthquake preparedness advice

In modern times the provision of earthquake advice for citizens is relatively recent, with early guidance on actions to take during a crisis developed in the 1950s as a result of the nuclear threat in the USA and United Kingdom during the cold war (Preston, 2015). Gradually, governments widened the scope of their advice to include, where relevant, a number of other potential threats, particularly those relating to natural hazards, such as earthquakes, hurricanes, and landslides (Bartolucci & Magni, 2016).

Following several major disasters in the 1960s, the United Nations General Assembly created the UN Disaster Relief Office in 1971, and this has since evolved to the United Nations Office for Disaster Risk Reduction or 'UNDRR', (UNDRR, 2021). During this time, the UN has also been responsible for a coordinating the development of a number of strategies and frameworks relating to disaster risk reduction (DRR). This included the Hyogo Framework 2005 and its successor the Sendai Framework for Disaster Risk Reduction 2015, both of which call on nations to build their resilience to natural hazards.

The Sendai Framework focuses on a number of areas, including disaster risk management, and emphasises the primary responsibility of states to prevent and reduce disaster risk (UNISDR, 2015). The Framework contains four Priorities for Action, and the first Priority, Understanding Disaster Risk, includes requirements such as ensuring disaster risk and hazard information are made available to the public, and that relevant education and training for disaster risk reduction exist (UNISDR, 2015).

One way that this is achieved by national authorities is through the development and publication of preparedness guidance for actions to take before, during and after an earthquake. Information started to appear several decades ago, with advice in the 1950s for American school children who learnt the 'duck and cover' drill as part of the civil defence programme for nuclear attack (Preston, 2015). By the time of the 1989 Loma Pieta earthquake, this drill was widely used in advice on how to respond during an earthquake with disaster education projects becoming common by this time (Tanaka, 2005). Similarly, in New Zealand, the Civil Defence remit was widened in 1965 to include not only the nuclear threat, but also natural hazards, such as earthquakes and floods (Swarbrick, 2020).

The focus of this research is on the provision of preparedness advice which, in the context of earthquakes, Lindell (2013) has described as providing preparedness communication to the public about potential risks and recommended behaviours and actions to mitigate, prepare for, deal with and recover from these risks. It has also been argued that providing this type of information raises public awareness regarding risks, and it may assist with responding to a sudden onset event if the public have prior knowledge, information and training in relevant actions and behaviours (Lindell, 2013; Rapaport & Ashkenazi 2019).

Palm (1981) argued that providing seismic preparedness information may result in changes to behaviour, since when individuals become more aware of risks they may undertake mitigation activities to reduce the impact of the hazard. Roces *et al.* (1992) studied risk factors following the 1990 earthquake in the Philippines, and concluded that the preparedness of communities must be strengthened by knowing the correct actions to take during earthquakes, and conducting drills to enhance this.

Earthquake preparedness, according to Tanaka (2005), is often seen as expensive or involving extra costs, and this may make it difficult for governments and communities to make seismic adjustments to their

environment. However, it has also been argued that one advantage of providing preparedness advice is the relative low cost of this approach for individuals, meaning that advice can be made equally available to the poor as to the wealthy (Lindell, 2013; Solberg *et al*., 2010). Providing preparedness advice can also reach large numbers of people, when compared to, for example, strengthening buildings or other structural methods of mitigation when relative costs are considered.

However, cost is not the only factor in determining the effectiveness of mitigation measures. Cutter *et al.* (2008), noted that citizens often have other priorities and concerns in addition to limits posed by the cost of preparedness activities. Risk reduction and vulnerability may be overlooked until after a disaster occurs. Similarly, elected officials may not be keen to promote hazard mitigation if this is perceived to be a threat to economic growth.

Even with these limitations, according to Paton (2003), governments spend increasing amounts of resources each year on developing and providing guidance to their citizens. Paton *et al.* (2010) however, have questioned whether the impact of preparedness programmes has yet been clearly demonstrated and commented that, '…despite the attention and financial resources devoted to public education, the goal of ensuring sustained preparedness in communities susceptible to hazard consequences has proved elusive'. This gap in understanding means that it is increasingly important to evaluate the effectiveness of these efforts. Does preparedness advice, for example, really influence what people do both before and during a disaster? What are the best means of sharing information so that different groups in society can both understand and act upon it? Without sufficient evidence to answer these questions, it is not possible to say with certainty that preparedness advice and guidance are having a positive influence on people's chances of surviving an earthquake (Paton, 2003).

2.1.1. Disaster and emergency planning

The processes surrounding disaster and emergency planning are firmly established and well documented (Lindell, 2013; Alexander, 2015). Many theories have been developed to describe the various disaster and emergency processes and cycles (Ciottone, 2006). It is not the aim of this work to discuss the principles of disaster and emergency planning, but it is worth mentioning the different phases and to highlight the preparedness stage where earthquake advice and guidance forms a key role in reducing the impact of any subsequent event (figure 2.1).

This simple diagram summarises the types of activities that occur at various stages of the 'disaster cycle'. Mitigation refers to pre-disaster activities that are taken to reduce future casualties and damage. Preparedness activities are also undertaken prior to the event but are intended to support actions taken when the disaster event occurs, this includes emergency exercises and training (Lindell, 2013). The response stage refers to the impact of, in this case, an earthquake and its immediate aftermath, and recovery refers

to longer-term reconstruction and rebuilding of more resilient communities. It is worth noting however, that not all disasters are as clearly cyclical as the diagram suggests, for example, climate change is an ongoing event that may require continual adaptation to an increasingly challenging environment.

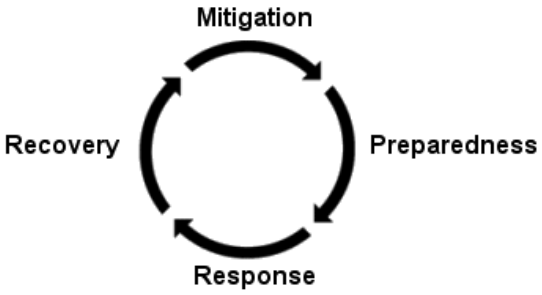


Figure 2.1. Simplified model of the disaster cycle

Advice and guidance relating to what to do during an earthquake provided by governments and other agencies can, therefore, in the context of the disaster cycle, be seen as a form of preparedness activity that takes place prior to an event (Verucci *et al.*, 2016). The information is intended to help people take the best actions at the time of a disaster, and this relationship between advice and what people actually do during shaking is the focus of this research.

2.1.2. Modelling behaviour during earthquakes

Several models and theories have been proposed by researchers in an effort to better understand behaviour, and influences on behaviour, during disasters. These include, among others, the 'social attachment model' (SAM) (Mawson, 2005), 'disaster resilience of place' (DROP) (Cutter, 2008), 'protective action decision model' (PADM) (Lindell, 2012), and others. However, these models tend to be generalised and applied to disasters in general rather than to a specific type of hazard, thereby making it less clear how well these models apply to the situation that unfolds during an earthquake. For example, are people's reactions to a sudden onset disaster the same as for a more gradual onset event, or one with greater warning times? Despite this, these models do offer some suggestion as to how people engage with the preparedness process and how some factors inhibit this engagement while others may encourage it, and so they are worth describing further.

The 'protective action decision model' (PADM) proposed by Lindell and Perry (2004) described the events and information flows that they saw as necessary to occur before protective actions and behaviours can take place. Prior to this decision making stage, a number of processes take place, and these are summed up as risk communication and risk perception (Lindell & Perry, 2012). In this model, people are made aware of protective actions via specific information from authorities, such as warnings and disaster preparedness programmes (Lindell & Perry, 2012). The outcome of the protective action decision making process, when combined with situational impediments and facilitators, results in a behavioural response that can include a protective action.

The PADM model suggests a decision making process that may lead to protective action being taken but as this was developed for disasters in general, further research would need to determine if it can be used to describe the circumstances that lead to these actions being taken during earthquakes. Presently, the sudden onset nature of earthquakes is not fully acknowledged in this model and decision-making processes in this context may be very different to, for example, those that lead to someone evacuating in advance of a predicted weather event.

The 'disaster resilience of place' (DROP) model proposed by Cutter *et al.* (2008) focuses on the relationship between vulnerability and resilience and starts from conditions prior to an event through to the recovery stages afterwards. The model indicates that the immediate effects of the event are influenced by mitigation actions and coping responses of communities, such as evacuation plans and information dissemination (Cutter *et al.*, 2008). As this model focuses on resilience at the community level and the social resilience of places across the disaster preparedness field, it is less relevant when focusing on and considering individual actions such as sheltering for protection during an earthquake.

The 'protection motivation theory' (Maddux & Rogers, 1983; Shenhar *et al.*, 2015) states that four conditions should be met for the population to be motivated to prepare for emergencies, and these are:

1. a belief that the threat is likely to affect them;
2. protective actions appear effective;
3. protective actions are not expensive;
4. they are able to perform the required actions.

Maddux and Rogers (1983) argued that expected outcomes may be a motivation to prepare and influence behaviour change by a) 'directly causing changes in behaviour and intentions', and b) 'by causing changes in self-efficacy expectancy that subsequently influence behaviour'. This could be applied to undertaking protective actions and behaviours during earthquakes if the outcomes from these actions can be seen to be positive.

The 'social-cognitive preparation model' developed by Paton (2003) suggests one reason why hazard education programmes have not been as successful as intended, in that people may not prepare if they do not perceive that the hazard is critical for them or their community. However, the model does not show the impact of the message, the type of communication, or the relevance of communication to the individual. The lack of awareness and preparation of hazard education and advice may also be due to information vulnerability, whereby people are not able to access information, or there is a lack of information (Mohadjer *et al.*, 2010). Even though preparedness information has been issued, it does not imply that the measures advised have been adopted (Paton & Johnston, 2001).

Provitolo *et al.*, (2011) proposed a model for the typology of human behaviour that relates to time and access to information, which, though it highlights behaviour for phases of disaster, does not apply well to the earthquake situation. They depict a continuum of time that assumes a direct link in time for each disaster phase. This may work for events such as cyclones or volcanic eruptions where there is an element of warning to prepare for the onset. Earthquakes however do not currently have a reliable warning period, or pre-disaster phase, so many of the behaviours described may not be applicable in the pre-disaster case of earthquakes. That is, the types of human behaviour included in the model are too general to be of value in the earthquake situation. This view is supported by Prati *et al.* (2012) who argued that different behaviours displayed during an event may reflect the different type of disaster, such as a slow onset flood compared to a sudden onset earthquake.

Other models, schematics and theories have also been proposed to describe the processes influencing protective behaviour before, during and after disasters. Murakami and Durkin's (1998) model of 'factors explaining various aspects of occupant behaviour' described the factors that can affect occupant behaviour in buildings in terms of shaking intensity, the personal environment, the physical environment, personal attributes, and earthquake drills, education and experience. Paton and Johnston (2001) proposed a model of 'risk perception - risk reduction' to explain how risk perception, self-efficacy and intentions lead to behaviour changes (Paton & Johnston, 2001). This was further developed by Paton (2003), into the social-cognitive preparation model that explains the relationship between motivations, intentions to prepare disasters and the resulting action taken. Paton argued that if individuals lack the appropriate motivations and intentions then preparedness programmes may be less effective than might otherwise be anticipated. Paton (2003) also found that preparedness activities such as securing tall furniture and checking emergency kits were indicators of adjustment behaviour, demonstrating a greater level of preparedness.

Of the models described here, few have considered the wide range of influences on people that may affect the actions taken at the time of an earthquake. This might include not only age and gender, but many other factors such as the sudden-onset of the event, the environmental context, as well as exposure to previous advice. However, whilst the protection motivation theory focuses on preparation, it might be applied to understand the effects and benefits of taking protective actions such as exercises and drills to prepare for an event.

2.2. What do people do during earthquakes?

The provision of preparedness advice relating to the 'during shaking' phase of an earthquake assumes that what people do at this time can have an effect on outcomes in terms of injuries and deaths. This assumes that providing advice can influence people's behaviour in a way that is favourable to survival. As the majority of casualties from earthquakes occur within collapsed structures or being struck by objects inside buildings,

Alexander (2012) also proposed that an understanding of how humans behave in buildings and how they interact with objects and structures will therefore contribute to the understanding of earthquake survivability. Similarly, Yun and Hamada, (2012) have argued that a more detailed understanding of what people do during and immediately after a severe earthquake can assist in providing advice and training on ways for residents to act that will reduce panic, injury or death in the future.

Other research that supports the case for providing preparedness advice for actions during shaking include Spence and So (2011) who have argued that for some events, the actions of people inside buildings during earthquake shaking can have an impact on the rates of injuries and fatalities. Similarly, Armenian *et al.* (1997) suggest that once an earthquake strikes and during earthquake shaking, one way of maximising survivability outcomes relies on appropriate actions taken by building occupants.

However, without first understanding what people do during an earthquake it is difficult to assess the effects of any guidance. This research also aims to investigate the relationship between behaviour and outcomes for earthquake survivors, meaning that it is relevant to explore existing accounts and research into the actions people take, or fail to take, to protect themselves at this time.

2.2.1. Behaviour during earthquakes

Despite the fact that the systematic study of behaviour during earthquakes is a relatively new endeavour, historical accounts exist from survivors of earlier earthquakes that offer an insight into actions and protective behaviour. The following narrative account is an example of an eyewitness report from the Lisbon earthquake of 1755:

> *"Most people were seized with giddiness and sickness, and some fell down, others were stupefied, and in general all were affected as if electrified though many that were walking or riding felt no motion but were sick".*
>
> Zachary Grey (1756)

Slade (1932) documented similar accounts, this time in relation to the February 1931 Hawke's Bay earthquake in New Zealand, for example:

> *"The first impact of shock seemed in most cases to produce a strong reaction of fear. All instinctively, and more or less blindly, sought exits from buildings, preferring to face death out of doors than to run the risk of being trapped inside. In some instances this blind unreasoning reaction seemed to precipitate death or serious injury. People rushed out without really considering where they were going, or whether they were likely to incur greater risk by so doing".*
>
> Slade (1932)

Others have attempted more systematic studies of behaviour during earthquakes. An early example of this is Franz and Norris (1934) who studied the Long Beach earthquake in California in 1933. They found that

about one third of participants in their study showed fear, including panic, paralysis or hysterical reactions, however, just less than half of respondents 'acted socially or with intelligence'. A number of people also reported feeling nausea and dizziness, and many people described running to save parents, children or siblings. Behaviours reported by Alexander (1990) during the 1980 Naples, Italy earthquake also indicated a variety of responses, the most frequent being to flee buildings, along with 'non-rational behaviours', such as panic, that were likely to be short-lived.

However, attempts to quantify such emotions may be unreliable due to variations across cultures, historical changes within cultures, and the subjective nature of terms such as 'panic' and 'hysterical reactions'. Popovic and Petrovic (1964) argued that mass panic was uncommon during disasters except when there is an increasing element of danger. This is supported by Quarantelli (1984) who summed up early assumptions typically made about human behaviour during a crisis or disaster, including panic, antisocial behaviour, hysteria and other irrational actions, and dispels these by saying that actually people display 'controlled behaviour, order and personal initiative'.

In more recent research, several studies have looked at what people do if they are inside a building when an earthquake occurs. Murakami and Durkin (1988), in a review of studies done from the mid-1970's, reported actions including:

- unable to react
- wait for a while
- reduce fire risk
- protect others
- give order to others
- protect property
- protect oneself
- seek refuge
- exit

They also found that the strength of the earthquake was a key component in affecting occupant behaviours, and that as the shaking intensity increased, behaviour and calmness of response deteriorated rapidly (Murakami & Durkin, 1988).

In a study that focused on a specific building collapse during a California earthquake in 1979, Arnold *et al.* (1982) found that just over a third of actions by people involved getting under a desk, while another third remained where they were. Standing in a doorway was also reported. Another case study by Armenian *et al.* (1992) following the 1988 Armenian earthquake, found that the first reaction of people inside buildings

was to run outside as a protective measure, and that this action reduced the injury rate. Peek-Asa *et al.* (2001) found that escaping from buildings during an earthquake could be either protective in avoiding death, or a factor in causing death.

Running from buildings during earthquake shaking is a commonly reported behaviour and response (e.g. Santos-Reyes & Gouzeva, 2020; Alexander 1990; Wagner *et al.*, 1994; Armenian *et al.*, 1992) and in many cases has a significant impact on survivability due to the risk of being struck by falling masonry. These studies do not probe into why these people ran from buildings, other than to suggest people were fleeing from perceived danger.

This absence of an explanation for actions is common in much research in this area, tending as it does to focus on describing behaviour rather than looking for the reasons behind those actions. Murakami and Durkin (1988) attempted to explain why people act as they do by relating this to the level of shaking. They suggested during minor shaking, people are fully capable of acting according to their own intentions, however once the shaking intensifies, motivation for personal safety and protection becomes more urgent, and this in turn results in a rapid deterioration of behavioural performance and control of their response.

In a survey of intentions from a sample in Israel about actions people would take if they were caught in an earthquake, Shapira *et al.* (2018) found that the preferred action by respondents would be to flee the building in which they were in (43%), enter the apartment protected space (19%), take cover under heavy furniture (13%), go to the staircase (8%), or sit against an inner wall (5%). It is interesting to note that these actions are in line with Israeli earthquake advice.

Taken together, these and other studies show that people engage in a variety of different actions during an earthquake. This impression may be further exacerbated by the fact that there is little consistency among researchers on the best way to classify behaviours. Some studies rely on the assumption that the meaning of terms such as 'self-protective action' is unambiguous, however this is clearly not the case, for example, how should the behaviour that a person believes to be protective, be classified if it actually places them at more risk? For example, running outside to escape when there is a real danger of injury from falling debris.

Nonetheless, a few authors do attempt to provide definitions of the behaviour that they describe, examples of which are shown in Table 2.1:

Term	Definition	Author(s)
Self-protective action	Individual attempts to protect themselves	Lambie *et al.* (2017)
Protective action	What people should do during earthquake shaking to protect themselves from injury or death	GeoHazards International (2015)
Protective behaviour	Recommended behaviour in advice	Prati *et al.* (2013)
Self-protective behaviour	To save lives	Alexander (2012)
Seismic adjustment behaviours	All types of actions and behaviours undertaken by individuals and households that have the capacity to either reduce immediate risk of damage and loss during an earthquake	Solberg *et al.* (2010)
Occupant behaviour	Actions to maximise survivability	Armenian *et al.* (1997)
Self-protective behaviour	Safety behaviour	Rahimi (1993)

Table 2.1. Definitions of behaviour

Other studies have used these and alternative terms such as, behavioural response, protective action, and human behaviour, but failed to provide further definition, including those given in Table 2.2:

Phrase:	Author(s)
Behavioural / emotional response	Santos-Reyes & Gouzeva (2020)
Human behaviour	Rapaport & Ashkanazi (2019), Goltz & Bourque (2017)
Self-protective behaviour	Shapira *et al.* (2018) Weinstein (1989)
Behavioural response / protective action	Lindell *et al.* (2016), Petal (2004)
Protective behaviour	Prati *et al.* (2012) Tekeli-Yesil *et al.* (2010)
Occupant behaviour / human behaviour	Spence & So (2011)
Protecting oneself	Archea & Kobayashi (1984)

Table 2.2. Undefined behaviour definitions

Leach (2004), has taken a somewhat different approach and defines three categories of human response to disasters, namely: calm, reflexive or automatic behaviour, and counterproductive reactions. This definition makes no specific reference to protective actions at all.

The impact that emotional state can have on behaviour has been recognised in several studies. The Italian earthquake in 1997 that struck the Umbria-Marche region was studied by Prati *et al.* (2012) and looked at

the various emotional and behavioural responses to the earthquake. The actions, or behaviours, that people took were classified into seven categories: escape, freezing, seeking shelter, no reaction, seeking information, reaching and protecting significant others, and recovery of personal belongings (Prati *et al.*, 2012). Unfortunately, each of these categories contains multiple types of actions that are quite different in nature to each other, for example 'reaching and protecting others' included the actions of 'contacting family members' and 'undertaking protective behaviour', thereby making a clear and exact analysis of the behaviours undertaken rather difficult.

In a recent study of three earthquakes in California that took place from 1987-1994, Goltz and Bourque (2017) looked at human behaviour during these events. They defined four of the protective actions that were central to their study: took cover, remained in place, went to others, and ran outside, and found that the majority of people took actions that were consistent with the advice of disaster response agencies – namely, minimal movement or taking cover during an earthquake. They found that actions discouraged by the same agencies were infrequently taken, such as running outside, and attempting to catch falling objects (Goltz & Bourque, 2017).

Another criticism that applies to some studies besides that they often provide little more than a description of behaviour without attempting to explain its cause, is that they fail to show how the behaviour relates to the earthquake advice that was prevalent at the time (Lindell *et al.*, 2016; Prati, *et al.*, 2012; Santos-Reyes & Gouzeva, 2020; Archea & Kobayashi, 1984).

An exception to this includes Audru *et al.* (2013), who conducted a survey in Martinique one month after a 7.4 magnitude earthquake, and showed that preparedness instructions and information provided through an official government campaign were mostly known, but that people's knowledge was affected by surprise, fear and panic that prevented them from behaving in an appropriate manner (Audru *et al.*, 2013). In another study by Otani *et al.* (2012) it was found that a lack of awareness among Chinese citizens about the appropriate actions to take may have resulted in many people being injured or dying as a result of inappropriate escape methods from buildings, such as jumping out of windows or falling from buildings.

Other researchers have looked at factors such as gender, physical location and emotional state as possible influences on behaviour. Actions taken by residents in the Emilia-Romagna earthquake in Italy in 2012 have been described by Prati *et al.* (2013). However, this earthquake struck at night, and many people did not react to the shock and remained in bed. Evacuation behaviour was also considered, and they found that women were less likely to leave the building, and also less likely to go down stairs, generally displaying less risky behaviour (Prati *et al.*, 2013). They found no differences between genders when taking protective actions, but did find that women reported more fear. The study argued that those who experienced greater fear also displayed riskier actions, such as leaving the building (Prati *et al.*, 2013). They found that more than

a third of respondents felt that the place they were in was unsafe and therefore left the building. The authors argued that the influence of fear means that escape is a frequent reaction to earthquakes. Whilst it was recommended by authorities that people seek a place of shelter when an earthquake strikes, this study found that less than 10% followed the advice (Prati *et al.*, 2013).

A study by Yilmaz (2004) following the 1999 Kocaeli earthquake in Turkey found that reactions during aftershocks to the earthquake included panic, leaving the room as soon as possible, not able to move, and no reaction. The research showed that while there was little difference between genders for leaving the room, twice as many women reported panic, and twice as many men reported no reaction (Yilmaz, 2004).

Quarantelli (1984), however, has argued against assumptions that people will panic or act irrationally during a disaster, and point out that while many people may be frightened, this does not automatically mean they will act impulsively and selfishly and may instead act with greater rationality than normal. In Alexander's (1996) study of the health effects of earthquakes in the mid 1990's it was noted that at least a quarter of responses involved panic, flight or a combination of the two, resulting in people running out of buildings.

In further studies, a lack of action has been identified, for example, Lindell *et al.* (2016) reported some building occupants 'freezing in place'. Similarly, Leach (2004) found people become passive when faced by danger or death, such as becoming immobile, remaining perfectly still, staring, and freezing with inaction. These actions, it was argued, occurred despite there being adequate systems and methods for escape that were taken by other people nearby. Leach (2004) argued that human responses to disasters and the likelihood of freezing can be attributed to neuro-cognitive function and the time it takes to process the steps from perception, or recognition, of the danger and taking action.

This inability to move in the face of danger has also been related to the "fight or flight" response that is well documented in humans when faced with danger (Alexander, 1990; Prati *et al.*, 2012; Santos-Reyes & Gouzeva, 2020). Prati *et al.*, (2012) argued that when faced with danger there are typically four key reactions, these are flight (escape the danger), fight (face the danger), paralysis, and affiliation. Paralysis equates to freezing described by Leach (2004) where the person experiences partial or total immobilisation to danger. Affiliation refers to when people head towards other people or places that are familiar (Prati *et al.*, 2012).

These studies of behaviour during earthquakes, while of interest in themselves, still leave the question of how actions may relate to advice previously received. This also raises the question of what constitutes relevant advice in this context. As Rustemli and Karanci (1999) observed, in terms of 'preventive measures', or taking 'protective actions, much research refers to actions before an event occurs and actions immediately preceding it, such as responding to warnings, rather than to measures to take during an event, such as drop-

cover-hold. In one study on preparedness involving Turkey and the USA, subjects recalled a number of suggested actions, including developing an earthquake plan, learning first aid, and stockpiling food and water (Kasapoglu & Ecevit, 2004). However, the list of recommended mitigation and preparedness actions recalled by participants did not include knowledge of actions to take during shaking.

Another problem that occurs when trying to compare actions taken with the preparedness advice received are differences that appear in the guidance provided. An example of this is the variation in advice on whether to leave a building or remain inside. This makes comparing studies based on different earthquake events particularly difficult.

Spence and So (2011) have reported that actions such as running outside from buildings during earthquakes in countries in Indonesia and Peru appeared to reduce the number of people injured or trapped. However, there have also been numerous reports of people running outside buildings during earthquakes and sustaining serious injuries (Lambie *et al.*, 2016; Wood, 2015), but it is not known whether the seriousness of these injuries would have been greater or lesser had the person remained in the building.

In a recent study on the Mexico City earthquake in 2017 by Santos-Reyes and Guozeva (2020) they found that escaping the building was undertaken by just over half of respondents, despite advice to stay indoors during an earthquake. Other actions included 'reaching and protecting' other people (17.1%), and seeking shelter (13.7%).

This difficulty is further compounded by the fact that different groups may have varied needs or abilities when it comes to deciding what the best advice is. For example, Spence and So (2011) note that evacuating a building is not always possible for groups such as the elderly, who may have a reduced ability to take an action (Peek-Asa, 2003), or those who are not at ground level when the shaking starts.

The responses and actions of people with disabilities during the Loma Prieta earthquake found that these ranged from moving to a doorframe or beam, holding on to their wheelchair or table, not moving much, or moving towards an exit (Rahimi, 1993). About one third of respondents held on to an object to stabilise themselves against the force of the earthquake, and another third held on to their wheelchairs.

In summary, therefore, while a considerable amount of research exploring the behaviour of people during earthquakes has been undertaken, no clear picture has yet emerged to describe a) what people do at the time of shaking and, b) how these actions are influenced by any official advice that has been provided.

Actions taken: New Zealand and Japan

With the limitations noted above, a brief review of some studies of earthquake behaviour in New Zealand and Japan is merited, given that these are the locations for the field studies included in this research.

In several older studies regarding actions taken during earthquakes in Japan, there is a focus on the actions aimed at reducing the chance of fire (Murakami & Durkin, 1988). This is reflected in Archea and Kobayashi's (1984) review of actions taken during the 1982 Off-Urakawa earthquake, where 46% of respondents reported acting to reduce the possibility of fire by extinguishing stoves, and 17% turned off gas supplies in kitchens. This research also revealed that less than 10% of people attempted to protect themselves by getting under furniture, and that there were very few pieces of furniture that a person could have got under in the homes studied (Archea & Kobayashi, 1984).

In a comparison study by Otani *et al.* (2012), they reported that during the 2011 earthquake, Japanese people knew the actions to take during an earthquake as they had previously been taught emergency evacuation procedures from an early age. However, Chinese people who were affected by the 2008 Sichuan earthquake were less informed about the actions to take, and reportedly jumped from windows or balconies to escape buildings (Otani *et al.*, 2012).

In studies looking at the behaviour of people during the Christchurch earthquake, Lambie *et al.* (2016 and 2017), used CCTV footage from Christchurch Hospital to analyse people's actions during shaking. They found that the most common action during shaking was to look around (30%), followed by holding on to something (26%), and walking (11%). No one was observed to perform the drop-cover-hold sequence despite the fact that this is advised in New Zealand (Lambie *et al.*, 2017).

A study by Tuohy *et al.* (2014) of elderly residents, following the 2010 and 2011 Canterbury earthquakes, found that this group was less able to protect themselves, when compared to the general population, at the time of shaking. At this time, participants were most likely to try and prevent themselves from falling over, such as leaning against something, sitting down, or holding on to something solid rather than following advice to seek shelter or drop-cover-hold. These findings were similar to those of Shapira *et al*. (2018) who also reported on the difficulties of elderly and disabled people when it comes to performing protective actions.

A more recent study by Horspool *et al*. (2020) focused on the 2016 Kaikoura earthquake that occurred during the night-time, and found a number of actions taken during the earthquake resulted in injuries to the person. These actions included moving to take cover, trying to help others, moving to or in a doorway, leaving the building, and getting out of bed.

Lindell *et al.* (2016), has made a comparative study of behavioural response to earthquakes in Christchurch, New Zealand and Hitachi, Japan. They studied the immediate behavioural responses on citizens in both cities following the 2011 earthquakes, and found the most common action in both cities was to freeze in place (to stop what they were doing and stay there). This was followed by secondary actions of taking cover (Christchurch), and evacuating immediately (Hitachi). Protecting people and property were less common

reactions. In general, they found the immediate behavioural responses in the two cities to be relatively similar.

Summary

It is clear from the above, that not only are behaviours during earthquakes many and varied, so too are the definitions and classifications applied to these actions by different researchers. This adds to the difficulty of drawing even quite broad conclusions about earthquake behaviour and guidance in general. This means that much research is relevant only to a specific event and constrained by its unique methodology.

Bartolucci and Magni (2016) have argued that "it is difficult and useless to suggest the right action to take in a disaster due to the high number of variables and situations". This approach seems to suggest that programmes to enable people to make an informed decision about actions to take during a disaster are perhaps not worth the effort. However, given the mixed picture described above, it may be too soon to take such an extreme position until a more coordinated approach to researching earthquake behaviour has been implemented.

Having explored how people behave during earthquakes, it is now appropriate to look at the other key component of this research, namely, the nature of the official guidance that is provided, and how this is considered in the literature.

2.3. Emergency preparedness and communication

The complex and uncertain nature of hazards and disasters means people increasingly rely on information about mitigation and preparedness from expert sources; this is usually in the form of public education programmes (Paton *et al.*, 2010).

To explore the relationship between what people do during earthquakes - including those behaviours described previously - and the influence of official guidance on those actions, it is also necessary to explore the content of messaging that is provided by government agencies and the methods used to disseminate these messages to their audiences.

As mentioned previously, there have been several international strategies and frameworks aimed at promoting disaster risk reduction around the world. However, individual nations are still responsible for implementing these and any other policies they decide are necessary in order to prepare and mitigate against disasters in their own country. How countries achieve this is varied, some governments choose to establish a coordinating emergency management agency with varying degrees of responsibility for overseeing disaster risk reduction and response, such as the National Emergency Management Agency in New Zealand (NEMA,

n.d.), whereas others choose to devolve responsibility to regional or local authorities, or have responsibilities devolved across several ministries or agencies, such as the United Kingdom (Cabinet Office, 2013).

Two questions faced by emergency managers, regardless of the organisation of institutions responsible for disaster risk reduction, are how best to disseminate information to citizens, and what should be the content of that information?

When it comes to deciding what guidance to give citizens with regards to earthquakes, there is no single definitive resource although international efforts have been made to produce a generalized set of recommendations (GeoHazards International, 2015; Shapira *et al.*, 2018). Governments may instead rely on the experience of emergency professionals along with a plethora of ideas about the best activities to do before, during and after a disaster. Unfortunately, research has also not yet established a consistent message on, for example, how to best survive an earthquake, perhaps owing to the many challenges involved in finding a causal relationship between what people do, and the outcomes in terms of survival, injury and death (Shoaf *et al.*, 1998; Johnston *et al.*, 2014).

There are also a variety of media (e.g. online, television, radio, written materials, drills and exercises) through which messages about earthquake safety can be delivered and some of these may be more effective or appropriate than others, depending on such factors as the built environment, the target audience and the resources available for messaging (Audru *et al.*, 2013; Ronan *et al.*, 2015).

2.3.1. Communicating earthquake risk

Li and Guo (2016) observed that raising awareness of the risks about sudden-onset hazards such as earthquakes requires effective risk communication processes to increase the knowledge and to improve their action plans. They go on to argue that information seeking by the public about risks is likely to promote preparedness and mitigation actions. However, as Tanaka (2005) has pointed out, developing disaster or emergency preparedness plans and effectively disseminating them to the public requires an understanding of the local population, and their characteristics and demographics to best target that information. What works for one population may not work so well for another, as Kasapoglu and Ecevit (2004) found with citizens in Marmara, Turkey, being more receptive to television messaging, whilst those in California Bay, USA preferred written documents.

One way in which information is commonly shared is through public information campaigns as well as training and drills for emergency response (Twum-Danso, 2002). This approach has been utilised for many areas of public health such as for promoting non-smoking (Grigg *et al.*, 2008), road safety (Guttman, 2016), vaccinations (BjÖrkman & Sanner, 2013), and disaster preparedness (Great Earthquake Shakeout Drills, 2015; Shenhar *et al.*, 2015). The effectiveness of such campaigns is evaluated by relating outcomes to a variety of

indicators, such as a reduction in smoking deaths, reduced road death toll, or an improvement in vaccination uptake. Ultimately these changes in outcomes reflect a change in behaviours by the intended audience of the campaigns (Shenhar *et al.*, 2015).

Unlike health campaigns where outcomes can be directly quantified through reductions in morbidity, it is impractical to wait for an earthquake before attempting to evaluate the effectiveness of advice. Therefore, public information campaigns aimed at reducing injury or death following earthquakes may be evaluated indirectly, for example, through measuring participation in drills, or the numbers of people undertaking preparedness activities (Herovic *et al.*, 2020).

In addition to campaigns, there are also various 'awareness days', such as world tsunami awareness day (5 November), and the international day for disaster risk reduction (the second Wednesday in October). The decade 1990-1999 was labelled the International Decade for Natural Disaster Reduction that promoted public awareness of disasters in communities globally (Shaw *et al.*, 2004).

A study by Goltz and Bourque (2017) of three Californian earthquakes from 1987-1994, reported that public education and information campaigns preceding the earthquakes appeared to have some influence on shaping people's behaviour although no clear causal relationship was established. This study is unusual in that it considers actions taken in three different earthquakes and it attempts to compare guidance provided with actions taken, although the methodologies used were not consistent across each case.

However, these attempts at communication are not without challenges. Shenhar *et al.* (2015) noted that they will be successful if they are able to reach a significant proportion of the intended audience. Paton and Johnston (2001) go further and point to the difference between receiving information and acting on it by recognising that the link between communicating preparedness information and taking action assumes that recipients of the information automatically assimilate, understand and utilise this, by following the suggested plans. Research has also shown that people's behaviours as a result of receiving risk communication varies and that the processes where people undertake preparedness activities after receiving risk information differs among individuals. In short, while education is expected to motivate people it does not change their personal characteristics (Tanaka, 2005).

More positively, when considering the effect of media information on people's knowledge and risk perception, Li and Guo (2016) have argued that information availability increases knowledge about earthquakes and that this knowledge can enhance people's imagination of the consequences of the dangers. MacDonald *et al.* (2017) and Levac *et al.*, (2012) also argue that teaching people about disaster risk and preparedness can mitigate some of the consequence in terms of reducing injuries, damage and social costs.

Others note that there is not a single method of communication that is suitable for all people, and that factors such as culture, education and learning preferences will affect how messages are received (Audru *et al.*, 2013; Mohadjer *et al.*, 2010; Paton *et al.*, 2010; Rüstemli & Karanci, 1999; Rosoff *et al.*, 2011). For this reason, developing communications strategies for disaster preparedness activities and linking them to the appropriate community or population context is important to ensure that people assimilate the information and act on recommendations or actions (Paton & Johnston, 2001).

Examples of audience factors that might need to be considered when delivering risk messages include those related to culture and gender (Izadkhah & Hosseini, 2010; Petal, 2011; Tanaka, 2005). Petal (2011) observed that socio-cultural factors that favour women, elderly and the young indoors, along with age, are of importance to public education advice, but does not elaborate further. Research into the public education programme in Martinique found that ensuring visual messaging that featured women, such as that used on television and in drawings, increased risk perception among this group (Audru *et al.*, 2013). A study with low-income Latino participants in California found that small group discussions as well as using 'promotoras', or promoters, as credible people to deliver preparedness education was the preferred method for learning (Eisenman *et al.*, 2009).

Surveys conducted in Martinique also showed that the public preferred to receive information via television media rather than printed material (brochures, newspapers), scientific conferences or meetings (Audru *et al.*, 2013). As a result, the government chose to focus on this method of delivery for their messaging. Similarly, Paradise (2005) showed that the type of media used to distribute public awareness messages influenced their effectiveness, and found that citizens who owned a television were generally more informed about earthquakes and the risks posed by them, than citizens who did not own a television and who were less educated about the cause of earthquakes. By contrast, authorities in Norway felt that it was better to disseminate information at public meetings, and not via written documents or through the internet, although this study was concerned with tsunami risks rather than earthquakes (Rød *et al.*, 2012).

In the USA a 'community as resource' concept led to a strategy of community-based programmes to prepare populations for disasters (Lichterman, 2000). These programmes generally seek to provide people with the knowledge and skills to be more self-reliant and self-sufficient during and following an emergency (Simpson, 2002).

An increasingly adopted medium for communication is the use of online resources. In Li and Guo's (2016) work on information seeking to assist decision making, they found that the online information environment played a significant role in influencing people's attitudes, judgements and decisions. They concluded that this easily accessible information has improved public awareness of hazards and assisted in the management of risk. However, challenges exist in the use of online methods of communication, including maintenance

issues such as version control, and ensuring other sources of information are available to those sections of society without access to the internet (Bryman, 2012).

In addition to the type of media used for messaging, the content of the message is also significant and the World Health Organization (2017) have suggested that effective messaging for public campaigns should:

- Avoid the use of technical terminology
- Provide consistent messages across a range of different sources
- Promote specific actions people can realistically take to protect their health
- Consider cultural contexts by pre-testing messages with intended audiences

There is also the nature of the target audience to consider. The protective action models described earlier all recognise that in the process of risk communication individuals respond in varying ways to receiving information. Risk communication is not just about delivering a message, but involves a complex mix of personal evaluation of the risk including prior attitudes (Shaw *et al.*, 2004), trust in those delivering the communication, and uncertainties associated with the risk (WHO, 2017). For this reason, the purpose of risk communication has increasingly recognised the need to accommodate personal and social factors as well as simply providing facts about hazards (Rød *et al.*, 2012). Shaw *et al.* (2014) have also made the more general point that promoting earthquake preparedness activities occurs amidst the demands of other day-to-day activities for the target audience.

A further problem to achieving effective communications can be the time between the messaging and the event to which the message applies. For example, the unpredictable timing of earthquakes means that guidance provided by governments may be aimed at encouraging long-term adjustments, such as hazard mitigation and emergency preparedness (Lindell and Perry, 2012) for an event that may occur many years into the future, if at all.

There is general agreement, therefore, that risk communication needs to utilise different processes and techniques to distribute messages about risk to previously identified individuals, communities, or organisations (Solberg *et al.*, 2010) and that the safety and wellbeing of communities living in hazard-prone areas depends on the effectiveness of this communication.

A preparedness action programme in Martinique provides an example of where multiple approaches have been used to engage communities. Methods utilised included travelling theatre, a prevention caravan and earthquake simulator, scientific conferences, art exhibitions, information stands in public areas and participation in carnival parades (Audru *et al.*, 2013). Workplaces were also targeted with specific messages, schools taught preparedness and action plans, and tourists were also given information leaflets outlining

actions to take during earthquakes. These diverse methods indicated that for this population personal learning experiences and visual demonstrations were preferred when compared with other methods of communication (Audru *et al.*, 2013).

Adaptive behaviour by at-risk communities has also been found to be maximised if local authorities reach a high proportion of the community with messages that answer a number of questions, namely (Drabek, 1999):

- Who is issuing the warning?
- What is the hazard?
- What geographical area is affected by the hazard?
- When is it coming?
- How probable is the event?
- Are there high-risk locations?
- What specific protective actions should be taken?

Clearly, some of these questions are easier to answer than others depending on the nature of the hazard. For example, it is not yet possible to accurately predict when an earthquake will occur or even, sometimes, who will most likely be affected (e.g. as in the case of the 2011 Christchurch earthquake).

Despite this variety of strategies, incorporating the culture of disaster preparedness and mitigation into people's lives continues to be challenging. For example, many citizens in the USA have been found to be unaware of their exposure to risks from natural hazards, planning only for the short term and over-estimating their ability to cope when disaster strikes (Kasapoglu & Ecevit, 2004). Similarly, a study conducted in New Zealand found that people over-estimated their knowledge and levels of preparedness (Paton & Johnston, 2001). This last study also found that if people over-estimated their levels of knowledge, they were less likely to pay attention to messages about the hazards that they felt they already understood.

Still further problems exist with messaging that may only be effective in the short term. In a commentary on the 2011 Great East Japan earthquake, Crowley and Elliott (2012) observe that Japanese society is collectively well prepared through frequent emergency exercises along with the public's sense of trusting and obeying official warnings and advice. However, they note that the flip side of maintaining a well-rehearsed level of awareness is that the public may become complacent and dependent on the government to ensure their safety and wellbeing.

Another time-related factor is the frequency with which information is presented. Research by Shenhar *et al.* (2015) on the effectiveness of cumulative earthquake preparedness campaigns in Israel showed that exposure to three campaigns over time had a positive effect on knowledge about earthquakes, but that an

immediate effect from a single campaign was not found. This research also found an improvement in public knowledge of earthquake preparedness, which they attributed to the awareness campaigns along with other related global events at the time, including the reporting of earthquakes. They conclude that to have a lasting impact on population awareness, campaigns should not stand alone, but be part of a wider process (Shenhar *et al.*, 2015).

Failure in communicating risk in a way that encourages people to prepare for earthquakes creates a condition of 'informational vulnerability' in communities (Mohadjer *et al.*, 2010). This may be caused by the inability of authorities or experts to adequately communicate risk information, or the inability of individuals in the community to comprehend that information. This may limit the ability of individuals and communities to develop and process the required information in order to be able to prepare for disastrous events (Baig & Sharif, 2013; Mohadjer *et al.*, 2010).

Crowley and Elliott (2012), have taken the idea of informational vulnerability further and argued that providing the right information also relies on the ability of researchers to communicate hazard risks or unknowns to governments and other stakeholders, as well as to the public.

Clearly, communicating risk effectively involves a number of factors ranging from the content and form of the messaging, the media used and the nature of the target audience. The advice contained in the message ultimately needs to be put into practice, and this can be encouraged in a variety of ways.

<u>In Practice – Advice, Exercises and Drills</u>

Earthquake education and preparedness advice can range from 'tips' disseminated through the media to more formal guidance and exercises or drills for specific audiences such as in schools or hospitals (Roces *et al.*, 1992). The document analysis that forms a later part of this research, for example, found a number of countries provided online information for their citizens with regards to earthquake preparedness.

While the majority of information is likely to be in written, spoken or pictorial form, it is also not uncommon for people to be asked to participate in some form of drill or exercise where actions to be taken during shaking are performed (Simpson, 2002). This is of particular interest here as the 'during' phase of an earthquake event is the focus of this research.

Exercises (events that test a response) and drills (that practice a skill) are recognised methods of preparing and training people to perform a particular action or series of tasks during an earthquake (Simpson, 2002). Paton and Johnston (2001) noted that it is important when considering the effectiveness of risk messages to focus on recall and behaviour. One way to enhance the ability to recall message content and undertake the

necessary actions is to participate in exercises or drills. This has the benefit of reinforcing knowledge into memory.

Leach (2004) argued that the reason why these active methods of training are effective is because performing a task enables the learned actions involved to be embedded in the long-term memory of individuals, making them more available for recall than if they had first to be processed in 'working memory'. Similarly, Bond (2017) argued that practical training overcomes the limiting effects of adrenaline on the brain, which allows for action rather than thinking, thereby helping individuals to act in line with their training in pressurised situations such as a sudden onset crisis. Fujinawa and Noda (2013) have also commented that the level of danger presented by the earthquake and people's prior earthquake experience or training are likely to impact on the actions that people take.

The ShakeOut exercise programme run by the Earthquake Country Alliance in California, USA, is an example of an exercise-based programme that has international recognition with many countries and organisations now using this method to help their citizens rehearse (Blake, 2011). A ShakeOut exercise held in New Zealand in October 2015 resulted in 1.36 million people signed up to participate (Vinnell *et al.*, 2020). During an educational campaign in Japan in 2007, actions to take during earthquakes were practised and included protecting your head, sheltering under a table, and not rushing outside (Fujinawa & Noda, 2013).

The Shakeout programme provides advice and material to help organisations develop exercises, and the philosophy behind ShakeOut is also that prior rehearsal of actions means people are more likely to act with the correct actions during an earthquake, and this is supported by documented benefits from exercises (Great Earthquake ShakeOut Drills, 2015; Vinnell *et al.*, 2020).

Many countries hold nationwide exercises to practice and test various parts of the emergency management structure and public response to earthquakes (Adams *et al.*, 2017; Simpson, 2002; Rosoff *et al.*, 2011). Studies undertaken into exercises and drills indicate that the activities being exercised should also include actions for those with disabilities, special needs and mobility problems (Tipler *et al.*, 2016; Dacey *et al.*, 2010). However, not all research into the effectiveness of exercises includes these groups. Simpson (2002) made no mention of the disabled, the very young or very old, those with specific vulnerabilities or special needs groups, in studies on the effectiveness of earthquake simulations and exercises.

In New Zealand, advice from NEMA (2010) has advised people to 'practice drop, cover, and hold on at least twice a year', and encourages citizens to undergo education and training in minimising risks from earthquakes, such as through holding drills, and planning to survive the secondary quake effects, such as tsunami or building collapse (Otani *et al.*, 2012).

A study looking at the responses and coping practices of children after the Christchurch earthquake in 2011 found that exercises and drills learnt at kindergarten (preschool) were used and referred to by primary school children who remembered to 'do the turtle' during the earthquake (Mooney *et al.*, 2017).

In Rapaport and Ashkenazi's (2019) review of the changes to protective advice in schools and kindergartens in Israel, they highlighted the importance of conducting earthquake drills to ensure public awareness of the earthquake instructions, particularly as changes to advice involved fleeing outside, rather than staying in and doing drop-cover-hold.

The scope of earthquake advice - 'during shaking'

While the above has considered some of the factors, strategies and challenges of providing earthquake advice, it is important to note that for the purpose of this research it is advice that specifically relates to the time of the earthquake, i.e. while the ground is shaking, that is of most interest.

Many studies focus on personal preparations that can be made prior to an earthquake and other disasters (e.g. Cutter *et al.*, 2008; Paton & Johnston, 2001; Paton, 2003; Paton *et al.*, 2010; Rustemli & Karanci, 1999; Tanaka, 2005; Tekeli-Yeşil *et al.*, 2010). Many of these studies also include analysis of factors such as gender, age, education levels and socio-economic levels, but they frequently fail to explore the readiness of people to take action when the shaking begins.

The few studies that do consider preparedness for when the ground starts shaking, such as Shapira, *et al.* (2018), Rosoff *et al.* (2011), and the report by New Zealand's Colmar Brunton poll (2019), have mainly done so by asking people what they intend to do if an earthquake occurs, but have not then gone on to see if actual behaviour has matched these reported intentions.

For example, in a study to ascertain the reactions of citizens to earthquakes, the proposed immediate response to earthquake shaking by 84% of participants was to duck and cover, rather than run from the building (Rosoff *et al.*, 2011). However, as this research used focus-group type discussions rather than a real earthquake situation, respondents were talking about their intended, rather than actual, actions. It is, therefore, not clear whether this is actually the action that they would do in the real situation. Evidence from Paton (2003) has indicated that the relationships between what people say they will do and actually do are not correlated. Talking about intentions does not necessarily lead to people actually being able to implement the action when required.

Lindell *et al.* (2009), have made one of the few distinctions between actions prior to, during and after a disaster and argue that preparedness programmes typically involve a variety of mitigation activities, including

providing passive protection at the time of impact, such as attaching large furniture to walls; active measures when disaster strikes, such as shutting off gas, and recovery undertakings in the aftermath.

Tanaka (2005) surveyed people in both the USA and Japan on their state of preparedness for an earthquake. The survey included 27 indicators of preparedness but only one made a direct reference to what to do during an earthquake, namely, 'Does your household have an earthquake plan (i.e. what to do *during* and after an earthquake)?' All other indicators referred only to preparedness actions to be taken prior to an earthquake.

Kasapoglu and Ecevit (2004) studied future behavioural responses to earthquakes in Turkey and the USA, and asked survey respondents what they recalled about recommended actions related to earthquake preparedness and mitigation. None of the list of recommended actions for the study included actions to take during earthquake shaking, such as drop-cover-hold, or sheltering or protect oneself, but the list did include actions to take before and after an earthquake, such as learn first aid and how to put out fires. This study appears to have missed an opportunity to include an important aspect of earthquake preparedness.

Similarly, Rustemli and Karanci (1999) focused on preparedness behaviours in Turkey, and participants in their study mentioned a variety of activities such as fixing furniture to walls and having stocks of food, but no mention was made regarding the types of actions they might take when an earthquake strikes.

<u>The content of Earthquake advice – 'during shaking'</u>

Both GeoHazards International (2015) and Shapira *et al.* (2018) identified two general but contrasting types of advice provided to people who are inside a building when earthquakes start, a) shelter inside the building and do the drop-cover-hold action; or b) leave the building immediately and go to an open area. Shapira *et al.* (2018) argued that a possible reason for this difference is the variation in the structural safety of buildings in different parts of the world. A simple answer may be that where buildings are not earthquake-resistant, leaving the building during shaking may provide a better outcome, whereas the reverse is also true. However, there is considerable debate on this issue (Armenian *et al.*, 1992; GeoHazards International, 2015; Shapira *et al.*, 2018; Rapaport & Ashkanazi, 2019), and the answer is not yet resolved, as there are many other factors to consider besides the strength of buildings.

Armenian *et al.*'s (1992) study on the 1988 Armenian earthquake also recommended that in buildings with strict enforcement of appropriate building codes, occupants should remain indoors to avoid being struck by falling debris outside, however for those buildings in areas of little relevant building control, running outdoors may be the best action.

Rahimi (1993) concluded that research around the immediate actions to take at the onset of earthquake shaking was still being debated, particularly around 'staying-put' versus 'running out'. The study also showed

that controlled, or calm, behaviour is a positive step towards making an appropriate decision for safe actions (Rahimi, 1993), illustrating that the human element may be as important as the physical environment.

In Murakami and Durkin's (1988) work on occupant behaviour in earthquakes, it was also found that knowledge of occupant behaviour in buildings formed an important role in the preparation of guidelines for earthquake preparedness, such as whether sheltering under a desk or standing in a doorway is safe.

Examples of where more specific advice may be required focus on groups such as the elderly or people with disabilities. Rahimi (1993), noted that drop-cover-hold may not be a suitable action to advise in the case of people with disabilities or the elderly, due to issues of reduced mobility. Tuohy *et al.*, (2014) also found that in a study of elderly residents on their actions in the Christchurch earthquake, participants were concerned that they were not able to follow official guidance that included drop-cover-hold owing to the physical inability to get down to ground level. Guidance at the time recommended that the elderly remain where they are and brace themselves in place (CDEM, 2010).

In a study by Verucci *et al.* (2016) that used digitally available earthquake preparedness resources from 76 websites, they found that 95% of the reviewed websites included the drop-cover-hold manoeuvre or similar (covering the head and neck), and a further 96% of websites recommended to remain indoors until the earthquake has stopped. Advice to stay calm was also included in 96% of websites. Staying away from windows and falling objects were included by 79% and avoiding escalators by 66% of websites. It is not possible to verify the source of the websites included in the study, and therefore the reliability of the websites used. The study found that content varied greatly, and that users accessing more than one source could possibly be confused as to the correct preparedness advice. This illustrates how preparedness advice generally has not provided a single clear strategy for action, but has produced a number of competing, or complimentary, views on how best to behave at the time of shaking, and this may have led to confusion among members of the public.

Drop-cover-hold

The drop-cover-hold response, mentioned above, is widely referred to in official guidance and forms a core component of many earthquake preparedness plans. It is considered one of the most effective and simple approaches for teaching the public about earthquake drills (Mahdavifar *et al.*, 2009; Rapaport & Ashkanazi, 2019; Alexander, 2012; Southern California Earthquake Centre, 2021). It is a practical action when few other options exist to take protection during strong earthquakes (Alexander, 2012).

The drop-cover-hold action requires a person to drop down to the floor or ground when an earthquake is felt, then take cover under a sturdy object, finally holding on to the object to prevent it from moving away from them due to the shaking. If no object is present, they cover their head with their hands to provide

protection. (Stuart-Black, 2015; Mahdavifar *et al.*, 2009; Ready, 2021; Rapaport & Ashkanazi, 2019). These actions are often presented in diagrammatic form similar to Figure 2.2 below:

Figure 2.2. Drop-cover-hold – (New Zealand NEMA)

The aim of the drop-cover-hold message is to save lives or reduce injury during earthquakes of people who are inside a building, and to protect them from loose objects in the room (GeoHazards International, 2015). The rationale behind drop-cover-hold is that it is safer to stay inside a building that is constructed to seismic standards, than to run outside and risk being hit by falling masonry (Stuart-Black, 2015).

A controversial alternative to the drop-cover-hold approach, is the 'triangle of life' concept that advises people to take shelter beside a large, solid piece of furniture or similar in order to be protected from falling beams, ceiling or roof objects (Mahdavifar *et al.*, 2009). The reasoning for this action is that falling objects may then form a void, or triangle in which the person is safe from being trapped by other debris (see Figure 2.3) (Copp, n.d.)

The triangle of life makes several assumptions (Mahdavifar *et al.*, 2009):

- Buildings always collapse, crushing all furniture
- People always know how the building might collapse and know the location of survivable voids
- People can move during strong shaking

Figure 2.3. The Triangle of Life

(Copp, n.d.)

This advice has been the subject of some criticism since it was issued in 1985 due it being based on observations made during a search and rescue response to the 1985 earthquake in Mexico and promoted following the event (Copp, n.d.). It is not considered appropriate for buildings with stronger building codes, such as those found in New Zealand, the USA, and Japan (Stuart-Black, 2015; Petal, 2004; Lopes, 2004). In a study undertaken following the ShakeOut exercise in New Zealand in 2012, participants questioned the use of drop-cover-hold, and the exercise was used to dispel myths about the safety of the triangle of life action

(Tipler *et al.*, 2016). Studies refer to continually having to dispel the myths that the triangle of life is more effective than drop-cover-hold (Tipler *et al.*, 2016; Lopes, 2004; Rapaport & Ashkanazi, 2019).

Mahdavifar *et al*. (2009) argued that the triangle of life could not be completely discounted, as some situations may exist where reinforced concrete buildings collapse and crush heavy, large objects making them ineffective as forms of shelter, thereby making it safer to seek protection beside an object in a void space. However, the study still concluded that drop-cover-hold was found to be the more appropriate action to take for a greater variety of reasons and situation (Mahdavifar *et al.*, 2009). Furthermore, Alexander and Magni (2013) found that after the 2009 L'Aquila earthquake in Italy where many buildings were constructed from unreinforced masonry, any voids within collapsed buildings were filled with debris. This would have made the triangle of life action ineffective. Nevertheless, the concept is still present in the public domain and, as the theory is sometimes resurrected after a major disaster, reference to this action is given here for completeness.

The lack of consensus about the most appropriate actions to take during an earthquake may help to explain why there has been little research into the influence of earthquake advice on actions taken. One study that attempted to relate actions back to guidance was done by Prati *et al.* (2013), but unfortunately this work compared actions taken during earthquakes in Italy with advice provided by the Federal Emergency Management Agency in the USA. As GeoHazards International (2015) have argued, due to differing cultures, beliefs, buildings, and geology there is no single piece of protective action that can be advised for all countries or regions. This also means that official guidance referred to in research must be relevant and available to the population being studied.

In summary, there have been a number of studies over the years looking at the protective actions taken by people during earthquakes, as well as recommendations made as to what actions are most appropriate in terms of reducing injury or death. However, there is a relative paucity of research into understanding or quantifying the official advice that is currently being provided in this area, and still less into the effects of this advice on people's behaviour.

2.4. Gaps in the research

Gaps in the above literature indicate that there remains uncertainty and a lack of clarity surrounding what people are told to do during an earthquake and what they actually do, along with the methods through which they are informed. Furthermore, much research that considers protective actions concentrates on a single earthquake event, and uses its own particular methodology. For this reason, it may not be appropriate to draw broader conclusions about advice and actions in general from such isolated cases.

This research, therefore, focuses on understanding the actions taken by people during two significant earthquakes and the influence of preparedness advice on those actions, along with identifying the content of preparedness advice from a number of sources.

The following chapter describes the context within which the empirical component of this research takes place, namely two field studies and a document analysis.

Chapter 3: Background to field studies and preparedness advice

This short chapter provides an overview of the two locations chosen for the field studies that comprise a part of this research, as well as a brief description of earthquake preparedness advice in general as disseminated by emergency management agencies around the world. This background information provides a context for the more detailed description of methodologies and sampling procedures contained in the next chapter.

Since earthquakes do not happen in isolation, no description would be complete without giving some attention to the historical and social context in which they occur. The following section looks at the seismic history of New Zealand and Japan, including earthquake preparedness and mitigation measures to reduce lives lost and damage to property as a result of earthquakes.

3.1. Christchurch and the February 2011 earthquake

New Zealand experiences around 20,000 earthquakes a year, however only about 200-300 are large enough to be felt without seismic monitors (CDEM, 2015). New Zealand also has a long history of seismic activity as the country is situated at the junction of the Australasian and Pacific tectonic plates, with the Alpine fault line one of the major faults running the length of the country (GNS, n.d.-a). However, until recently the region of Canterbury where Christchurch is located was not an area of New Zealand that had been strongly associated with frequent or strong earthquakes.

The earliest documented reports of earthquakes in New Zealand were for a tremor that took place in 1773 and later reported by Captain James Cook in 1777 (Eiby, 1968). However, earlier narrative reports exist from Maori culture about large earthquakes over the preceding 400 years (Eiby, 1968).

Thomson (1859) provided a description of early New Zealand that included reference to, and descriptions of, several earthquakes. Commenting on the 1848 Marlborough earthquake, that inflicted major damage in Wellington and which was felt across much of the country, Thomson noted that:

> *"…every wooden house in the town was rocked to and fro, all the stone and brick buildings were injured…"*
> *"had Wellington been a stone-built town, hundreds of its inhabitants would have perished…".*
>
> Thomson (1859)

Skinner (2009) observed that early European settlers were aware of the damage that earthquakes could cause, and from about 1848 there was an understanding that brick and stone was less resilient than timber, however many British settlers in New Zealand preferred to continue building with brick and stone as this was both reminiscent of home and a sign of sign of wealth, prestige and permanence. Skinner (2009) viewed the

1848 Marlborough earthquake as a significant turning point in attitudes towards building design and materials in relation to seismic activity.

Thomson (1859) also recorded reactions to the January 1855 earthquake and aftershocks in Wellington, and this may be one of the first recorded descriptions of actions taken by people during earthquakes in New Zealand.

> *"men…lay on long poles, lest a fissure in the earth should open; women and children were stretched on beds in the streets in agonies of terror; dogs howled; stabled horses were covered in sweat; and ducks, hens, and pigs cried piteously."*
>
> Thomson (1859)

New Zealand's most destructive earthquake, in terms of lives lost, is the Hawke's Bay earthquake that occurred on Tuesday 3 February 1931. The earthquake struck at 10.47am during a working day, with a magnitude Mw 7.8, and lasted about 2 minutes (Slade, 1932; McSaveney, 2017). Eye-witness reports from the event indicate the severity of the earthquake, and people were reported to have fled outside only to be struck by falling masonry. The fires that followed the earthquake led to the death of many of those who had been trapped under fallen buildings (McSaveney, 2017). This event, along with lessons from the war-time 1942 Wairarapa earthquakes, helped shape New Zealand's earthquake preparedness and response system, and led to the establishment of two organisations, the Earthquake and War Damages Commission, and the Ministry of Civil Defence.

Disaster preparedness

New Zealand has a structured and long-standing system of civil protection, currently under the remit of the New Zealand National Emergency Management Agency (NEMA). NEMA provides policy advice to the government and manages the central government response for large scale emergencies that are beyond the capacity of local authorities. The Agency also provides support for emergency management planning and operations, and ensures there is coordination at local, regional and national levels (NEMA, n.d.-a). NEMA is a new agency, formed in December 2019, and replaced the Ministry of Civil Defence and Emergency Management (MCDEM) that existed during the Christchurch earthquake of 2011.

One of the key planning and preparedness roles of NEMA, and its predecessor, MCDEM, is the provision of public disaster preparedness plans. Historically this used to consist of advice on actions to take before, during and after a disaster, including earthquakes, volcanic eruptions or other natural events, and which was distributed as part of local telephone books. There was and still is an extensive programme for schools that teaches children the actions to take during an earthquake, and emergency drills are run throughout the school year.

Planning for emergencies in New Zealand goes back to at least 1926 when Hawkes Bay had an emergency plan involving the local hospital. This was five years before the devastating 1931 earthquake (McGregor, 2002). It is not clear whether this plan included actions to take during earthquake shaking.

As part of its public education programme, NEMA has undertaken disaster preparedness surveys of New Zealanders every year since 2006, however these tend to focus on general preparedness rather than earthquakes specifically (NEMA, n.d.-b). The results are publicly available on the NEMA website.

22 February 2011 earthquake

At 12.51 on Tuesday 22 February 2011, Christchurch was struck by an earthquake with a magnitude Mw 6.2 (GNS, 2011). The epicentre was 10km SE of the city centre, and at a depth of 5km (GNS, 2011), shown in Figure 3.1. Perceived shaking close to the epicentre reached MMX, classified as 'violent' on the MM Scale (Royal Society of New Zealand, 2011). In total, 185 people were killed as a result the earthquake, with more than 6,659 reported injuries (Ardagh *et al.*, 2012). A large number of buildings in the central city area were damaged, some completely. This included the multi-storey Canterbury TV (CTV) and Pyne Gould Guinness (PGG) buildings where the majority of fatalities occurred (see Figure 3.2).

This was not the first large earthquake to strike Christchurch. On 4 September 2010, a Mw 7.2 earthquake struck at Darfield, 50km west of the city in the Canterbury region. This earthquake was perhaps the first indication of fault lines not previously identified as active by geo-scientists and which later led to the 22 February 2011 Christchurch earthquake (Royal Society of New Zealand, 2011).

Following the Darfield earthquake in 2010 there were constant aftershocks in and around the region (GNS, n.d.-b). The continual exposure of the population to these aftershocks was unusual and may have had an influence on the actions people took over the subsequent months with regards to their response to later shaking.

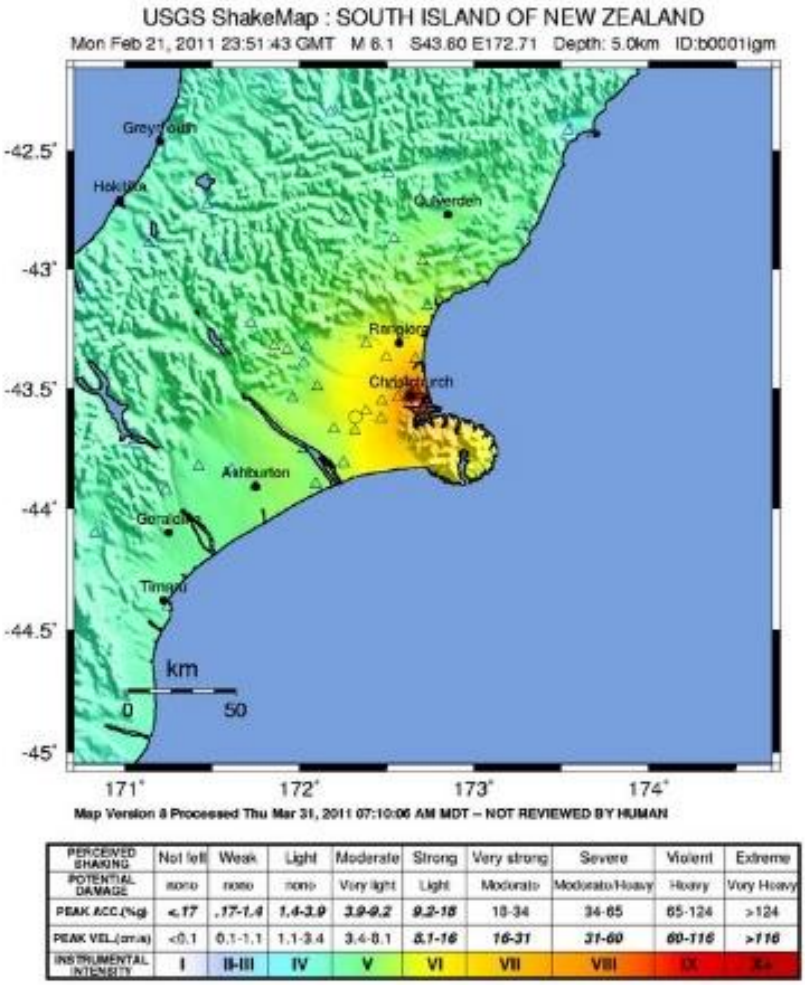


Figure 3.1. ShakeMap of the 22 February 2011 earthquake (USGS, 2011a)

One reason for the increased damage in the February 2011 earthquake compared to the larger September 2010 earthquake was that the epicentre of the February earthquake was close to central Christchurch. In the 22 February earthquake the ground accelerations were three to four times that of the Mw 7.1 September earthquake, and up to six times greater in the eastern suburbs (Kaiser *et al.*, 2012). However, ground shaking in the February earthquake was consistent with that observed for similar earthquakes elsewhere globally (Royal Society of New Zealand, 2011).

The 185 deaths from the earthquake were mapped by the New Zealand Police, see figure 3.2. Collapse of the CTV and PGG buildings in the central city area caused the greatest loss of life. Fatalities from the CTV building were 115, with 18 from the PGG building. The collapse of the CTV building was described as 'pancaked all the way to the ground' and occurred about 10 seconds after the earthquake began (Royal Commission of Inquiry, 2011). Other buildings also suffered significant damage where fatalities occurred, and 12 people died in the suburb areas.

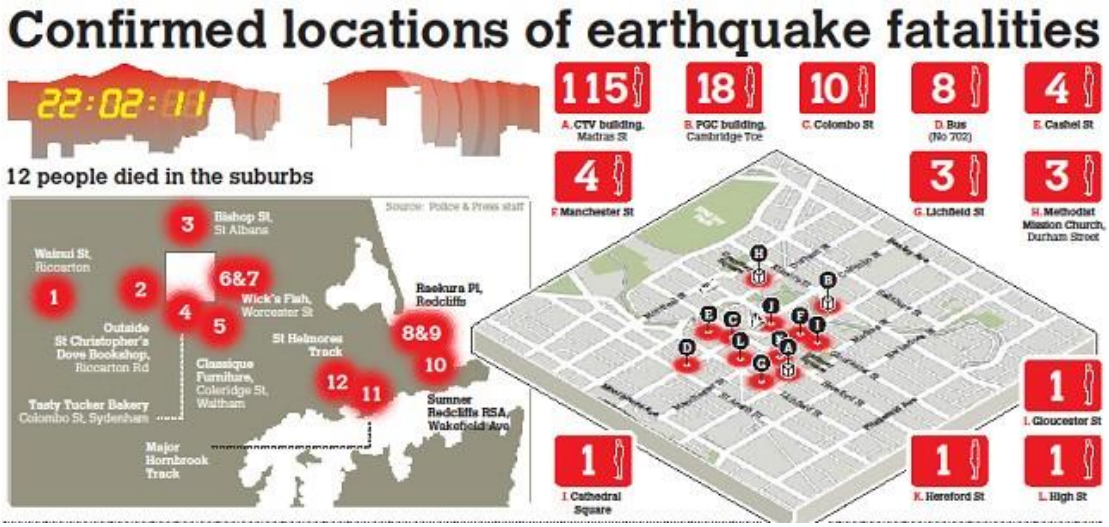


Figure 3.2. Location of fatalities in the 22 February 2011 earthquake

Ref: NZ Police, 2011

The New Zealand government set up a Royal Commission of Inquiry for the earthquake to identify whether any lessons could be learnt from the event (Royal Commission of Inquiry, 2011). In particular the Commission reviewed the time the earthquake struck and people's actions in the collapsed CTV building in the immediate period during and after the earthquake. The coroner investigated the nature of events surrounding the fatalities (Matenga, 2014). This level of detail and investigation into the casualties and fatalities of an earthquake provides information on people's actions and outcomes not often recorded after earthquakes.

New Zealand earthquake preparedness advice

Hazard advice for New Zealand is published by NEMA (formerly MCDEM), and advice published in April 2010 was the official advice in use at the time of the earthquake in February 2011, titled 'Working from the same page: consistent messages for CDEM' (CDEM, 2010). Whilst freely available to the public via the Ministry website, no data is available on how many people referred to this text version. There is also a pictorial form of the drop-cover-hold message showing each of the three actions that forms part of New Zealand's earthquake preparedness communication to the public (NEMA, n.d.-c), and members of the public may be more likely to come across this than the official document.

Relevant extracts of the 2010 advice have been included below as these actions are central to understanding the field component of the research. A more detailed copy of the advice is included in Appendix 1.0. Advice contained in the 2010 version of the actions to take during an earthquake are (CDEM, 2010):

If you are inside when the shaking starts, you should:

> "20. Drop, cover, and hold on. Move only a few steps to a nearby safe place. Most people injured in earthquakes move more than three metres during the shaking."
>
> "21. If you are elderly or have limited mobility, remain where you are, bracing yourself in place."
>
> "22. If you are in bed, stay there, hold on, and protect your head with a pillow. You are less likely to be injured if you stay in bed. Broken glass on the floor can injure you."
>
> "23. Stay away from windows. Windows can shatter with such force that you can be injured by flying glass even if you are several metres away."
>
> "24. Stay indoors until the shaking stops and you are sure it is safe to exit. In most buildings in New Zealand, you are safer if you stay where you are until the shaking stops. If you go outside after shaking stops, move quickly away from buildings to prevent injury from falling debris."
>
> "25. If you are in a coastal area, drop, cover and hold during an earthquake and then move immediately to higher ground when the shaking stops or, if the area is flat move as far inland as possible. Earthquakes off the coast can generate tsunami."

If you are outdoors when the shaking starts, you should:

> "26. Find a clear spot away from buildings, trees, streetlights and power lines."
>
> "27. Drop to the ground and stay there until the shaking stops. Injuries can occur from falling trees, streetlights, powerlines, and buildings debris."
>
> "28. If you are in a vehicle, pull over to a clear location, stop and stay there with your seatbelt fastened until the shaking stops. Trees, power lines, poles, street signs, overpasses and other overhead items may fall during earthquakes. Stopping in a clear location will reduce your risk, and a hard-topped vehicle will prevent you from flying or falling objects. Once the shaking has stopped, proceed with caution. Avoid bridges or ramps that might have been damaged by the quake."
>
> "29. If you are in a mountainous areas or near unstable slopes or cliffs, be alert for falling rocks and other debris that could be loosened by the earthquake. Earthquakes often trigger landslides."

The advice was re-issued in June 2015 after the Christchurch earthquake, with updated content on actions to take during an earthquake (CDEM, 2015). Emphasis in the later version for indoor actions focuses on drop-

cover-hold and remaining indoors until the shaking stops. Outdoors there is additional advice to drop-cover-hold in coastal areas.

3.2. Sendai and the Tohoku (Great Eastern Japan) Earthquake

Japan sits on the edge of four continental plates, the Eurasian, Pacific, Philippine and North American plates. This region is prone to constant seismic activity, and has experienced some of the world's greatest and most destructive earthquakes. The geophysical nature of the region also means that there is a high tsunami risk following earthquakes. Nearly 20% of the world's recorded earthquakes with a magnitude 6 or greater have occurred in or around Japan (Cabinet Office, 2015).

The history of earthquakes in Japan has been well documented (Smits, 2015), and the earliest reliably documented event occurred in the Nara Prefecture in 599. The strongest recorded earthquake being the Great Eastern Japan earthquake in March 2011 (List of earthquakes in Japan, 2021). During 1854 and 1855, three large earthquakes struck Japan, the Ansei Great Earthquakes, causing significant damage (Ansei great earthquakes, 2021), and the 1855 earthquake striking Edo, now Tokyo. Smits (2015) argued that the Ansei-Edo earthquake had a subsequent positive effect on the scientific study of earthquakes, and awareness among the public of measures to mitigate the consequences of earthquakes.

Disaster preparedness

Japanese authorities have a national remit to protect the lives of citizens, livelihoods, property and the natural environment from disasters. This remit was a result of Typhoon Ise-wan in 1959, that lead to several disaster-related pieces of legislation and the formation of disaster preparedness and response plans in the early 1960s (Cabinet Office, 2015). The Japanese government has nominated 1st September as disaster preparedness day, and carries out events and campaigns to raise the awareness of the public to disasters, including activities such as drills and exercises (Cabinet Office, 2015). Sendai City hosted the Third UN World Conference on Disaster Risk Reduction (DRR) in March 2015, where the Sendai Framework for DRR was adopted as an outcome of the conference (UNISDR, 2015).

The Cabinet Office within government is responsible for ensuring cooperation and collaboration between government organisations in disaster management. This role includes the planning of basic disaster management policies and response to large-scale disasters, as well as providing overall coordination. The Fire and Disaster Management Agency (FDMA) is an agency that sits under the Cabinet Office. Disaster preparedness advice for citizens is published by the FDMA and is publicly available on their website (FDMA, n.d.).

Japan has an Earthquake Early Warning (EEW) system in operation that links to mobile telephones, televisions and radios, sounding a special chime when there is a warning of an earthquake (Fujinawa & Noda, 2013; SIRA,

2013). Depending on the type of earthquake and warning system, there may be up to 10 seconds warning (Fujinawa & Noda, 2013), which may allow enough time for people to move to a place of safety.

The school education system has included a component of disaster education in the curriculum since 1945, and this focuses on two main areas, 'the science of disasters' and 'the life skills for disasters' (Kitagawa, 2015), with both the Hanshin 1995 earthquake and the Tohoku 2011 earthquake being focus points in the disaster education programme.

11 March 2011 earthquake

On 11 March 2011 a magnitude Mw 9.0 earthquake struck at 14:46 local time, at a depth of 29km and the epicentre was off the east coast of Japan, see Figure 3.3 (Dunbar *et al.*, 2011; USGS, 2011b). This event triggered a tsunami with wave heights reaching between 40-43m in the Tohoku (Miyagi) coastal area (Ando, 2013) that inundated 4km inland near Sendai city (Dunbar *et al.*, 2011). The Earthquake Early Warning (EEW) system first sent out warnings 5.4 seconds after the earthquake was first detected, and in total sent 15 warnings, each with an increasing magnitude (Fujinawa & Noda, 2013). This resulted in most people having at least 10 seconds to take action to protect themselves and prepare for evacuation (Fujinawa & Noda, 2013). The tsunami also caused severe damage to the nuclear power station at Fukushima, resulting in release of radiation across a wide area. This cascading disaster had impacts far beyond the east coast of Japan, including damage to infrastructure and buildings in Hawaii, Peru and Chile, loss of wildlife on Pacific Islands (Dunbar *et al.*, 2015), and disruption to global supply chains (Arto *et al.*, 2015).

As a result of the earthquake and subsequent tsunami, 21,839 people were officially reported dead or missing (Cabinet Office, 2015). In the Miyagi Prefecture (including Sendai), the combined earthquake and tsunami resulted in 9540 reported deaths, 1225 missing, and 4145 injured (National Police Agency of Japan, 2020). In some prefectures it was difficult to ascertain exactly whether the numbers of deceased were due to the earthquake or the tsunami, in other prefectures the deaths were obviously located far from the coast (Dunbar *et al.*, 2011).

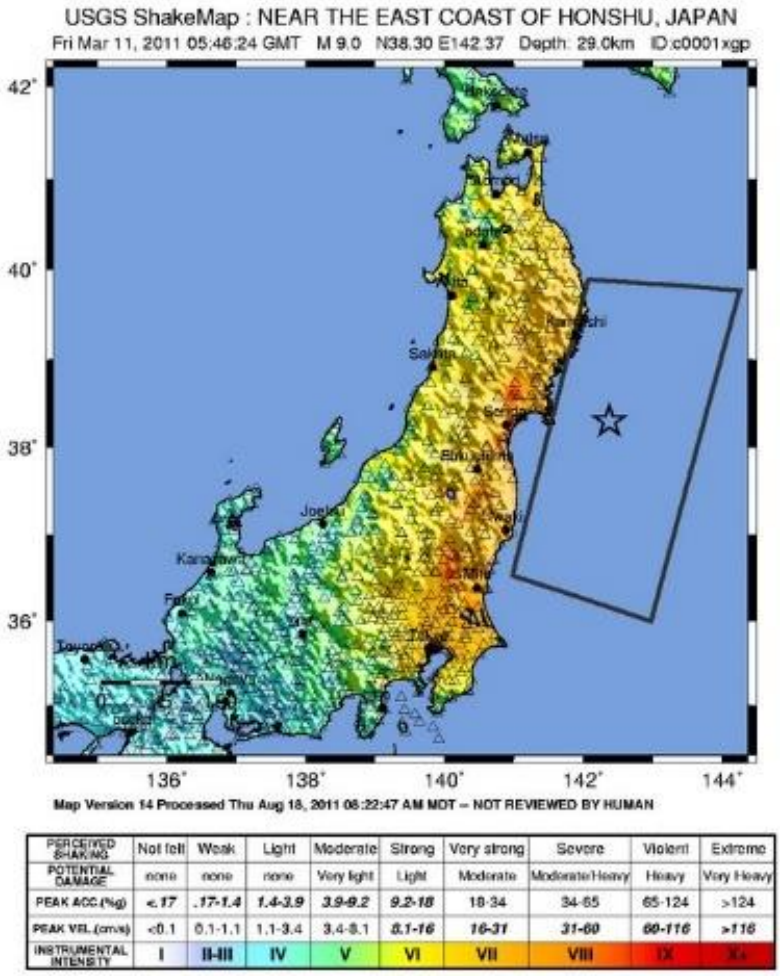


Figure 3.3. USGS ShakeMap of 11 March 2011 earthquake. Ref: USGS, 2011b

<u>Japanese earthquake preparedness advice</u>

The Fire and Disaster Management Agency (FDMA) in Japan has issued advice to citizens on actions to take during an earthquake. These actions cover a variety of situations, both indoors and outdoors, and has been used to inform the discussion of the surveys undertaken in Sendai as part of this research. The general advice is shown below and the full description can be found in Appendix 2.0

FDMA advice for a variety of indoor situations:

1. General housing -basic points at home:

   Get under a stable desk or table and hold onto its legs tightly. Protect your head with a cushion or the like and stay put until the tremors stop.
2. When sleeping in a bedroom:

   If a tremor wakes you, secure your safety by getting under your bedding or bed, if possible.

3. When in a bathroom:

   If you feel a tremor, open the door immediately to secure your exit route, then wait until the tremors stop.
4. When in the kitchen:

   Get under a table or the like and wait until the tremors stop
5. Condominiums:

   Note that tremors are more intense on the upper floors than on the ground level
6. Offices:

   Move away from cabinets, shelves, lockers, and copying machines in the office. Cover your head and get under a desk or the like to protect yourself.
7. Supermarkets, Department stores:

   Protect your head with a bag or shopping basket and move away from showcases or high shelves stocked with items that may fall.
8. Movie theatres, theatres:

   Protect your head using a bag or the like and find shelter between the seats. Stay put until the tremors stop.
9. Underground mall:

   Protect your head with a bag or the like and try not to panic. Stay put until the tremors stop.
10. Schools:

    Get under a desk to protect yourself from falling objects in the classroom. Follow the instructions of the teacher without taking sudden actions (such as fleeing the building in a panic).
11. Elevators:

    The basic rule is to press the buttons for all floors and get off at the first floor where the elevator stops. Be sure, however, never to rush onto a floor with fire or other serious danger."

FDMA advice for Outdoor Situations:

1. Residential district:

   If a strong quake strikes, the stress of residential districts will probably be blocked off with collapsed objects.
2. Business districts, Downtown:

   Window glass, outer walls, and signboards may fall from high- and middle-rise buildings downtown or in business districts.
3. Seaside

   The biggest earthquake danger facing you at the seaside is the tidal wave (tsunami). Move to

higher ground or an evacuation site immediately, without waiting for instructions or evacuation advice.

4. Riverside

   Tidal waves travel up water-filled rivers

5. Mountainous, hilly districts

   Move away from dangerous areas such as steep sloping land, watching out for falling rocks as you proceed.

FDMA advice for Transport Situations:

1. While driving a car

   Unforeseen accidents may result if you try to make a sudden stop.

2. Railways

   Be prepared for an emergency stop. Stay low and keep hold of handrails o straps to avoid injury.

3. Shinkansen (Bullet train)

   The Urgent Earthquake Detection and Alarm System (UrEDAS) stops the train in the event of an emergency.

4. Subway

   Subway trains will come to an emergency stop when a quake intensity 5 Lower is detected. If the train is between stations, it checks and proceeds to the nearest station at low speed.

5. Bus

   The bus driver may brake suddenly. Stay low and hold of a handrail or strap to avoid injury."

As with New Zealand, the earthquake advice in Japan is freely available, and located on the Fire and Disaster Management Agency website. It is not known how frequently it is accessed by the public. Other organisations in Japan also issue versions of the earthquake guidance, for example residents associations in Sendai and Tokushima provide advice in both English and Japanese (SIRA, 2013; TOPIA, 2014).

3.3. Summary of preparedness advice

A summary and comparison of the protective actions advised by the respective emergency management agencies of New Zealand and Japan is shown below in Table 3.1. Advice that is similar in nature is located in adjacent cells, and spaces in the table reflect that no comparable information is provided by the country:

New Zealand advice	Japanese advice
Drop, cover, and hold	Get under a stable desk or table and hold onto its legs tightly. Protect your head with a cushion or the like and stay put until the tremors stop.
Elderly or have limited mobility, "remain where you are, bracing yourself in place."	
In bed – stay there, hold on, and protect your head with a pillow	In bed – get under your bedding or bed
Move only a few steps to the safest nearby place, away from windows that may shatter and large furniture that could fall	
Stay indoors until the shaking stops and you are sure it is safe to exit	
	Elevator – press the buttons for all floors and get off at the first floor where the elevator stops
Outside: if possible find a clear area away from buildings, trees, streetlights and power lines, as these may fall causing injuries during an earthquake. Drop to the ground and stay there until the shaking stops."	Business districts, downtown – window glass, outer walls, and signboards may fall from high- and middle-rise buildings downtown or in business districts. Protect your head with your shoes or the like and move as far away from the buildings as possible
Vehicle: if possible, pull over to a clear location, stop and stay there with your seatbelt fastened until the shaking stops	Driving a car – unforeseen accidents may result if you try to make a sudden stop
Coastal area: drop, cover and hold during an earthquake. Move immediately to higher ground when the shaking stops or, if the area is flat, move as far inland as possible.	Seaside – move to higher ground or an evacuation site immediately
Mountainous areas or near unstable slopes or cliffs: be alert for falling rocks and other debris	Mountains – move away from dangerous areas such as steep sloping land, watching out for falling rocks

Table 3.1. Comparison of selected New Zealand and Japanese advised protective actions

(NEMA, 2010; FDMA, n.d.)

It is worth noting that there are some differences in the advice given by each country. New Zealand has as its primary message 'drop-cover-hold', without any further details on how this might be achieved. In Japan, the primary message is also to seek shelter and describes the specific actions to needed to achieve this.

Both countries contain information regarding specific outdoor situations that are relevant to country geography, such as coastal and mountainous areas. Likewise, advice is given for hazards from buildings, such as glass and street furniture. Japanese advice mentions protecting the head whilst moving away from the buildings, while New Zealand recommends dropping to the ground and staying there until shaking stops. Advice for driving a vehicle is provided by both countries, with New Zealand providing advice about what to do, and Japan warning drivers of the hazards of stopping too quickly.

3.4. Context of earthquake preparedness advice documents

The United Nations Office for Disaster Risk Reduction (UNDRR) and the Sendai Framework recommend that governments issue hazard preparedness advice for citizens (UNISDR, 2015) that includes advice, guidance and training on how to prepare, respond and recover from disasters. This advice is generally produced by government authorities, and in some cases by national Red Cross organisations or NGOs, such as Save the Children. The advice is provided in a variety of formats and might also include exercises and training for workplaces and schools.

Generally, the advice is contained in a document or series of documents comprising easy to read and understand information about preparing for, responding to, and recovering from an earthquake disaster. The preparedness messages can be delivered in a variety of methods to a range of audiences, and these include web-based information pages for general public reference, community-based drills such as ShakeOut and practicing the drop, cover, hold technique, or using television advertising to remind and demonstrate to viewers the appropriate actions to take during earthquake shaking.

3.5. Summary

This chapter has highlighted the long seismic histories in both New Zealand and Japan, highlighting the role of disaster management agencies in protecting their respective populations. These agencies issue earthquake preparedness advice to citizens that cover the periods before, during and after an earthquake. In most cases, the advice provided by the two countries is similar, however a more in-depth description is contained in the Japanese advice of various locations and the types of actions to take in each.

By providing a description of the background to the earthquakes in Christchurch and Sendai that are the subject of this study, the findings from the surveys can be interpreted in terms of likely relevance to other

situations, be these more or less comparable. Similarly, an understanding of preparedness advice in general will inform the evaluation of guidance provided in the two field locations.

Chapter 4: Methodology and context

The review of literature in Chapter 2 highlighted a gap in the research surrounding the actions people take during earthquake activity. Numerous studies exist that look at behaviour and actions for a single earthquake event (Prati *et al.*, 2012; Prati *et al.*, 2013; Arnold *et al.*, 1982; Archea & Kobayashi, 1984; Santos-Reyes & Gouzeva, 2020), but there are few that consider two or more (Lindell *et al.*, 2016; Goltz & Bourque, 2017). Increased challenges are associated with researching more than one earthquake simultaneously, but there are also advantages to be gained. Researching two earthquakes using similar methodologies allows for comparison of sample populations using the same survey tool, therefore enabling similarities and differences to be more robustly assessed. Furthermore, using two earthquake events enables a wider understanding of differences in behaviour and actions likely to be affected by factors such as demographics, strength of earthquake, and preparedness activities.

This chapter provides an introduction and background to the two field studies that comprise a substantive part of this research. Firstly, it outlines the research design and discusses the process and criteria for selecting the two earthquake events included in the research. This is followed by a description of the questionnaire tools used for each sample, and the process for administration of the questionnaires including sample selection. Lastly, the methods used for data analysis are described, and limitations or constraints associated with the research process are outlined. The terms 'questionnaire' and 'survey' are used interchangeably throughout this thesis. The final part of this chapter provides an introduction to the qualitative study of earthquake advice documents from around the world, and the selection and analysis processes for these documents.

4.1. The Field Studies

The core of this research focuses on gathering information about people's decisions and actions during two earthquake events, meaning that social research methodologies are an appropriate means to collect field data. In addition, several other criteria were considered when selecting the most appropriate methodology, such as cost, time involved and additional resources required. Together, these factors determined the methodological design and approach to the research and are described below.

4.1.1. Research strategy and design

Denscombe (2010) has argued that well-constructed and responsible research should meet three criteria, namely, the research should be suitable for the area of investigation, it should be feasible in practical terms, and, finally, it should be ethical. These criteria helped to shape the design of this research, considering as it did, the nature of the subject concerned, i.e. actions and experiences during earthquakes, the need to be

achievable within the available resources, and to protect the welfare of the subjects included in the study in view of the experiences they would be reflecting upon, i.e. surviving real earthquake events.

In common with much social research that explores connections between earthquakes and people's behaviour, for example Lindell *et al.* (2016) and Prati *et al.* (2013), a survey strategy was identified and adopted as the most appropriate for this research. This method was favoured over in-depth interviews, focus groups and case studies, as it enabled large amounts of information to be gathered concerning a relatively unexplored area.

As this research was largely exploratory in nature this raised the question of how best to gather information about a topic for which there is little previous information. As the research questions focused on people's actual actions, it was necessary to select a method that enabled this information to be obtained, for example, to find out what the person actually did, rather than what they thought they would do in some hypothetical event. Several approaches were considered, each with advantages and disadvantages.

Structured interviews provide a means to gain in depth information about peoples' motivations for actions (Bryman, 2012), however attempting to design a suitable interview schedule with little prior information on which to base the questions may have been pre-emptive and although this approach can yield useful information, it would restrict the number of people who could be included in the research resulting in a relatively small sample size. The resources required to interview large samples of the population from two earthquake events was beyond the resources of this research.

A focus group approach (Bryman, 2012) was also considered but this would have resulted in discussion-based responses from small numbers of people, when individual responses were preferred as it was felt that these would more accurately reflect what people recalled about their own experience during an earthquake. Observational studies, such as those undertaken by Lambie *et al.* (2016) were also considered, but the availability and challenge of identifying and obtaining surveillance records and connecting these with potential respondents made the option impractical.

There existed, therefore, a number of approaches that may have been used for data collection, each with its own strengths and weaknesses (Bryman, 2012). The choice of a survey-based study also had the additional advantage of being readily translatable into other languages, as was the case here, where both English and Japanese versions were deployed.

A written questionnaire was selected as the survey tool of choice for the field studies, as this could be delivered across different countries when translated and adjusted for cultural differences. The survey could also be delivered verbally if needed, for example if a respondent was unable to read or write. This

questionnaire-based approach has also been used by others in social earthquake research (Lindell *et al.*, 2016; Goltz & Bourque, 2017; Prati *et al.*, 2012).

In order to obtain sufficiently large samples from the surveys, the decision was made to use postal and internet delivery methods for this research. As Bird (2009) has argued, these means of delivery are acceptable methodologies in the social science aspect of natural hazard research, particularly as they are cost-effective, can cover a large area, and respondents have time to consider their responses. However, they also point out that the interviewer cannot shape the questions, and in some cases, response rates can be poor (Bird, 2009).

For the Christchurch survey, delivery was via the postal service. This raised the issue of return rates that can be as low as 10%, although with notifications and reminders this can be raised to over 70% (Denscombe, 2010; Millar & Dillman, 2011). In order to address this problem and to maximise returns, it was decided that surveys would be collected by hand from respondents in Christchurch.

In Sendai, there were cultural and language issues to consider that had not been present in Christchurch (the researcher is a native to New Zealand). For this reason, a modified approach was taken to the administration of the surveys although the content remained consistent. After consideration, a web-based method of delivery was chosen and would be administered via a third-party under the supervision of the researcher. This was achieved through collaboration with Tohoku University in Japan, and the use of the Rakuten Insight marketing and research company. This is a similar approach to that taken by Johnson and Nakayachi (2017).

This collaboration ensured delivery of the survey was possible through translation, sample selection and collection of data, and helped to maximise returns. To assist with participation and completion of the questionnaires, Rakuten offered reward vouchers for participants. While some research suggests that returns from web-based surveys can be as low as for those sent by post (Denscombe, 2010), other research points to this not being the case, and argue that online responses may be greater than postal ones (Millar & Dillman, 2011).

4.1.2. Field study selection

The use of field studies is a recognised way to study the social aspects of a population in response to an earthquake (Lindell *et al.*, 2016; Denscombe, 2010; Bryman, 2012). However, no two earthquakes are the same, and in order to reduce the effects of the influences of factors outside the focus of interest of this research, two locations were sought that shared similar levels of development, national building codes, earthquake experience, and well-documented public earthquake preparedness systems. It was also desirable to select locations that experienced earthquakes at a similar time in the past, and where the intensity levels were comparable.

Earthquakes that occurred between 2010 and 2014 were considered for inclusion in this research, as the event would still have been relatively recent in relation to when the surveys were completed. Complex disasters were considered, such as the combined Japan 2011 earthquake, tsunami and radiation events, however it was recognised that this could introduce another variable into people's behaviour, and therefore the research focus would need to be in a location that was impacted solely by the earthquake. Within these criteria, two earthquake events were identified, namely:

- Christchurch, New Zealand - 22 February 2011
- Sendai (Great Eastern Japan), Japan - 11 March 2011

The two events were compared using a number of variables such as intensity, magnitude, depth and location.

Criteria for the selection of the field studies are outlined below:

- Intensity – As a measure of earthquake intensity the socially-based Modified Mercalli (MM) scale was preferred over the moment magnitude (Mw) scale. The MM scale better describes the impact on people, as it is based on the consequences of shaking rather than the geological measurement of forces involved (USGS, n.d.-b). It also identifies levels at which a change in behaviour or actions might be necessary to respond to the earthquake shaking. This is relevant to this study as the description of the human response across the different intensity levels make this scale useful for social research. This is reflected on the GNS Science website which states that, 'In New Zealand…the Modified Mercalli intensity scale is a better indicator of an earthquake's effects on people and their environment' (GNS, n.d.-c).

  The MMVII level was set as the minimum for defining the intensity of earthquakes to include in the study, as the events needed to be capable of causing potential damage, as well as requiring people to change their actions and behaviour during the earthquake. The USGS ShakeMaps were used to identify areas of greatest shaking and appropriate intensity, thereby identifying areas of potential damage and response by people. The USGS definition for MMVII is shown in Table 4.1 below. A full description of the scale is in Appendix 3.0.

MM intensity	Shaking	Description
VII	Very Strong	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.

Table 4.1. Modified Mercalli scale from USGS (USGS, n.d.-b)

- Location – Urban areas with a population greater than 100,000 were chosen as a basis for inclusion in the study. This was to ensure an adequate sample size could be selected from the affected population, and that the sample would be within a confined geographic area.
- Magnitude and depth – As mentioned above, earthquake intensity as measured by the MM scale provides a better indication of the earthquake impact on people, rather than magnitude and depth (GNS Science, n.d.-c), therefore these parameters did not form part of the selection process.

New Zealand and Japan both have their own versions of the Modified Mercalli scale, adapted for use in their respective countries and cultures, but both retain the same reference to the effects on people and their environment in terms of where an earthquake would register on the scale. In Japan the equivalent to the MM scale is the Shindo Scale and the equivalent point of intensity at MMVII is described as '5 lower' to '5 upper' by the Japanese Meteorological Association (JMA, n.d.).

Definitions for MMVII for New Zealand and Japan are given in tables Table 4.2 and Table 4.3 respectively.

Shaking	MM intensity	Description
Severe	MM7 - damaging	General alarm. People experience difficulty standing. Furniture and appliances are shifted. Substantial damage to fragile or unsecured objects. A few weak buildings are damaged.

Table 4.2. MM definitions from GNS Science (GNS, n.d.-c)

Seismic intensity	Human perception and reaction	Indoor situation	Outdoor situation
5 Lower	Many people are frightened and feel the need to hold onto something stable.	Hanging objects such as lamps swing violently. Dishes in cupboards and items on bookshelves may fall. Many unstable ornaments fall. Unsecured furniture may move, and unstable furniture may topple over.	In some cases, windows may break and fall. People notice electricity poles moving. Roads may sustain damage.
5 Upper	Many people find it hard to move; walking is difficult without holding onto something stable.	Dishes in cupboards and items on bookshelves are more likely to fall. TVs may fall from their stands, and unsecured furniture may topple over.	Windows may break and fall, unreinforced concrete-block walls may collapse, poorly installed vending machines may topple over, automobiles may stop due to the difficulty of continued movement.

Table 4.3. Shindo scale definitions from JMA (JMA, n.d.)

The two locations, Christchurch and Sendai, met the intensity criteria described above as well as having other similarities such as occurring within a short time of each other. This data is shown in Table 4.4 below along with other information relating to each earthquake event. It is worth noting that there was a greater difference on the Mw scale between the two locations than on the MM scale, underlining the importance of using the latter for this research. It is also interesting to observe that the peak ground acceleration of both these earthquakes were some of the greatest experienced globally (Peak ground acceleration, 2021). This may have increased the likelihood that people would have taken some form of action in response to the shaking.

Earthquake details	Christchurch, New Zealand	Sendai, Japan
Intensity (MM)	X – intense	IX – violent
Magnitude (Mw)	6.2	9+
Depth	5km	29km
Epicentre	Christchurch City, Port Hills	70km offshore, east coast Japan
Date and day	22 February 2011 – Tuesday	11 March 2011 – Friday
Time (local)	12:51 pm	14:46 pm
Peak ground acceleration (single)	2.2g	2.7g
Duration	24 seconds	6 minutes
Population (city)	386,100 (2011 pre-earthquake)	1,031,704 (2008)
Total injured	6659	Data mixed with tsunami
Total deaths	185	Data mixed with tsunami

Table 4.4. Comparison of the 2011 Christchurch and Tohoku earthquakes.

(GNS, n.d.-c; StatsNZ, n.d.; Ardagh *et al.*, 2012; USGS, 2011a; USGS, 2011b; Peak ground acceleration, 2021)

The geographical area in which the survey took place in Sendai did not include any locations directly affected by the tsunami that accompanied the earthquake.

4.1.3. Questionnaire design, development and content

In addition to choosing a methodological approach and locations for the field work, a suitable questionnaire needed to be designed. The questionnaire development process, including the structure, format and description of each section in the questionnaire, is described here.

Bird (2009) has criticised much disaster research for failing to provide enough detail about the methodology employed. This limits the findings of research, and to avoid similar problems the description provided here is intended to allow other researchers to replicate or compare the research findings as required. Nonetheless, where appropriate, development of the questionnaire was guided by previous disaster field studies in order to assist with the comparison and validation of questions used (see: Bird, 2009; Petal, 2004; So, 2011). In particular, reference was made to studies that had included questions on the actions taken during shaking and the reasons for those actions (e.g. Arnold *et al.*, 1982).

In addition to questions relating to actions taken, it is common to ask participants about their location, position and activities at the time of the earthquake (Arnold *et al.*, 1982; So, 2011) and such questions were also included in this questionnaire.

Other considerations taken into account when developing the questionnaire, included language, structure and layout, and question wording. The original questionnaire was written in a plain English style that attempted to be unambiguous and avoid jargon (Bird, 2009). As well as aiding the understanding of the survey by respondents, this approach had the added advantage of enabling the same questions to be used for the Sendai case study as they were readily translated into Japanese by colleagues at IRIDeS, Tohoku University.

The final questionnaire design contained six sections with a layout designed to take participants through the questions in a logical manner, and in an order that did not lead or pre-suppose knowledge or desired answers. This followed the generally accepted principle that questions in a questionnaire are arranged in a logical order to ensure participants understand the research (Bird, 2009).

The type of questions selected for the questionnaire meant that all but three of the questions were closed questions. The majority utilised a combination of yes / no options, Likert scales, or lists with options for answers. In common with good practice, complex questions such as those referring to more than one behaviour at a time were avoided, and double-negatives were excluded (Bryman, 2012; Bird, 2009). This preference for closed questions also allowed more direct comparisons to be made between the two field study locations.

Nevertheless, three open-ended questions requiring free text answers were included at the end of the survey, and these gave participants the opportunity to add their own ideas or thoughts about actions to take during earthquakes. Other free text answers were accepted only where the respondent had selected ‘other’ from a list of options.

It is common practice to conduct a pilot survey to test questionnaires before use (Bird, 2009; Bryman, 2012). This process was done on a small sample of 12 respondents to ensure that questions were easily understood and that the responses provided useful and relevant information. The completed draft questionnaire and supporting documents were also checked by several people in New Zealand and the UK who had either earthquake experience or a research background. The pilot process identified a number of questions where there were problems with language and jargon, ambiguity, incomplete instructions, and duplication of question themes. These issues were rectified for the final version of the document. The questionnaire was not piloted in Japan, but reviewers from Tohoku University IRIDeS and Rakuten provided comment and queried the questionnaire as part of the translation and web development process.

To enable a comparison between two studies, the questions and conditions should ideally be the same for both samples. This was achieved with only minor alterations being made to accommodate cultural differences between New Zealand and Japan. This concerned demographic information such as definitions of education levels, and categories for religion and ethnicity, and did not impact on responses linked to the actions people took during shaking.

Questionnaire content

The questionnaire was developed with the aim of gathering answers to the research questions. Each section of the questionnaire focused on different aspects of the research. As the order of questions in a survey can affect responses (Bird, 2009; Bryman, 2012), the flow of the questions focused on the earthquake event first, followed by actions taken, feelings and fears experienced, any injuries received, preparedness activities undertaken, and finally the respondents' personal details (i.e. demographics). A challenge during the development process was to keep the questionnaire a reasonable length, yet include enough questions to obtain the required information (Bird, 2009; Bryman, 2012).

The front page of the questionnaire contained the unique ID and qualifying screening conditions to be completed in order to participate in the study. This included reference to reading the supporting information in order that participants were able to make an informed decision to take part, and to fulfil the ethical conditions (see below). Participants were able to give their consent to participate by selecting "Yes" to three questions. The front page also repeated the date of the earthquake being referred to, as there was more than one event in the Christchurch area, and for the Sendai participants it highlighted that only the earthquake and not the tsunami was being referred to. A copy of the English version of the questionnaire is located in Appendix 4.0.

The first section of the questionnaire focused on the location of the person when the earthquake struck, including whether the person was within the geographical boundaries of either Christchurch or Sendai. Respondents were also asked whether they were inside or outside a building. The questions for those outside

a building ascertained where the person was in relation to the surrounding structures, and whether these impacted on actions taken during the shaking. These questions were informed by research from So (2011) and Petal (2004). The questions were designed to find the proximity of the participant to a building, structure or other external objects that could fall on to them.

Questions for those respondents inside a building determined the location of participants, the nature of the room they were in (e.g. kitchen, office, bathroom), their position in the room and the objects that were in the room with them (e.g. table, computer, shelving units). Questions also included the number of doors between them and an exit to the outside, the level of damage sustained by objects in the room, and the general damage to the building. Finally, questions were asked about the building construction and age to better understand its characteristics. The aim of these questions was to gather information that might indicate how a person's position in a building, and the room contents might influence actions.

Section two of the questionnaire focused on the actions taken during the earthquake, including activities that the person was performing when the earthquake struck, the actions they took during the period of shaking, and the reasons they gave for these actions. Questions were also asked about the drop-cover-hold action that is promoted by authorities in both New Zealand and Japan. Participants were also asked about any personal items they saved during the earthquake, and whether they provided or received assistance from anyone else.

The third section focused on the feelings and emotions people experienced during the earthquake, and sought to reveal how feelings interact with people's actions. Questions focused on finding the most common or over-riding emotions and fears that people experienced. The feelings included as options in the questionnaire were taken from the description of 'basic emotions' proposed by Ekman (1992), and other commonly expressed emotions reported by the public, such as panic (Quarantelli, 1986). In addition, a series of questions using Likert Scales, considered the levels of six specific emotions that were experienced during the earthquake, namely: fear, anxiety, helplessness, confidence, calmness, and being in control (Ekman, 1992; Prati *et al.*, 2012). Five-point Likert scales were used, with scales ranging from 1 (strongly disagree) to 5 (strongly agree). This format is widely recognised as a methodological approach in this type of survey where ordinal data is desirable (Bryman, 2012; Croasmun & Ostrom, 2011).

The fourth section of the questionnaire focused on any injuries people sustained during the earthquake and whether there was a link to the actions they took. The questions were designed to avoid medical jargon and terminology, and included time of injury, injury description, severity of injury, location in the building when injured, activities when injured, the cause of the injury, and whether they were trapped as a result of the earthquake. Particular attention was given to the phrasing of these questions to ensure they were understandable and unambiguous to respondents without any medical knowledge.

Professional knowledge regarding pre-hospital medical care (the researcher is a registered paramedic) was used to formulate this section, particularly injury classification and rating of injury severity. Care was taken to ensure that each discrete category of injury would be understandable by non-medical persons and to avoid the use of clinical terminology that has been a feature of some previous studies (e.g. Petal, 2004).

The fifth section of the questionnaire focused on earthquake experience and preparedness activities. Participants were asked about their previous experience of earthquakes to consider whether this was an influencing factor on current responses. This included questions about the perceived strength of the current event against previous earthquakes. Additionally, information about earthquake exercises undertaken, training completed, and awareness of official guidance was included to ascertain the respondent's awareness of government advice relating to earthquake actions.

The three free-text questions were located in this section and allowed participants to write, in their own words, any comments about appropriate and inappropriate actions to take during earthquakes. Additionally, questions about actions to take when trapped were included as this rarely forms a part of earthquake advice and has received little attention in other research. These questions and the format were considered necessary to give respondents the opportunity to express their thoughts on protective actions.

The final section of the questionnaire asked for demographic information. The personal details gathered included age, gender, education level, occupation, religion, ethnicity, level of mobility, and levels of connectivity (i.e. television, mobile phone, and internet). This information was used for categorisation during the subsequent analysis in order to see if any differences in responses were contained within these factors.

4.1.4. Administration of the questionnaires

Prior to administering the questionnaires in both Christchurch and Sendai, both ethical and practical considerations needed to be taken into account, this included such issues as obtaining consent, protecting the welfare of respondents and choosing the most effective method of delivery for each field study.

Informed consent, ethical considerations and data protection

In common with much social research, this study raised ethical considerations around gathering personal information from members of the public. Of particular concern were issues around the emotional impact of recalling distressing information along with more common issues such as data protection and informed consent. The issue of ethics in social research is widely covered and guidance for this research came from Eckenwiler *et al.* (2015) and Bryman (2012).

Respondents in the surveys for this study were to be asked to recall potentially distressing events, and it was important to acknowledge this and to safeguard and respond to needs of the respondents to minimise the

chance of distress being caused by participating in the survey. However, the nature of the questions and their format did not require in-depth descriptions of personal experiences, meaning that it was considered unlikely that these would cause undue psychological stress, nevertheless the emotional well-being of participants was considered as part of the questionnaire development process. In addition, it was made clear that participation was voluntary and sufficient additional information was provided for respondents to make an informed decision (see below).

Ethics approval was gained from UCL Ethics Committee (reference 5659/001, and data protection reference Z6364106/2014/05/25).

A further ethical consideration was how to protect the information provided by respondents. This was achieved, in part, through compliance with the UK Data Protection Act in relation to the secure storage and handling of personal details through password protected databases. In addition, the Christchurch surveys were anonymised and original versions stored in a secure setting. For the field surveys carried out in Sendai, the Japanese marketing research company Rakuten Insight conducted the web-based questionnaire. All personal data for the survey was held by Rakuten Insight in accordance with their protocols, and no personal information was transferred to the researcher, other than the anonymised personal details contained in the final section of the questionnaire.

Bryman (2012) has argued that, in most circumstances, subjects in a research project of this nature should be provided with sufficient information to enable them to make an informed decision when consenting to participate. For this reason, respondents in this study were required to have the mental capacity to give their consent. Persons younger than 20 years old were also excluded.

The front page of the questionnaire therefore, required participants to select 'Yes' in response to three questions about their understanding of the research (were they 20 years or older, were they in Christchurch or Sendai at the time of the earthquake, and had they read the additional research information), and agree to a statement about their participation in the study. Christchurch participants were provided with relevant information about the study in a brochure which they could keep. Sendai participants received similar information via the website. At any point until the questionnaires were returned, participants were free to withdraw from the research without providing any information or reason for doing so.

Sample selection

Prior to delivering the questionnaires, the population from which the sample was to be drawn was identified. Selecting a sample that was representative of the general population was preferable as this would allow for extrapolation of findings to the wider population.

Research is often conducted with samples of convenience, where the people are readily available, such as groups of university students, or people working in a single workplace (Denscombe, 2010). For this research, a wider cross-section of society was required, including across a range of ages and gender, as it was desirable to understand the actions taken from a wide range of people in the community. The aim of the sampling process, therefore, was to ensure a mix of people that closely reflected a cross-section of the population who could have been expected to be in the city (i.e. Christchurch or Sendai) at the time of the event. Whilst different approaches were taken to obtain the samples in each field location, the criteria outlined for inclusion remained the same.

Having first identified the broad requirements of the sample, the definition was refined to describe the eligible population. Setting the age limit of 20 years for inclusion in the research ensured that at the time of the earthquake subjects in the sampled population would have been over 18 years of age, thereby excluding school children and ensuring that only those who had been of adult age, i.e. 18 years and older, at the time of the relevant earthquake were included in the study. This defined the scope of the sample, and while there may be merit in exploring the experiences of younger people in earthquakes, it was beyond the scope of this initial piece of research. Whilst at school, earthquake education programmes are often provided to children where they receive instruction about actions to take during shaking and undergo practical activities associated with earthquakes. This research specifically excluded education programmes that focused on children.

In Christchurch, a minimum sample of 150 completed questionnaires was planned for inclusion in the study. Working on a 50% return rate, a starting sample of 300 was required. This figure was arrived at after considering what might be suitable samples sizes for further analysis within sub-groups, such as for age or gender, as well as the available resources for completing the survey. To select the random sample, postcode boundaries were used to identify areas that had the greatest shaking intensity during the earthquake as reported by USGS (Royal Society NZ, 2014). These included the city centre and areas close to the epicentre of the earthquake, in line with the areas of greatest reported intensity according to the MM level.

The sample was generated systematically from across the business sector. This population was chosen in order that participants could be approached during working hours using publicly available contact information. For this reason, a bias in the sample towards working adults must be acknowledged. The sample of businesses was selected from listings in a business directory and accessed through the business directory (Yellow Pages Group Ltd, 2014) for the Christchurch city area on 13 August 2014. The businesses selected were required to be located within the set of identified postcodes. A randomised selection of 300 businesses and their contact numbers was taken from the directory. Once an organisation was identified, contact details were recorded, including an email, phone number, postal and street addresses, and website where available.

Contact was made by telephone to explain the research and to ask whether a person fitting the selection criteria would like to participate. This took place during October and November 2014. One person from each address was asked to participate, generally the person answering the phone or someone they nominated, ensuring they fitted the inclusion criteria. There were problems locating some organisations selected as part of the random sample, as phone numbers and addresses had changed in Christchurch due to the earthquake, and some businesses had relocated due to unsafe or demolished buildings. Where this occurred, it was counted as a no reply, and the business excluded from the sample.

In the case of Sendai, the sample selection process had to manage cultural and language challenges along with logistical and financial barriers. After consultation with IRIDeS at Tohoku University in Japan, use of a commercial research company was identified as the most effective method to select people to participate in the research, distribute the questionnaire, and return the data. The company used was Rakuten Insight, a Japanese marketing and research company with experience in delivering surveys of this nature. The company had previously been used by researchers at IRIDeS at Tohoku University for similar investigations. Rakuten Insight reward participants for completion of questionnaires with shopping vouchers for use on their website.

The sample from Sendai was selected randomly by Rakuten from those who were registered on the Rakuten Insight website and who also met the requirements of the sampling criteria used in the Christchurch study. This method selected 300 respondents for the sample.

Questionnaire delivery

The methods used for delivering the questionnaire were important to ensure as high a return rate as possible. For the Christchurch sample, the questionnaire was distributed by postal mail to participants who had previously given consent to be contacted. The questionnaires were posted to arrive with participants in the last week of November 2014. It was agreed between the researcher and the participant during the phone call that the questionnaire would be collected in person from their place of work in December 2014.

The decision to collect the completed surveys in person was made to maximise returns from participants. Previous studies indicate that returns from postal surveys can be as low as 10% (Denscombe, 2010). In total, attempts were made to contact 300 businesses, with 133 not able to be contacted or refusing to take part. There were 167 businesses that agreed to participate and who were sent a questionnaire. Of the final 167 participants, 144 surveys (86.2%) were returned.

In the case of Sendai, the questionnaire was sent out to a sample randomly selected by Rakuten to people already registered on their marketing database and whom they identified as living in Sendai. Rakuten were asked to deliver 300 completed questionnaires. It is not known how many people were sent the

questionnaire in order to obtain this level of response. The online questionnaire was accessible for two weeks from 30 January 2017.

This approach of using both postal and web-based surveys resulted in different the delivery methods between the two cities for the questionnaire, however as the content of the questionnaires remained the same, it is can be argued that it is reasonable to make comparisons between the two data sets.

Additional information

Along with the questionnaire, participants received additional supporting information. The rationale behind providing these supporting materials was to ensure participants had the necessary information about the research before committing to be involved and to encourage a higher response rate.

Information for Christchurch participants contained a reminder of the earthquake details as the earthquake occurred more than three years prior to the survey, and there was more than one significant aftershock after February 2011. The Sendai sample received similar information via the website, translated into Japanese, which contained details of the March 2011 earthquake, and a reminder that events relating to the tsunami were not part of the research.

The questionnaire was posted out to the Christchurch sample in a pack containing the following documents:

- Introduction letter
- Research information leaflet
- Questionnaire
- Questionnaire instructions
- Envelope for the completed questionnaire, with collection details on the outside

Copies of the questionnaire, introduction letter and instruction sheet are located in appendices 4.0, 5.0 and 6.0 respectively.

4.1.5. Coding and analysis of data

The objective of conducting the questionnaires was to collect information on people's actions during earthquakes, reasons and feelings that might have influenced these actions, injuries sustained, and preparedness advice received or activities undertaken prior to the earthquakes. This section outlines the processes used in the coding and analysis of the completed questionnaires.

Coding is the process of assigning a numerical value to responses in a survey, allowing for some quantitative analysis to be applied to the data, and is a standard process in social earthquake research (Medelyan, 2020; Petal, 2004; Prati *et al.*, 2012). During the questionnaire development and pilot process, the questions were

structured to ensure that responses could be adequately coded. A coding framework was developed that contained numerical values assigned to each of the possible responses for each question.

The three free-text questions in the questionnaire were also coded with the aid of a coding sheet. This involved identifying categories of information and key phrases and words in the text that represented those categories. Prior to coding, Japanese text was first translated to English using Google Translate. The codes and headings used for these questions were included in the coding sheet.

Having coded the data, basic descriptive statistics were applied. Demographic data was used to structure, organise and summarise findings, describe the data, and to find correlations and associations, if any, in the data. As Denscombe (2010) has argued, treating the data in this way assists in describing the various elements of the information, and interpreting the meaning within it.

A general or descriptive overview of the data, as recommended by Bird (2009) was conducted using SPSS (ver. 26). As the data was measured on nominal or ordinal scales, this restricted the subsequent statistical analysis of the data to using non-parametric techniques. Two assumptions needed to be met in order to use non-parametric techniques, firstly that the sample was random, and secondly that the observations are independent, i.e. each respondent can only be counted once, and data from one respondent cannot influence the data from another (Pallant, 2013). Those assumptions are true for this data.

Prior to analysis, data was manipulated to deal with any missing data or other anomalies. In some of the questionnaires returned by the Christchurch sample, there were some missing responses. This was partly due to the questionnaire being on paper, and people being able to move to the next question without fully completing the previous one, something that was not possible on the web-based survey for Sendai. In these cases, the completed questionnaire was still included in the research, but this meant that the sample size was reduced for some questions. There was no missing data in the Japanese responses due to the techniques used in the web-based version of the questionnaire.

For exploring the frequency associations between many of the variables within the surveys, Fisher's exact test was used for statistical analysis. This allowed for the test to be applied to variables where expected frequencies, as opposed to observed values, were too small to meet the assumptions of the alternative, Pearson's Chi-square test for independence. Fisher's exact test is often only used in the case of small sample sizes and 2x2 tables, however this is for historical reasons owning to the difficulty of manually calculating the statistic for larger cross-tabulations (McDonald, 2014). For consistency, it was decided to use Fisher's exact test throughout the analysis, rather than switch to Chi–square for 2x3 tables. A cross check with Chi-square showed that the use of either test would not have affected the outcome of any analysis at either the $p = 0.05$

or p = 0.01 levels. In fact, the Fisher's exact test was actually slightly more stringent than the Chi-square test for independence. In all cases, a two-tailed test was used.

As this is one of few investigations of its type, exploring the behavioural relationship between advice and actions in earthquake preparedness research, less studies exist with which to make direct comparisons and little guidance is available on where relationships might be found. This means that some of the findings in this research are pointers to areas where further investigation might be worthwhile, rather than definitive conclusions. For this reason, a few results with probability alphas of between 0.05 and 0.1 have been reported. To clearly distinguish these from the more conventionally reported p values of less than, or equal to, 0.05 or 0.01, these are referred to as 'weak' relationships or associations in this thesis. Several authors have argued for the legitimacy of this approach in initial research to avoid rejecting possible associations that may be worthy of further investigations because, for example, sample sizes were small, or definitions were vague owing to the limited data available at the start of the investigation (Cesana, 2018; Wasserstein *et al.*, 2019). This is the line that has been adopted here.

Some debate exists regarding the appropriate inferential statistical test to use for analysing data derived from Likert Scales. The 2-sample T-Test and the Mann-Whitney U test are common options and have been the subject of an influential study by De Winter & Dodou (2010) which found little difference between the reliability and error rates of either measure. For this study, it was decided to use the Mann-Whitney U test for analysing the data from the Likert scales in the survey. This is a non-parametric test more suitable for the categorical and ordinal nature of the scales used (e.g. strongly disagree to strongly agree)

The Likert scales used to measure the six emotions experienced during the earthquake were also checked for internal reliability using Cronbach's Alpha coefficient to check whether respondent's scores on one indicator tend to be related to their scores on other indicators. Pallant (2013) suggests that the coefficient value should be greater than 0.7 when used to indicate the reliability of scales, although they acknowledge some flexibility in this figure. For the scales used in the Christchurch questionnaire the coefficient was 0.874. For the Sendai questionnaire the value was 0.792.

4.1.6. General research limitations and constraints

In common with other research of this nature (Lindell *et al.*, 2016; Goltz & Bourque, 2017), this study was subject to some limitations and constraints. There were constraints around sampling, including limited resources, time and budget, and these factors impacted on selection of the sample size and process. This section discusses some of those limitations, including how these factors have been managed.

The sampling process used in Christchurch resulted in more business employees than community groups or local government workers, and excluded parts of the population such as the unemployed or retired. Some

businesses may have been excluded as not every organisation was listed in the Yellow Pages on-line directory between 1 and 13 September 2014. Residential addresses were excluded from the sample, but as people at work are also residents, this approach was felt to still capture people present in the city during the day.

Collaboration with Tohoku University to undertake the fieldwork in Sendai, was necessary due to the language barrier, but also to assist with the sampling logistics. Changes to the questionnaire process meant it was delivered as a web-based tool rather than postal, and this restricted participation to only those people who had an email address and internet access. The sampling process in Sendai also only included those people on the Rakuten membership list.

Despite these differences, the sample definition was otherwise the same in both field studies, and included a wide range of subjects in terms of age and gender. For this reason the differences in survey methods, it can be argued, should have had a limited impact on the data when it comes to comparing the two samples. Future comparative studies would benefit from having larger samples and identical sampling methods to reduce the possibility of any confounding effects.

The issue of recall bias, where the passing of time affects a person's ability to accurately recall events, (Prati *et al.*, 2012; Pelz, n.d.; Paradise, 2005) was reduced and compensated for by comparing earthquakes that both occurred in 2011. Both samples were subject to a delay after the earthquake occurred before responding to the questionnaire, 3.5 years in Christchurch and 5 years in Sendai. To mitigate some of the problems around recall bias, supporting information was provided with the questionnaire that contained some brief information about the earthquakes.

Another bias that may have occurred was through the non-response of particular subgroups (Denscombe, 2010). For example, those who suffered severe injury during the earthquake may have been less keen to recall the event, and so choose not to participate in the survey. This is a problem shared with other studies of this nature (Labott *et al.*, 2013), and is difficult to overcome. In the case of this study, the number of subjects reporting injuries was small, however it is not known if this was due to self-deselection, or whether a larger sample size would have overcome the problem.

A further constraint was due to the sample sizes used in this research, 300 in Sendai and 144 in Christchurch. This meant that the responses to questions had low frequencies for some options. This impacted on the ability to conduct the Chi-square test for independence, and hence the Fisher's exact test was used instead. Future research with larger sample sizes will help reduce this problem. Nevertheless, as has been previously observed, this study explores a relatively little-researched area, and is therefore largely aimed at providing a descriptive overview of the subject on which future research can build. For this reason, the focus on descriptive statistics and comparison between groups rather than correlational techniques is acceptable.

4.2. Review of earthquake preparedness advice

A subsidiary part of this research considered earthquake preparedness advice given by governments around the world. The rationale for this was to better understand the type of information available, any specific protective actions advised, and whether there was advice provided for specific hazards or groups in society. The aim was to understand the range of content, format of advice, and themes that inform actions during earthquakes. This then allowed for the findings from Christchurch and Sendai to provide information as to the appropriateness of the format and content of this guidance.

4.2.1. Data collection

The review of global earthquake preparedness advice was a form of document analysis that sampled information from internet websites. Target documents were those provided by governments and their agencies, and the information needed to be open access to the public without restrictions. Another criteria for inclusion in the analysis was that inclusion of information on activities to take during an earthquake. The sample was further refined by excluding specific earthquake education programmes such as those for schools, hospitals, and universities, thereby confining the sample to information that targeted the general population as a whole. Webpages that contained only videos or pictures were excluded from the study.

Online searches for information meeting the above criteria were conducted using a combination of key words identified as being relevant to the pages of interest. These were derived from phrases commonly associated with preparedness advice or associated with the titles of national disaster agencies. The keywords listed below were used in conjunction with a country name. Searches were also conducted in other languages; including Arabic, Russian, Spanish, French and other minority languages.

- Earthquake preparedness
- Disaster management agency organisation
- Civil Protection Defence
- Actions to take during earthquake
- Drop-cover-hold
- Advice what to do during earthquake
- Disaster earthquake education

The final sample for the national earthquake advice documents was defined as including all documents that adhered to the inclusion criteria identified above, and located using the identified key words. Searches were first conducted in English, then in the native language of the country where this was accepted as an input to the Google search engine. Applying the above criteria returned search results from 74 countries or territories. However, the data for seven countries was unavailable due to broken hyperlinks. This left a total

of 67 countries or territories for inclusion in the document analysis, and these are listed in chapter 5 and detailed in Appendix 7.0.

4.2.2. Coding and content analysis

The documents obtained from the online search were in text form and, as with the free-text responses in the two field studies, content analysis was selected as the preferred method of analysis as this is a recognised method of quantifying the text (Bryman, 2012; Medelyon, 2020). Before analysis was undertaken, where English versions of documents were not available, Google Translate was used to translate the text into English, and in some cases native language speakers were asked to translate documents. Where multiple official documents existed for a country, the most comprehensive version was used.

Webpages can be considered like online documents, and contents analysed according to the text and images they contain (Densombe, 2010). Therefore, the process of content analysis allowed for an objective and systematic analysis of the text, and to quantify it in predetermined categories in a systematic and replicable way (Bryman, 2012). This concept enabled a comparison and collation of words and phrases found in the earthquake advice documents.

Coding analysis has been used in other research (e.g. Lambie *et al.*, 2016; Petal, 2004), and this informed the coding process, identification and development of the key phrases and words for inclusion in this research. The coding process followed a standard system associated with content analysis (Medelyon, 2020). Once the documents were selected, the text was broken into smaller phrases or single words. The documents were compiled in a table under a series of headings, and then coded for key words that related to the identified actions. These methods are similar to those used by Petal (2004) in a review of earthquake preparedness advice for Turkey and the USA, and Bird (2009).

A coding framework was developed that defined the variables and allocated numerical codes to the key words and phrases under each variable, and a definition for that variable. The coding framework was used to ensure consistency and reduce bias in the analysis process. Coding focused on text only, and no coding was done on pictures, illustrations, or diagrams included in the advice. Only information contained in the 'during shaking' section of the advice was included in the analysis. For advice that did not include a specific 'during shaking' section, the entire document was used to search for text that contained actions to take during earthquake shaking.

An initial review of the documents revealed eight overarching themes and areas for the coding process that formed the starting point for categorising the data. The precise meaning of these categories is described further in later chapters. The eight categories comprise:

- The format of the information
- Whether reference is made to emotions
- Advice specific to indoor situations, both general and protective
- Advice specific to outdoor situations, both general and protective
- Advice on hazard reduction
- Advice for specific situations
- Advice for groups in the community
- Advice relating to entrapment

The data obtained from this coding process provided information in terms of a) the categories of advice provided, b) the frequency of that advice, and c) descriptive examples from the original text, of the advice given. Frequency tables were compiled along with bar charts, and were used to depict the frequency of words and phrases for each of the eight variables.

4.2.3. Limitations and constraints

There were a number of limitations and constraints within this aspect of the research and these need to be considered when drawing conclusions from the data.

The review of these advice documents was based on webpages from the internet. Although the text came from recognised government or disaster management agency websites, the currency and relevance of advice cannot be guaranteed as many webpages were undated, and version control was also absent in most cases. Whilst this can be considered a limitation in terms of research practice, it does however replicate the situation that members of the public would face when searching for the same material.

All the preparedness advice documents included in the study were in text format. Advice that contained only videos or pictures were excluded due to the increased challenge of interpreting cultural nuances during the analysis of the data, where there is no text (Denscombe, 2010). However, in most cases, text pages were found that complimented any videos or pictures. Excluding advice that was only available in video or picture format resulted in removing some countries and organisations from the study.

Finally, one of the criteria for inclusion in the research was that all documents needed to be publicly available online. It is recognised that some countries may not make information available in this format, and have therefore, by definition, been excluded from the sample.

With regard to these limitations, it must be remembered that the purpose of this part of the research study has been to explore the nature of the advice provided, rather than to evaluate its impact on people's behaviour, or the degree to which it is accessed by the public. In contrast, the two field studies attempt to explore the relationship between advice and behaviour. By combining the findings of these two elements of

the research, it may be possible to draw tentative conclusions about not only what advice is generally provided around the world, but also whether that advice is likely to influence people's actions during an earthquake.

4.3. Summary

In summary, this chapter has described the methodology and context for the research, and introduced the field studies conducted in New Zealand and Japan, including the criteria for selecting these locations. Few earthquake studies explore more than a single event, and the benefits and challenges of comparing two earthquakes in this research were discussed.

A description was given regarding the questionnaires used in the field studies, and despite some differences between the Christchurch and Sendai delivery processes, an argument was made that this did not have a significant impact on the information collected. The data analysis methods have been described, and the predominantly nominal and ordinal data collected from the questionnaires has been outlined. Limitations and constraints associated with conducting the field studies were described, including how these have been managed.

Finally, the rationale for including a review of national earthquake preparedness advice documents was discussed. Understanding the range of protective actions recommended by countries will be used to inform the discussion of actions taken during earthquake shaking. The next chapter contains the output from this review, as well as the results and findings from the two field studies.

Chapter 5: Results and findings of the field and document studies

This research involves three pieces of empirical investigation, namely the two field questionnaires and the document analysis of earthquake preparedness advice documents issued by countries around the world. The results of these enquiries are outlined in this chapter. Firstly, the findings from the questionnaires conducted in Christchurch and Sendai are described including the demographics of the sample groups and their reported actions as well as the results of various analyses using contingency tables, Fisher's exact test and the Mann-Whitney U test. Secondly, the findings from the document analysis are presented and structured around the eight key variables that were identified in the previous chapter.

5.1. Field studies – description of the two samples

For reasons previously discussed, the sample sizes in Christchurch and Sendai were different. In Christchurch from an original sample of 300 potential participants, 133 either refused to participate or could not be contacted, leaving 167 respondents. Of the 167 postal questionnaires sent out there were 144 completed questionnaires collected, giving a return rate of 86.2%. For postal and phone surveys this is considered a high return rate (Bryman, 2012).

As described in the previous chapter, the method of data collection for the Sendai field study was in the form of an online version of the same questionnaire administered via a third party. This approach enabled a sample of 300 completed and returned questionnaires to be obtained.

Owing to the difference in sample sizes and to enable comparison to be made between Christchurch and Sendai, descriptive results are presented as both percentage and absolute values.

5.1.1. Demographic description

Basic demographic information was gathered from both samples and this included factors such as age, gender, education and ethnicity. The demographic characteristics of the samples are compared below and summarised in table 5.1. In addition to allowing comparisons to be made between the two field studies, this also allowed for the two samples to be compared with their general populations to give an indication of the representativeness of the data.

Age

The samples had an age range from 20 to 85 years and 20 to 75 years, and a mean age of 47.0 years and 47.6 years, for Christchurch and Sendai respectively. For analysis the samples were divided into three age groups comprising 20 to 39 years, 40 to 59 years, and 60 to 99 years. This allowed comparisons between age groups to be made in terms of their responses to other questions in the survey. The distribution of respondents in each age group is given in Table 5.1 (see below).

These distributions can be compared with the national census taken for the general populations. Numbers from the 2013 New Zealand census (Stats NZ, 2020) show the size of the age group 20-39 years in the general population was 27.3%, for 40-59 years, 27.7%, and 60+ years, 20.4%. This indicates that this sample was weighted towards the 40-59 age group. This may have been due to businesses being targeted as the primary source for the research, and therefore is weighted towards people of working age.

The respondents from Sendai differ somewhat to the national population documented in the 2015 census where 22.3% were in the 20-39 years range, 26.9% were between 40-59 years, and 33.3% were aged over 60 years (Statistics Bureau of Japan, 2015). Like the Christchurch sample, this was more weighted towards the middle age group.

Gender

Both samples showed a similar split by gender, with 47.1% male and 52.9% female in the Christchurch sample and 48.7% male and 51.3% female in Sendai. These figures differ only slightly from their populations, with there being 49.2% males in the New Zealand population in the 2013 census (Stats NZ, 2020), and 48.6% males in the Japanese population in the 2015 census (Statistics Bureau of Japan, 2015). Figure 5.1 shows the sample by age group and gender.

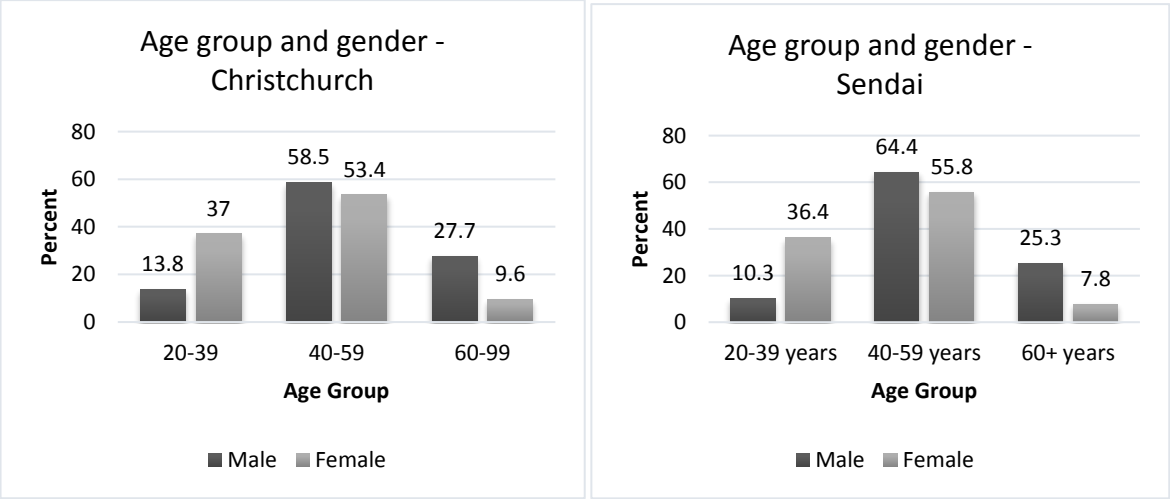


Figure 5.1. Christchurch and Sendai samples by age group and gender (%)

Level of education

Respondents were asked to state their highest level of education obtained. Nearly half (45.7%) of the Christchurch sample identified that high school was their highest education level, with 28.6% having attended tertiary education. A further 25.0% had a technical or vocational qualification.

In Sendai, education levels showed 34.3% of people had attended up to high school level, and 42.7% had completed tertiary education, a higher proportion than in Christchurch. A further 7.7% had a technical or vocational qualification, and 5.0% went to graduate school.

Religion

'No religion' was the most common response in Christchurch and Sendai (57.6% and 47.3% respectively). In Christchurch, Christianity was selected by 38.8% of the sample, with only 3.6% reporting they associated with another religion. In Sendai, 34.7% stated Buddhism was their religion, with Christianity and Shinto each being 2.7% of the sample.

Ethnicity

Both samples were questioned about their ethnicity, with the Sendai sample reporting being 100% Japanese. The majority of the Christchurch sample identified their ethnicity as New Zealand European (91.4%). New Zealand Maori was reported by 2.9%, and Chinese by 1.4%. The remaining 4.3% reported belonging to another, non-specified, ethnicity. This is somewhat different to the general ethnicity of the New Zealand population shown in the 2013 census, where Maori were 8.1% of the population, and other ethnicities made up 13.0% (Stats NZ, 2020). In Japan other ethnic groups are not represented on the census (Statistics Bureau of Japan, 2015). As ethnicity responses were all, or nearly all, from one group, no further analysis was conducted using ethnicity as a variable since the sample size for minority groups would have been prohibitively small.

Household size

The size of households in which respondents from both samples lived shows a difference between cities. In Christchurch the most common household sizes were two people (35.3%) and four people (30.2%), and those households with one, three or five people comprised 7.2%, 12.2% and 15.2% respectively. Households in Sendai showed the number of people with between 1 and 4 people was fairly even, ranging between 19.0% and 26.0%. Only 9.3% lived in households with 5 or more people. Table 5.1 contains further details of household size.

Levels of connectivity

The levels of internet connectivity and access to mobile telephone and television were measured for both samples, with both cities showing similar results. All of the Christchurch sample had a television, 95.0% had a mobile phone, and 99.3% had access to the internet. In Sendai 97.0% of the sample had a television and access to a mobile phone, and 93.7% had internet access.

Summary table

Table 5.1 below provides a summary of the demographic data for both Christchurch and Sendai.

Demographic characteristics	Christchurch		Sendai	
	%	n	%	n
Age - mean	47.0 years		47.6 years	
20-39 years	26.1	36	23.7	71
40-59 years	55.8	77	60.0	180
60-99 years	18.1	25	16.3	49
Gender				
Female	52.9	74	51.3	154
Male	47.1	66	48.7	146
Education				
High school	45.7	64	34.3	103
University	28.6	40	42.7	128
Technical college	25.0	35	7.7	23
Graduate school	-	-	5.0	15
Household size				
1	7.2	10	20.7	62
2	35.3	49	26.0	78
3	12.2	17	25.0	75
4	30.2	42	19.0	57
5+	15.2	21	9.3	28
Ethnicity				
New Zealand European	91.4	128	-	-
New Zealand Maori	2.9	4	-	-
Chinese	1.4	2	-	-
Japanese	-	-	100.0	300
Religion				
Christianity	38.8	54	2.7	8
Buddhism	-	-	34.7	104
Shinto	-	-	2.7	8
No religion	57.6	80	47.3	142
Connectivity				
Television	100.0	139	97.0	291
Mobile phone	95.0	132	97.0	291
Internet	99.3	138	93.7	281

Table 5.1. Summary of demographics of Christchurch and Sendai samples – excludes 'other' categories

Occupational field

In Christchurch the greatest number of respondents said they worked in retail (20.7%), followed by 15% in manufacturing and 10.7% in health. Other specific sectors each represented less than 10% of respondents. The high range of "other" responses (32.1%) was in part due to a number of people who used this option to describe their occupation, e.g. manager, rather than indicate which sector they worked in. This may have been due to the wording of the question in the survey.

The situation in Sendai was similar, with 'no occupation' recorded by 19% of respondents. Of those who gave an occupation, 8.3% worked in retail, 7.7% were home-based, and 6.3% worked in IT. A significant number (32.3%) selected 'other', and this may again be due to misinterpretation of the question.

Owing to the high number of undefined 'other' responses, this category was not used for further analysis but is included here for completeness.

Mobility issues

Information surrounding levels of mobility of respondents at the time of the earthquake was recorded in both Christchurch and Sendai. The Christchurch sample reported low levels of disability, impaired mobility or vision impairment, with 0.7% reporting they were unable to bend, and 0.7% reporting they had a visual impairment. No one reported they were in a wheelchair, needed assistance to move, used a walking aid, or were bed-ridden.

In the Sendai sample, there were 16 responses across the six categories. Respondents could select more than one option to describe their mobility issues, and the most common issues were visual impairment and using a walking aid, each representing 1.3% of the sample. Other reported mobility issues included having to use a wheelchair (1.0%), requiring assistance to move (0.7%), being unable to bend (0.7%), and being bed-ridden (0.3%).

As with the occupation category, low frequencies for this sub-sample meant that it was not used for further analysis, but is included here for completeness.

5.1.2. Previous experience of earthquakes and preparedness activities

Previous exposure to earthquakes, along with prior knowledge of preparedness advice were factors that this research explored owing to their possible influence upon actions taken at the time of shaking. This included questions about exposure to drills and exercises, and specific questions about awareness of the drop-cover-hold action. Opportunity was also taken to ask about preparedness activities that had been taken by respondents in anticipation of an earthquake.

Previous earthquake experience

In Christchurch, 97.9% (n=140) of respondents had previously experienced an earthquake, and this high number may have been due to the Mw 7.1 magnitude earthquake in nearby Darfield in September 2010 with a series of ongoing aftershocks of which the 22 February 2011 earthquake was one. Of the Christchurch sample, only 65.7% (n=94) said that the February 2011 earthquake was the strongest earthquake they had experienced. Slightly less of the Sendai respondents had previously experienced earthquakes (90.0%, n=270), however, 98.0% (n=294) reported that the 11 March 2011 earthquake was the strongest they had felt.

Official earthquake preparedness advice and drop-cover-hold

Of the Christchurch respondents, 85.3% (n=122) were aware of official earthquake preparedness advice regarding actions to take during an earthquake, with 96.5% (n=138) having heard of the drop-cover-hold action. Levels of awareness were found to be lower in Sendai with only one third (34.0%, n=102) reporting that they were aware of official advice about actions to take before, during and after an earthquake. However, 72.3% (n = 217) of respondents said they were aware of drop-cover-hold. This difference in Sendai between awareness of advice and awareness of drop-cover-hold may appear to be contradictory, and the cause is unclear. Possible explanations include terminology used in official guidance or issues with the translation of the survey.

Previous exercises or drills

Less than half the Christchurch sample (44.1%, n=63) reported that at some stage they had undertaken an earthquake exercise or drill. Of those who provided a description, the most common were exercises undertaken at school (25.0%, n=36). A small number also reported doing exercises at work (4.9%, n=7). Other exercise situations included Civil Defence organised events, and in the case of parents, at their child's school. Two thirds (67.0%, n=201) of the Sendai sample reported having previously engaged in earthquake exercises or drills, however, due to the cost of including more questions in the survey more detailed data was not obtained for where these exercises were done.

Home-based preparedness activities

Respondents in both cities reported following advice and preparing for an earthquake prior to the 2011 events, as shown in Figure 5.2. In Christchurch the most common activity in the home was having a torch (89.6%, n=129), followed by a radio (74.3%, n=107) and a survival kit (66.7%, n=96). Only 4.2% (n=6) reported no activities. In Sendai, respondents reported that within the home, 79.7% (n=239) and 67.3% (n=202) reported having a torch and a radio respectively.

In both cases, it is interesting to note that by far the most common activities were ones that involved preparing the environment, such as securing heavy items, rather than behaviour-based training such as exercises, drills or first aid courses.

Workplace preparedness activities

For those people at work, higher numbers had participated in some kind of exercise or drill. This may be due to statutory responsibilities of employers to prepare their staff for earthquake events and raises an interesting question about whether home-based workers and carers receive adequate opportunity for earthquake-related training and preparedness. There is a similar disparity between home and work for the numbers of people undertaking first aid training. Between Christchurch and Sendai, the former shows

substantially more participation in first aid training, but the reason for this is unknown. Figure 5.3 shows preparedness activities undertaken in the workplace.

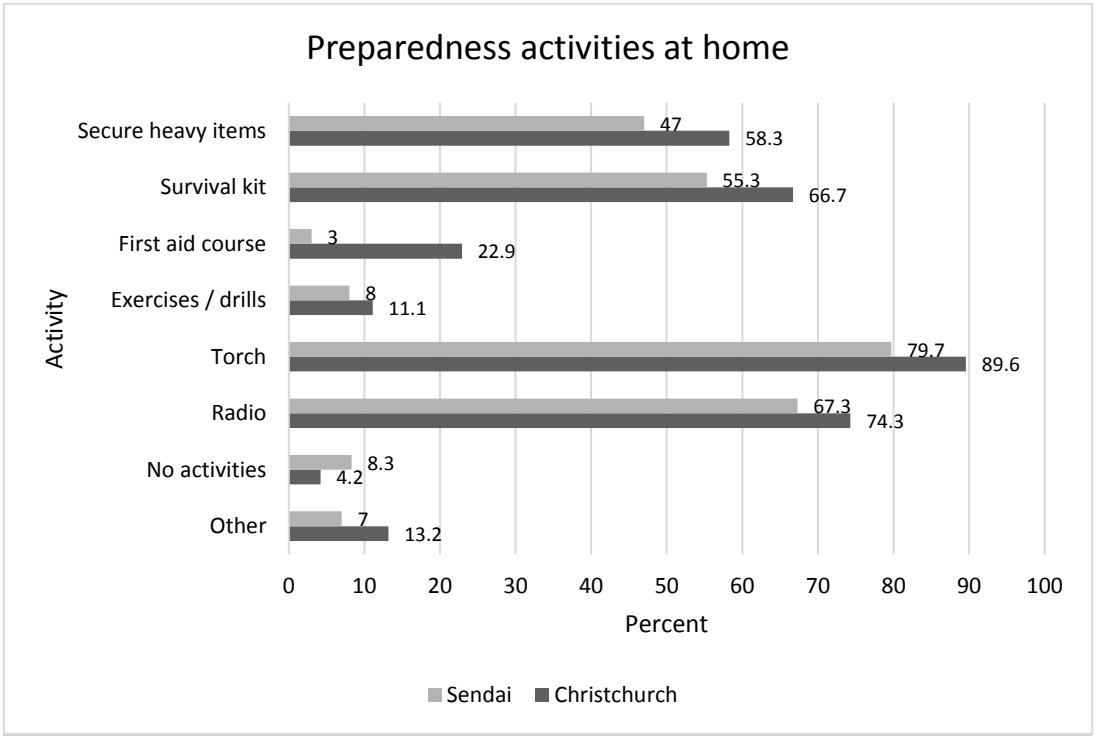


Figure 5.2. Preparedness activities at home for Christchurch and Sendai

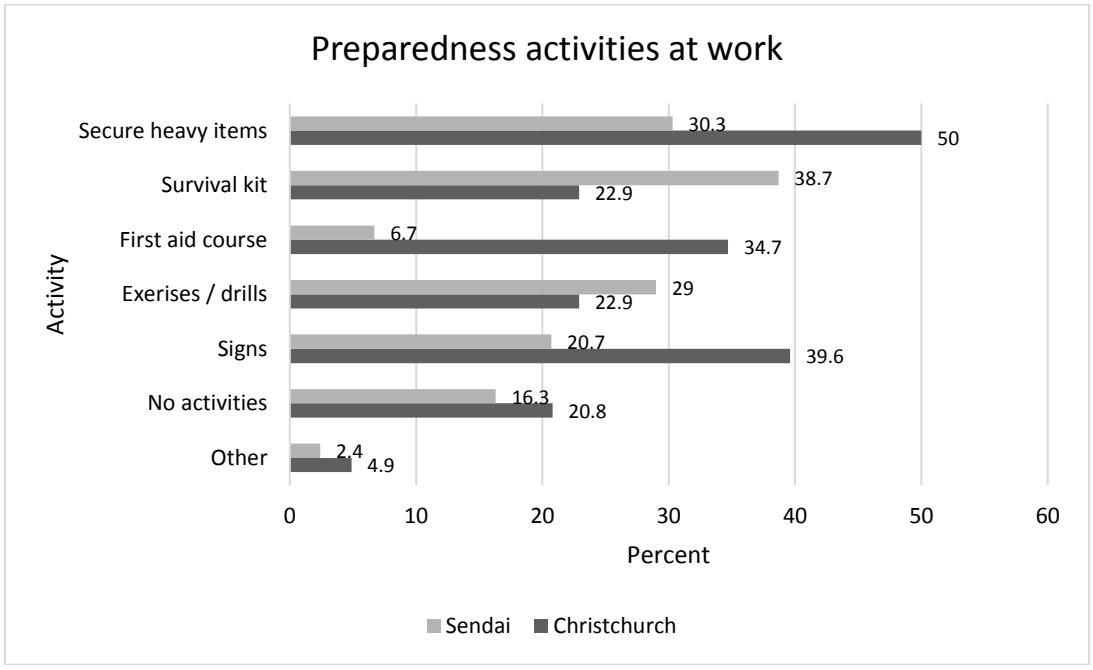


Figure 5.3. Preparedness activities in the workplace for Christchurch and Sendai

5.1.3. Description of respondent locations during the earthquakes

Respondents were asked to give details of their location at the time of the earthquake, and to describe the nature of their surroundings. More than three quarters of Christchurch (83.3%, n=120) and Sendai (89.0%, n=267) respondents reported being inside a building when the earthquake struck.

Inside – level of building

Respondents who were inside a building during the earthquake indicated the floor level they were on at the time of the earthquake, as shown in Table 5.2. In both samples most respondents were at ground level. However, the Sendai sample shows more people on higher floors. This difference may be explained by the presence of more high-rise buildings in Sendai than Christchurch.

Inside – Level of building	**Christchurch**		**Sendai**	
	%	n	%	n
Basement	0.8	1	3.7	10
Ground	66.9	79	43.4	116
First	16.9	20	19.5	52
Second	10.2	12	6.7	18
Third	0.8	1	6.7	18
Fourth	0.8	1	6.0	16
Fifth or higher	3.4	4	13.9	37

Table 5.2. Level of building that respondent was on when earthquake struck

Inside – number of doors

Respondents who were indoors at the time of the earthquake were asked about the number of doors in the room they were in, and the number of doorways they would have to pass through from their location to exit outdoors. This was in order to give an indication as to how easy it would have been to exit the building should the respondents have chosen to do so. Responses are shown in Table 5.3.

The majority of people in Christchurch were in a room with only one door (60.3%, n=73), this reduced to 41.9% (n=112) in Sendai. Of the Christchurch sample, 41.3% (n=50) reported that they had to pass through only one door to exit, however there were greater numbers in Sendai who would have had to pass through two or more doors. This may reflect the type and style of the buildings involved.

	Christchurch		Sendai	
	%	n	%	n
Doors in room				
1	60.3	73	41.9	112
2	27.3	33	33.3	89
3	5.0	6	14.2	38
4 or more	5.0	6	9.0	24
Don't know	2.1	3	1.5	4
Doors to exit				
1	41.3	50	32.6	87
2	37.2	45	44.9	120
3	14.0	17	15.4	41
4 or more	7.4	9	5.6	15
Don't know	0.0	0	1.5	4

Table 5.3. Doors in the room and doors to the exit from the room

Inside – items in the room

Respondents were asked to indicate the types of objects present in the room with them at the time of shaking. The responses are shown below in Figure 5.4.

In Christchurch the most common items were a table or desk (64.6%, n=93), computer equipment (52.1%, n=75), shelving units (47.9%, n=69), and chairs or sofas (46.5%, n=67). In Sendai this was similar, and the most common items were a table or desk (80.4%), followed by computer equipment (61.8%), chairs or sofas (54.7%), and a television (50.6%). The main variation between the samples was the presence, or otherwise, of shelving units, bookcases, televisions and machinery. The reasons for these differences are unclear, some may be cultural, while others may be due to the nature of workplaces included in the survey.

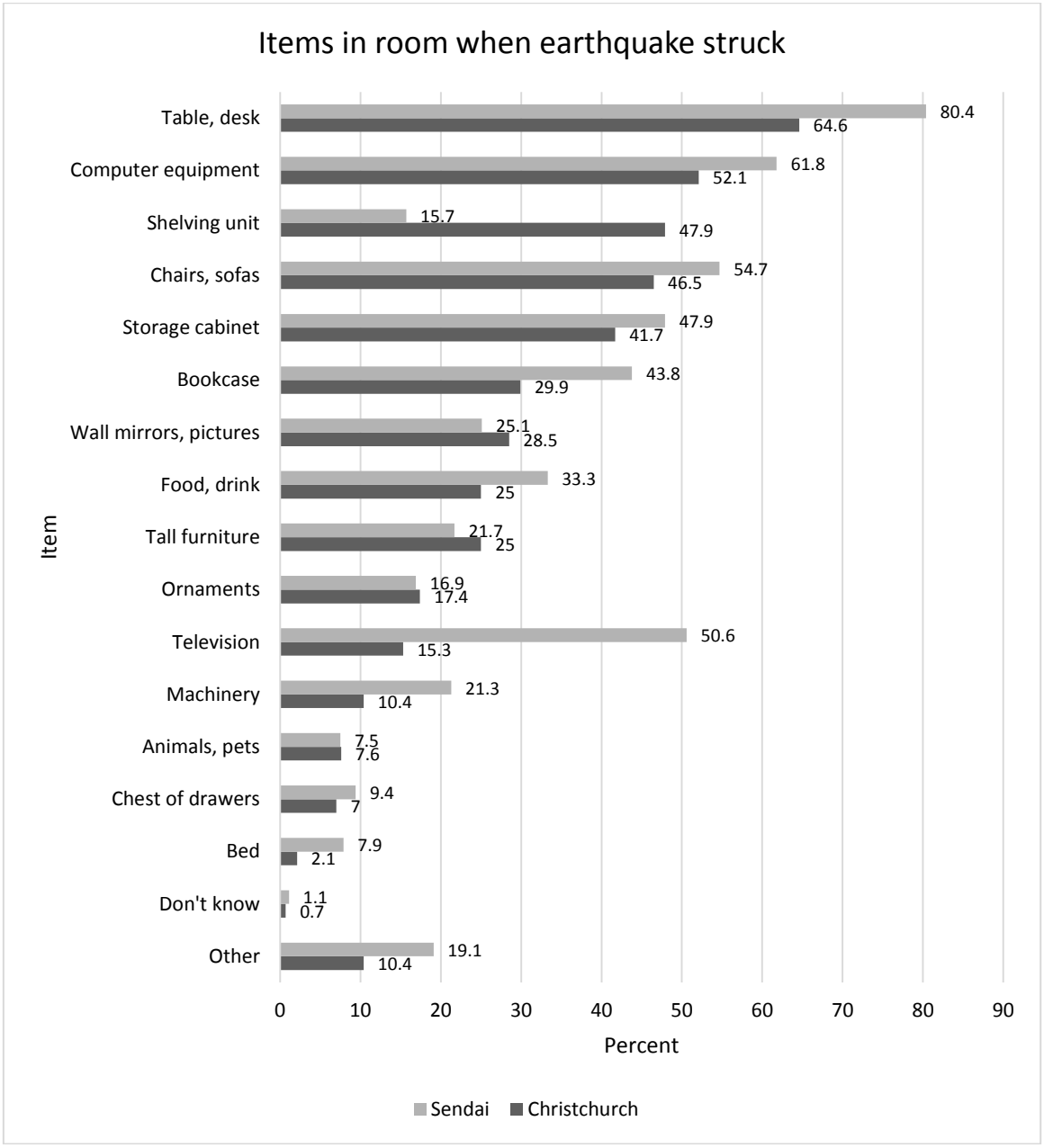


Figure 5.4. Items in the room with the person during the earthquake (%)

Inside – other people present

In both Christchurch and Sendai, the majority of respondents reported being with at least one other person at the time of the earthquake. However, in both samples, another quarter of respondents reported being on their own. Table 5.4 shows the relationship between the other people present and the respondent.

Other people present in room	Christchurch		Sendai	
	%	n	%	n
Colleagues	38.9	56	41.6	111
Alone	26.4	38	28.1	75
Member of public / stranger	16.7	24	8.6	23
Family	6.3	9	15.4	41
Children 0-17yr	4.2	6	7.5	20
Friends	2.1	3	3.4	9
Other	5.6	8	4.1	11

Table 5.4. Other people in the room with the respondent

Inside – damage to items in the room

The degree to which damage occurred in the room may have indicated the intensity of the earthquake in that particular location, and whilst the samples reported few situations of complete destruction, damage appears to range from small items falling over to significant damage to the room. Figure 5.5 shows the level of damage to items in the room the respondents were in.

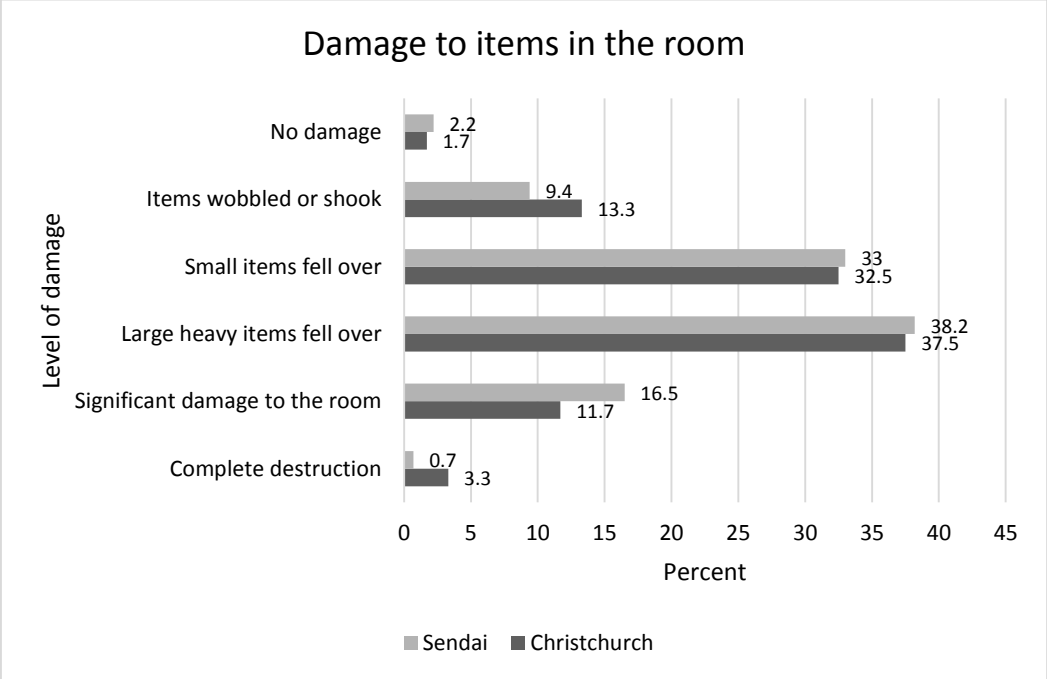


Figure 5.5. Damage to items in the room the person was in during the earthquake (%)

In Christchurch, respondents who were inside most frequently described levels of damage to the room as 'small items fell over' (32.5%, n=39) and 'large, heavy items fell over' (37.5%, n=45). The Sendai sample more

frequently reported large heavy items fell over (38.2%, n=102), although the difference between the two samples was small.

Inside – damage to building

Respondents were asked to describe the damage to the building they were in at the time of shaking (see Figure 5.6.). In Christchurch, more than two thirds of damage was reported as either minor (37.2%, n=45), or moderate (33.9%, n=41). In Sendai, moderate damage was reported to buildings by 36.0% (n=96) of the sample, and 26.2% (n=70) reported substantial damage. These levels of damage are consistent with reported effects on the MM scale and the Shindo scale for earthquakes of the intensity experienced.

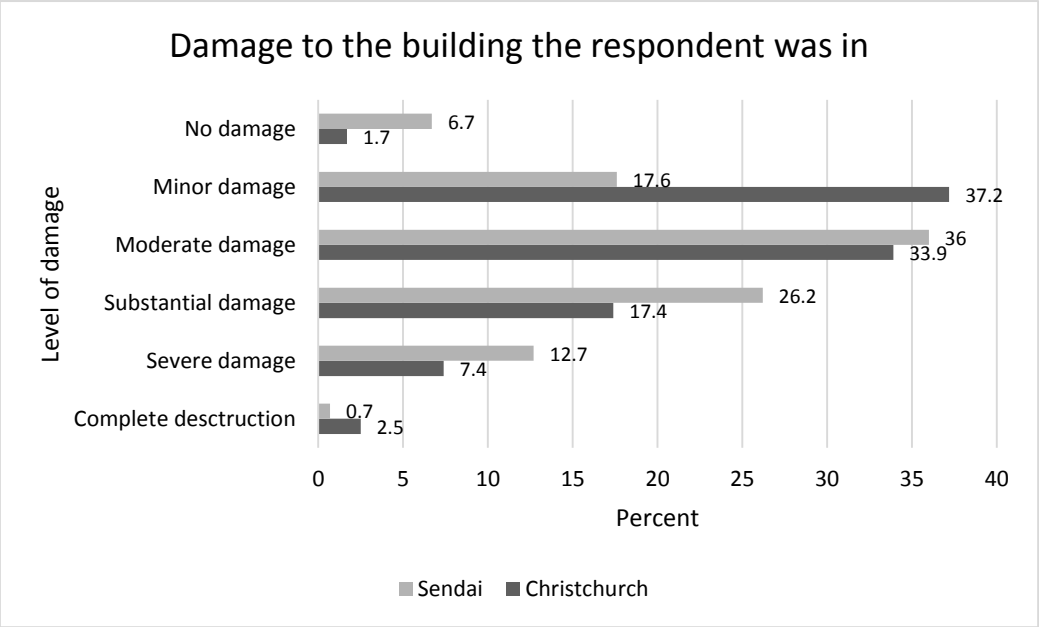


Figure 5.6. Damage to the building the respondent was in during the earthquake (%)

Outside – location

The questionnaire included alternative questions about the location for respondents who were outside when the earthquake occurred. When asked their location, 33.3% (n=16) of the Christchurch sample who were outside reported they were next to a building, and 31.3% (n=15) said they were on the road. In Sendai of the sample who said they were outside when the earthquake struck, 36.4% (n=12) were on a road, and 27.3% (n=9) were next to a building. The full range of responses are shown in Table 5.5.

Location outside	Christchurch		Sendai	
	%	n	%	n
Next to a building	33.3	16	27.3	9
On the road	31.3	15	36.4	12
On a footpath	14.6	7	18.2	6
Open space / park	10.4	5	0.0	0
Home garden	4.2	2	0.0	0
Other	6.3	3	18.2	6

Table 5.5. Location of respondents outside

Outside – surrounding structures

Respondents were asked about the structures near to them during the earthquake, as shown in Table 5.6. In Christchurch the most common items were vehicles (22.2%, n=32), street lamps (19.4%, n=28), and power poles (18.1%, n=26). In Sendai the most frequent objects were traffic lights (69.7%, n=23) and power poles (66.7%, n=22). The higher frequency of surrounding structures in the Sendai sample may reflect the higher density and infrastructure of the city.

Surrounding structures present	Christchurch		Sendai	
	%	n	%	n
Traffic lights	7.6	11	69.7	23
Power poles	18.1	26	66.7	22
Vehicles	22.2	32	51.5	17
Streetlamps	19.4	28	45.5	15
Large glass windows	13.2	19	27.3	9
Awnings or overhangs	6.3	9	15.2	5
Advertising billboards	2.8	4	36.4	12
Other	4.9	7	9.1	3

Table 5.6. Surrounding structures of respondents outside

Outside – level of damage to buildings

Respondents were asked to consider the level of damage to the buildings nearest them. This question was intended to provide an indication as to whether damage to buildings affected actions taken. The majority of the Christchurch sample described this as either minor (33.3%, n=16) or moderate (39.6%, n=19). In Sendai, the respondents were more likely to report that damage to buildings near them was moderate (45.5%, n=15), despite this, slightly more buildings were reported to have been completely destroyed in Christchurch. The full set of responses are shown in Figure 5.7.

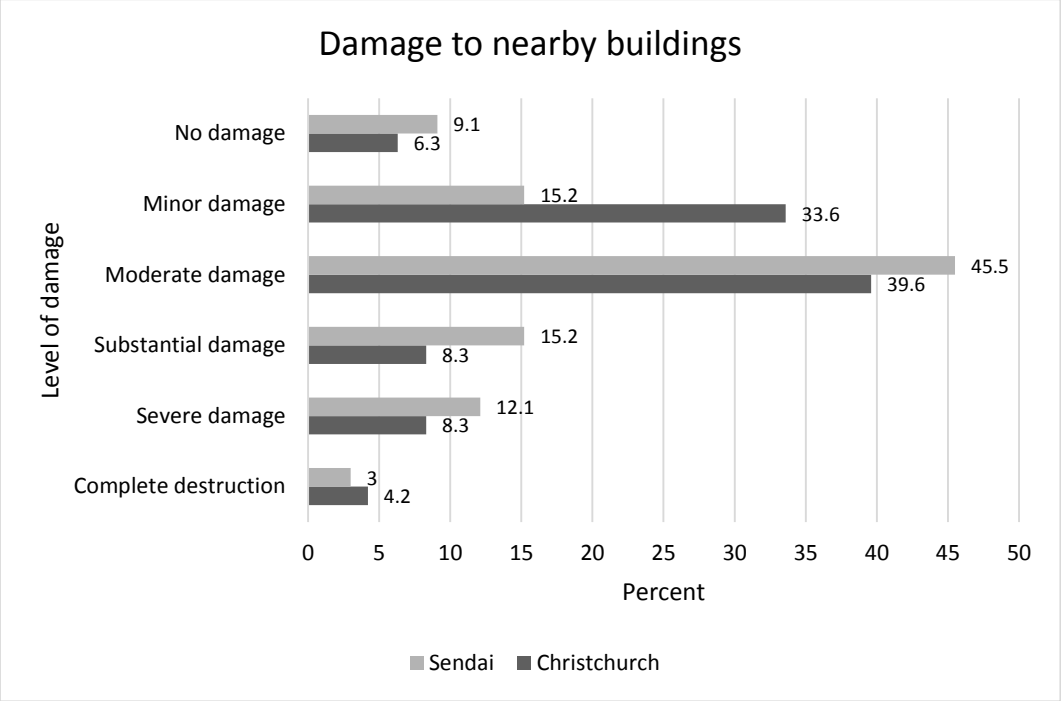


Figure 5.7. Damage to nearby buildings to the person during the earthquake (%)

5.2. Actions during earthquake activity

A key focus of this research has been to identify the actions that people take during earthquakes. This is of interest both in itself, for example in understanding what are the most common behaviours, and in terms of exploring the influences on those actions. This section focuses on the reported actions of respondents when the earthquake started and during the earthquake, along with the feelings they experienced.

5.2.1. Activities immediately prior to the earthquake

Respondents were asked to describe their activities immediately prior to when the earthquake struck to ascertain whether their activity influenced the actions taken, and responses are shown below in Table 5.7. When the earthquake struck, in both locations the majority of respondents reported being at work (63.6% in Christchurch and 50.3% in Sendai). The samples, therefore, comprise subjects who were mainly working at the time of the earthquake. This is likely to be down to the sampling method, as previously mentioned, and should be borne in mind when extrapolating any conclusions to a wider context.

Activities at time of earthquake	Christchurch		Sendai	
	%	n	%	n
Working	63.6	91	50.3	151
Eating	8.4	12	3.3	10
Driving	7.7	11	4.3	13
Shopping	4.2	6	4.0	12
Sleeping	0.7	1	3.7	11
Exercising	0.7	1	1.3	4
Other	14.7	21	33.0	99

Table 5.7. Activities undertaken at time of earthquake

5.2.2. Responses to earthquake shaking

Actions during the earthquake

Respondents were asked about the actions they took during the earthquake, and were able to select more than one type of behaviour from a range of options. In Christchurch the most frequently reported action was avoiding objects (35.4%, n=51), followed by staying in place (34.7%, n=50). This is in contrast to Sendai where the most frequent actions were staying in place (74.7%, n=224) and drop-cover-hold (38.3%, n=115).

Despite national advice to the contrary, many respondents in both countries chose to exit buildings during the earthquake rather than remain inside. Additionally, in Christchurch, where drop-cover-hold is integral to the earthquake guidance provided, surprisingly few respondents reported taking that action (4.2%, n=6). This relationship between advice given and actions taken is discussed in greater depth in subsequent chapters.

Also, of interest is that the majority of respondents in both samples reported taking multiple actions during the earthquake, which again contrasts with the approach taken in the relevant guidance which tends to focus on a single action or sequence of actions. The responses are shown in Figure 5.8 below where the percent given represents the proportion of respondents taking each action compared with the sample size as a whole.

Actions taken during the earthquake	Christchurch		Sendai	
	%	n	%	n
Avoid objects	35.4	51	27.7	83
Stayed in place	34.7	50	74.7	224
Go outside	22.9	33	20.3	61
Away from building	20.1	29	18.7	56
Protect others	20.1	29	21.3	64
Stand in doorway	19.4	28	16.7	50
Shelter under table	18.1	26	20.3	61
Sit or lie down	9.0	13	26.0	78
Personal items	6.9	10	17.7	53
Stop vehicle	6.3	9	4.0	12
Drop-cover-hold	4.2	6	38.3	115
No action	4.2	6	0.0	0
Other	15.3	22	24.0	72

Figure 5.8. Actions taken during earthquake shaking in Christchurch and Sendai

Reasons for taking actions during shaking

Respondents were asked to explain why they chose to take the actions they did. In Christchurch, the responses were for all actions taken together. By contrast, in the Sendai survey, owing to a misinterpretation by the marketing company involved, respondents were allowed to give reasons for each of the actions they had taken. Despite the differences, comparison of the two samples was made by averaging the responses given in Sendai. Furthermore, the Sendai sample gives an additional level of detail to the data. The results are shown below in Table 5.8 and Table 5.9.

In Christchurch, the most frequent explanation for the actions taken was that they were instinctive responses (49.6%, n=63). This was followed by a belief that the action 'seemed sensible' (21.3%, n=27). In Sendai, the two most frequent explanations were in the opposite order to that found in Christchurch with mean percentage values of 32.4% and 40.0% for 'instinct' and 'seemed sensible' respectively.

These responses are discussed in greater depth in subsequent chapters. However, it is worth pointing out a few interesting observations at this point.

Respondents in Sendai who reported sheltering under a table were more than twice as likely to cite 'previous exercises' as a reason for this behaviour than were respondents for any other action. Nearly half of Sendai

respondents that went outdoors felt that it 'seemed sensible', and almost the same proportion gave this reason to explain having attempted to save personal items. This raises interesting questions for the provision of advice and training, and might suggest that drills are more effective than more passive methods of providing guidance when it comes to shaping behaviour.

Reasons for taking actions	Christchurch	
	%	n
Instinctive behaviour	49.6	63
Seemed sensible	21.3	27
Previous exercises	10.2	13
Previous experience	7.1	9
Don't know	1.6	2
Told to do so	0.0	0
Other	10.2	13

Table 5.8. Reasons for actions taken in Christchurch

Action	It seemed sensible %	Instinctive behaviour %	Previous experience %	Told to do so %	Previous exercises %	Don't know %	Other %
Stay in place	42.0	25.0	8.9	3.6	4.0	7.1	9.4
Drop-cover-hold	40.9	26.1	18.3	2.6	9.6	0.9	1.7
Avoid objects	28.9	47.0	16.9	2.4	2.4	2.4	-
Sit or lie down	41.0	32.1	9.0	2.6	5.1	2.6	7.7
Go outside	49.2	34.4	6.6	9.8	-	-	-
Protect others	34.4	43.8	18.8	1.6	1.6	-	-
Shelter under table	34.4	11.5	23.0	6.6	21.3	1.6	1.6
Away from buildings	48.2	35.7	8.9	5.4	1.8	-	-
Save personal items	43.4	34.0	13.2	1.9	1.9	5.7	-
Stand in doorway	44.0	32.0	4.0	8.0	2.0	4.0	6.0
Stop vehicle	33.3	41.7	16.7	-	8.3	-	-
Other	38.9	25.0	8.3	-	4.2	11.1	12.5
Mean value	40.0	32.4	12.7	10.2	5.7	4.4	6.5

Table 5.9. Reasons for actions taken in Sendai (%)

Saving personal items

Respondents were asked whether they saved any personal items during the earthquake. The most frequently saved item by the Christchurch sample was a mobile phone (25.0%, n=36) followed by a wallet or handbag (11.8%, n=17). Computer equipment was saved by 7.6% (n=11) of respondents. This was in contrast to the Sendai sample where 22.7% (n=68) mentioned their mobile phone, 18.3% (n=55) of respondents mentioned their computer, and 16.0% (n=48) saved their wallet or handbag. A large number of Sendai respondents (26.7%, n=80) also mentioned they saved other unspecified items. All responses are shown in Table 5.10.

Personal items saved	**Christchurch**		**Sendai**	
	%	n	%	n
Mobile phone	25.0	36	22.7	68
Wallet / handbag	11.8	17	16.0	48
Computer equipment	7.6	11	18.3	55
Animals	6.9	10	8.7	26
Documents	2.1	3	5.0	15
Ornaments	0.7	1	3.0	9
Other	6.9	10	26.7	80

Table 5.10. Personal items saved during the earthquake

Attitudes to drop-cover-hold

Respondents were also asked about their views on the drop-cover-hold action, in particular, whether it was a) possible, and b) safe to do the action during the earthquake. In Christchurch more than half of the respondents felt that drop-cover-hold was possible (58.3%, n=84) while 52.1% (n=75) thought it was safe to do so. The figures for Sendai were 45.3% (n=136) and 44.3% (n=133) respectively.

Interestingly there was a lot more uncertainty in Sendai as to whether it was safe to perform drop-cover-hold with 42.3% (n=127) in Sendai saying they did not know if this was possible, compared to just 16.0% (n=23) in Christchurch. Attitudes and awareness of drop-cover-hold are discussed further in Chapter 7.

The responses for both questions are shown in Table 5.11 below.

	Christchurch		Sendai	
	%	n	%	n
Possible to drop-cover-hold				
Yes	58.3	84	45.3	136
No	36.8	53	43.3	130
Don't know	4.9	7	11.3	34
Safe to drop-cover-hold				
Yes	52.1	75	44.3	133
No	31.9	46	13.3	40
Don't know	16.0	23	42.3	127

Table 5.11. Attitudes to drop-cover-hold

Providing and receiving assistance during the earthquake

Both samples were asked whether they provided or received assistance during the earthquake. In Christchurch 39.2% (n=56) of respondents indicated that they provided assistance to others, and this was mostly to colleagues and strangers. For those that received assistance (14.7%, n=21) during the earthquake, this was mostly from colleagues. In Sendai, 16.7% (n=50) reported providing assistance to someone, but only 5.0% (n=15) reported receiving it. The Sendai survey did not further explore who the assistance was given to, or received from.

5.2.3. Feelings experienced during the earthquake

Responses were given to six statements about feelings experienced during the earthquake; these related to levels of anxiety, fear, helplessness, confidence, calmness, and feeling in control. These questions used a 5-point Likert scale, to rate the intensity of the emotional response. The first three statements were concerned with potentially 'negative' experiences while the remaining three implied more optimistic or constructive feelings. Median scores from the Likert scale (min = 1, max = 5) for each feeling from both cities are shown in Table 5.12.

In response to the statement 'I felt anxious during the earthquake', the majority of people agreed or strongly agreed in both Christchurch and Sendai. In Sendai 45.3% (n=136) of respondents said that they strongly agreed with the statement, whereas in Christchurch this reduced to 31.2% (n=44). Overall, 75.2% (n=106) of respondents in Christchurch and 74.0% (n=224) in Sendai agreed or strongly agreed that they felt some form of anxiety during the earthquake (see Figure 5.9.). As is discussed in later chapters these high levels of reported anxiety may have an impact on the effectiveness of preparedness advice and training at the time of shaking owing to the role of anxiety in the fight and flight response.

Feeling ('I felt…')	Christchurch	Sendai
Anxious	3.95	4.01
Fearful	3.74	3.94
Helpless	3.67	3.53
Confident	2.49	2.20
Calm	2.67	2.85
In control	2.31	3.04

Table 5.12. Median scores for feelings based on 1-to-5 Likert scale rankings

In response to the statement 'I felt fearful during the earthquake', nearly half (48.7%, n=146) of Sendai respondents strongly agreed, compared with half that in Christchurch (25.9%, n=37). Overall, 64.4% (n=92) of respondents in Christchurch and 68.0% (n=204) in Sendai agreed or strongly agreed they felt fearful during the earthquake (see Figure 5.9.). Very few people strongly disagreed with the statement. One possible explanation for differences in the levels of fear is that the earthquake in Sendai lasted considerably longer (6 minutes), than the one in Christchurch (24 seconds), giving people more time to become aware of and experience the sensation of fear.

In response to the statement 'I felt helpless during the earthquake', the Christchurch sample reported higher levels of agreement, with Christchurch (63.2%, n=89) and Sendai (52.4%, n=157) reporting some level of helplessness (see Figure 5.9.). Intuitively, a positive correlation of helplessness with fear might have been expected. The higher levels of helplessness in Christchurch may be attributable to the population having experienced continual aftershocks in previous six months following the Darfield earthquake in September 2010, and express a certain level of resignation to these events.

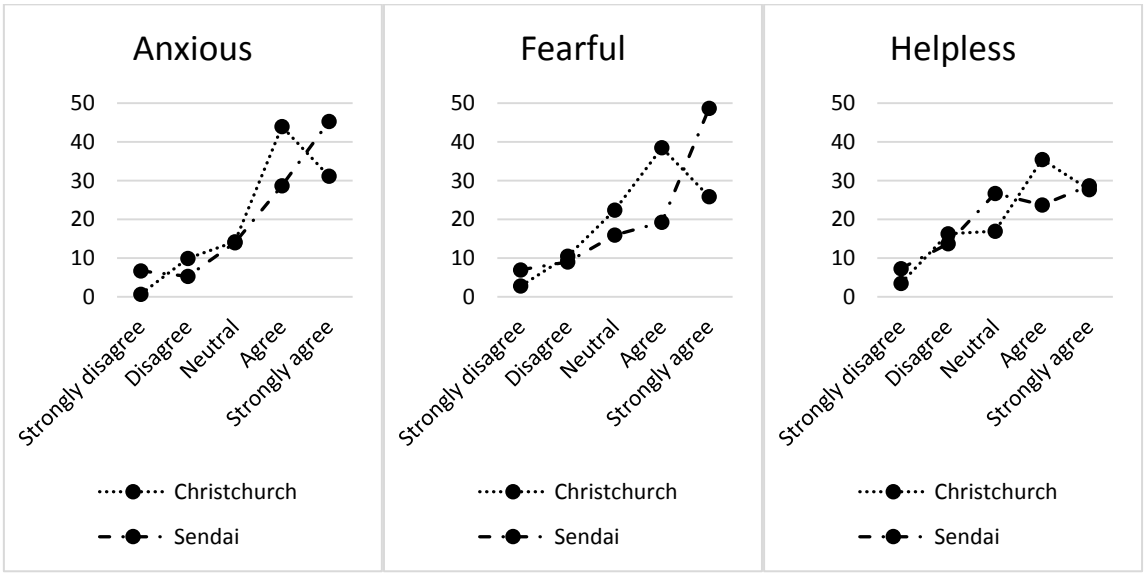


Figure 5.9. Those who felt anxious, fearful and helpless during the earthquake (%)

In response to the statement 'I felt confident during the earthquake', very few respondents strongly agreed with the statement, only 2.1% (n=3) in Christchurch, and 2.0% (n=6) in Sendai (see Figure 5.10.).

In response to the statement 'I felt calm during the earthquake', the feelings were generally more neutral, with respondents neither strongly agreeing nor disagreeing. Just under a quarter of respondents in both samples reported feeling calm at the time of the earthquake, 22.0% (n=31) in Christchurch, and 22.7% (n=68) in Sendai (see Figure 5.10.).

The statement 'I felt in control during the earthquake', shows the greatest difference between the two samples, with Christchurch generally disagreeing with the statement, and Sendai tending to agree. In Christchurch, 28.4% (n=40) strongly disagree, and 31.9% (n=45) disagree. This contrasts with Sendai where 36.7% (n=110) were neutral, and 28.7% (n=86) agreed they felt in control (see Figure 5.10.). The reasons for this are unclear, it may again be a sign of the resignation that Christchurch inhabitants had as a result of their frequent exposure to aftershocks. There may also be cultural differences in the way in which the concept of 'control' is interpreted and expressed, although these are not explored further.

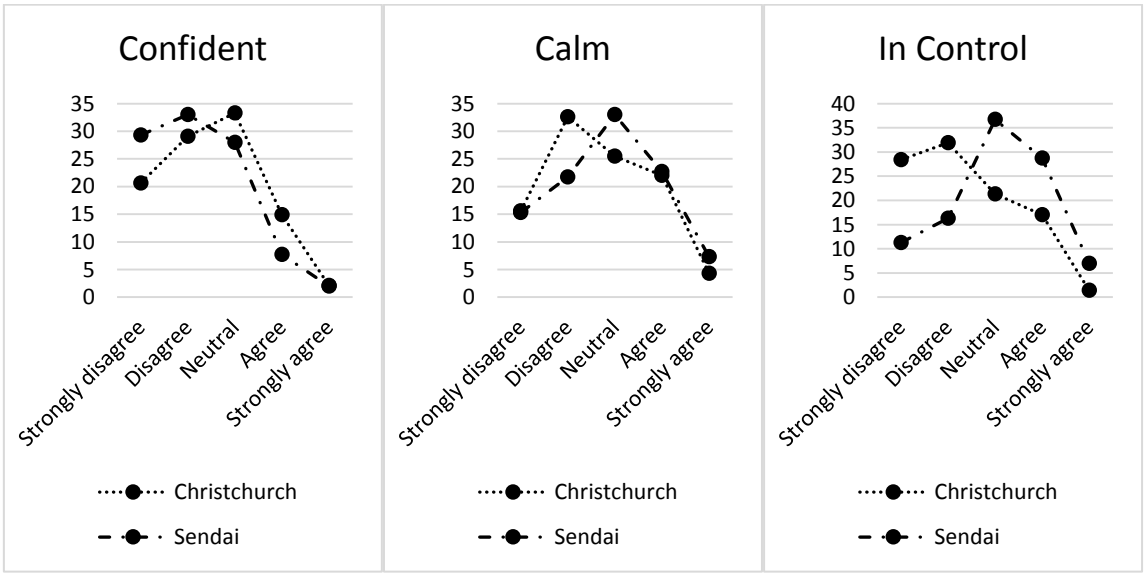


Figure 5.10. Those who felt confident, calm and in control during the earthquake (%)

Fears during the earthquake

Respondents were asked what they were most fearful about during an earthquake, and were able to select multiple answers, as shown in Figure 5.11 below. In Sendai the greatest proportion of respondents expressed a fear of building collapse (49.3% n=148). Across all answers, with the exception of building collapse which was closely matched, Christchurch respondents appear more likely to express specific fears than those from Sendai. The fears of building collapse and being trapped are discussed in chapter 6.

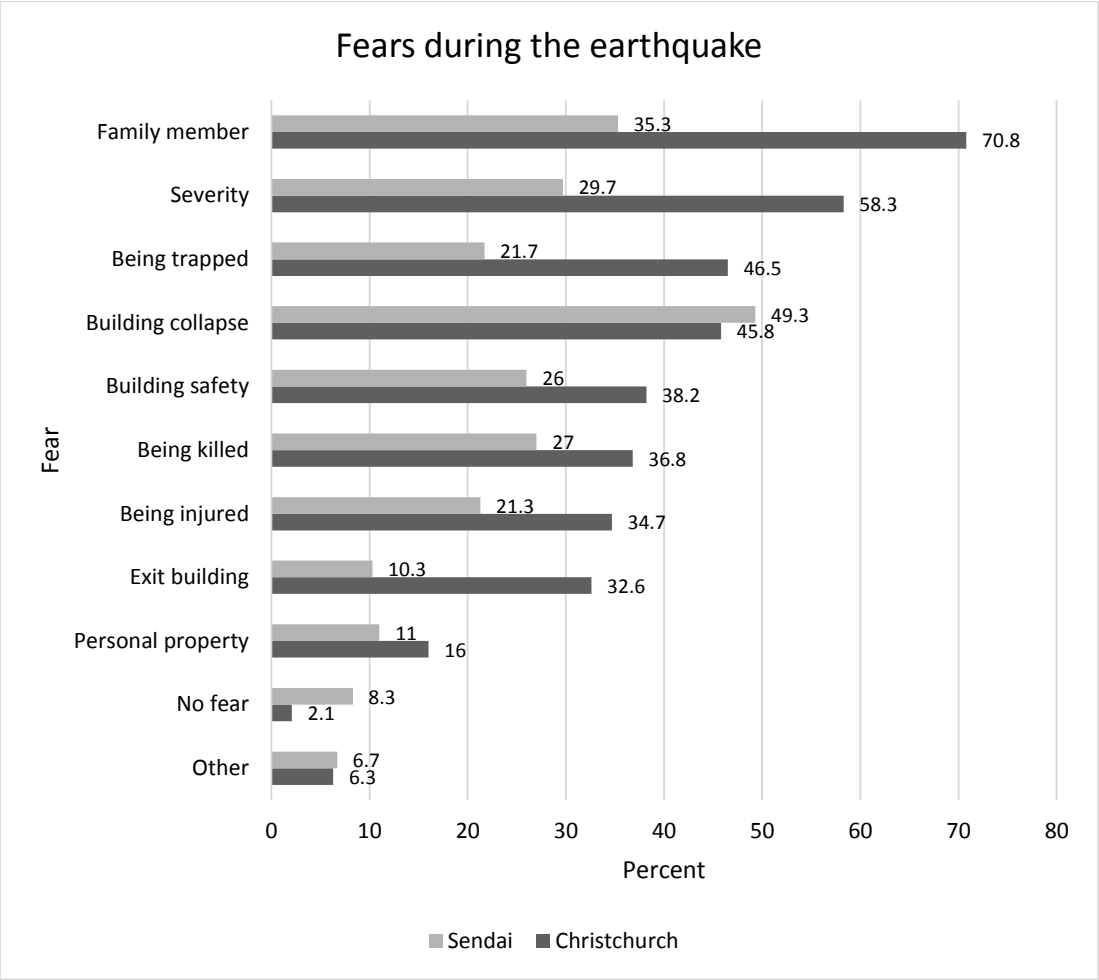


Figure 5.11. Fears experienced during the earthquake (%)

5.2.4. Self-described actions

Participants were given the opportunity to describe, in their own words, the actions they thought would be appropriate, and inappropriate, to take during an earthquake. These free-text responses were analysed using content analysis, based on the frequency of key words or phrases, and the results are shown below in Figure 5.12 and Figure 5.13.

<u>Appropriate actions</u>

When participants were asked what they thought would be the appropriate actions to take during earthquake shaking, in Christchurch the most commonly used phrase was drop-cover-hold (32.6%). This is unsurprising considering it is the most commonly taught procedure in New Zealand, in fact the frequency of responses might have been expected to be higher if the national guidance was shaping the behaviour of the population more generally. However, this contrasts with the relatively few respondents who reported actually completing the action during the earthquake, and highlights the importance of distinguishing between people's declared intentions and their actual behaviour. The former is not indicative of the latter.

Research that only evaluates how much people are able to recall about preparedness advice (e.g. Paton, 2003) may therefore give little insight into what they actually do during an earthquake.

Two other actions were also mentioned frequently – to 'get under a strong structure' (25.0%) and to 'stand in doorway or reinforced area' (20.1%). The Sendai sample had a slightly different view on the appropriate actions to take, and those that were considered most appropriate were getting 'under a strong or solid structure' (25.0%), and to 'move away from glass or items that might fall over' (22.7%). 'Taking cover and covering head with hands' was also highly reported (17.7%).

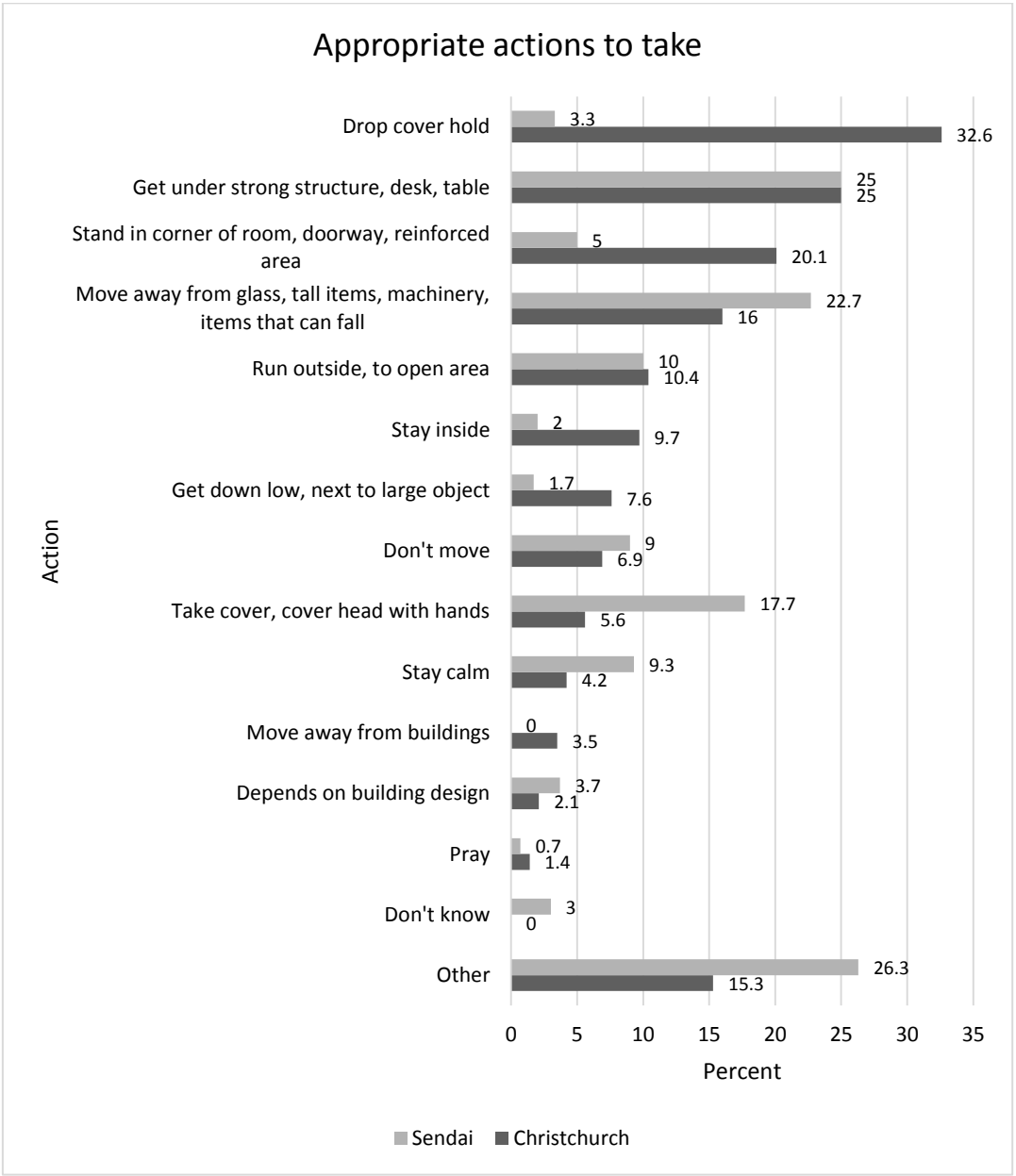


Figure 5.12. Appropriate actions to take as described by respondents (%)

Inappropriate actions

Respondents to the survey were also asked what they thought would be inappropriate actions to take during earthquake activity, and responses are shown in Figure 5.13. In both Christchurch and Sendai, 'to run or go outside' was comfortably the most frequently identified action to avoid during shaking (59.7% and 55.0% respectively). This is standard advice in both New Zealand and Japan, and so a simple interpretation of respondents' views on appropriate and inappropriate actions suggests that guidance on what not to do is more consistently reflected in people's opinions than advice on what to do and further research might be needed to explore why this is so.

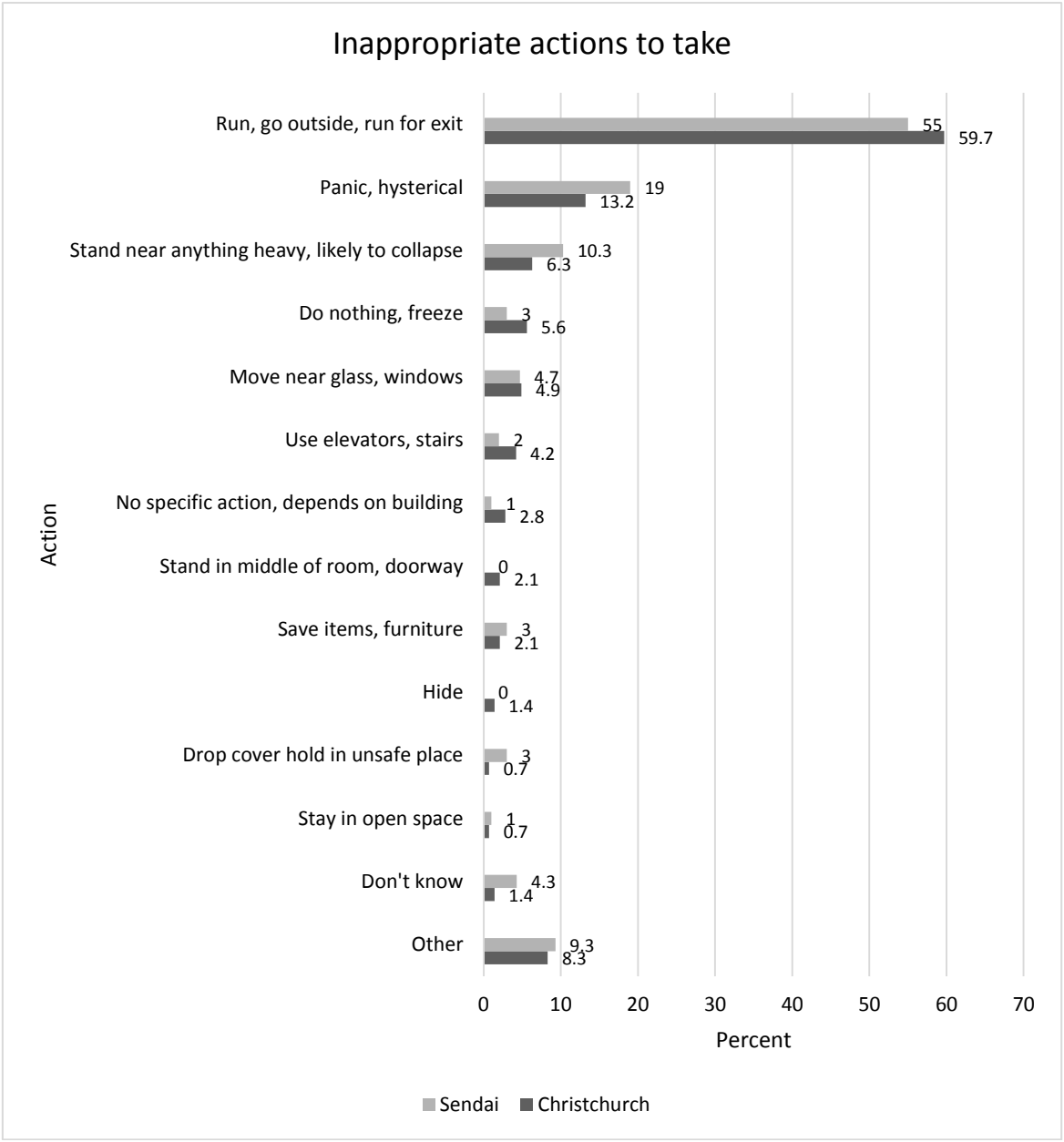


Figure 5.13. Inappropriate actions to take during an earthquake as described by respondents (%)

5.3. Influences on actions taken during the earthquake

The previous section considered the results of the field surveys by analysing the frequency of responses to the questions and, where appropriate, utilised content analysis for text-based answers. In order to gain an insight into the factors that might influence people's protective actions, a number of variables were considered for further analysis. The key variables analysed are age, gender, feelings and advice given by public agencies (undertaking exercises, awareness of official guidance, and attitudes towards drop-cover-hold). Whether respondents provided or received assistance was also considered as a factor. This section therefore, describes a number of these relationships and associations that have been explored from the data.

The choice of statistical method is determined by the nature of the data involved (Bryman 2012). In the two surveys, the data is either nominal or ordinal thereby limiting the techniques used to investigate the relationships and associations that it may contain. The main analysis involved cross-tabulation, Fisher's exact test and the Mann-Whitney U test. The data was analysed using SPSS version 26 (IBM, 2020) and R (R Core Team, 2020). In the statistical analysis, only results that were later developed in this thesis are described below.

The results of these analyses are given below. Firstly, the actions taken during the earthquake are analysed against three people-centred variables: age, gender and feelings. These are followed by analysis of actions taken against three preparedness-centred variables: exercises and drills, attitudes towards drop-cover-hold, and awareness of official advice.

5.3.1. Age and actions taken

Actions taken during the earthquake were analysed using contingency tables and Fisher's exact test to find whether any relationship existed between age groups and actions taken.

No significant relationships were found for these variables in Christchurch. Nonetheless, some trends can be seen between age groups and three of the actions taken. The proportion of respondents in the younger group who 'sought shelter in a doorway' was less than half that of both the middle age and older groups (18.5% compared to 40.5% and 35.7% respectively). Similarly, with the action 'to go outside', the younger group were also around half as likely to report this action as the other age groups (20.0% compared to 46.8% and 36.4% respectively). Conversely the older group was more likely 'to stay in place' (78.6%) than either the youngest (53.3%) or the middle age (45.5%) groups.

In Sendai, analysis of age group and actions taken showed a significant relationship was found between age and 'taking shelter under a table' ($p = 0.009$), with 32.4% young, 18.3% middle and 10.2% elderly respondents taking this action. Several explanations are possible for the increased likelihood that young people will take

this action, such as differences in the mobility of elderly people, exposure to different, or more recent training, or being less informed about sheltering.

Whilst this was the only significant relationship found between age and actions taken, a weak association was found with drop-cover-hold (p = 0.077) being undertaken by a greater proportion of young people (49.3%) than either the middle (36.1%) or elderly (30.6%) age groups.

Furthermore, in Sendai a greater proportion of the elderly age group (34.7%) reported 'avoiding objects' during the shaking than the other two groups (21.1% and 28.3%). Of the people who reported 'going outside' during the earthquake, the smallest proportion was in the middle age group (18.6%), as compared to 29.7% and 28.6% in the young and elderly age groups respectively.

Similarly, young and middle-aged respondents were more than twice as likely to report protecting others during the earthquake (23.9% and 23.3% respectively) than the elderly group (10.2%).

The analysis of age and actions in both Christchurch and Sendai shows little consistency in the actions taken across the three age groups. This raises an interesting question about the effectiveness or otherwise of the preparedness advice and training provided by authorities. At the very least, if the impact of this guidance is equally affecting each age group, then one might expect more consistency across them. The implications of this are discussed in later chapters.

Age and attitudes to drop-cover-hold

This research considered whether age was a factor in respondents' attitude towards drop-cover-hold, and in particular whether it was a) possible, and b) safe to do the action. In both cities, no significant relationship was found between age and attitudes towards drop-cover-hold using Fisher's exact test.

The Christchurch sample indicated that the middle age group were most likely to believe that the drop-cover-hold action was possible (63.6%), and the younger age group was least sure (47.2%). Age also appeared to influence people's opinion towards whether drop-cover-hold was a safe action to perform, with a weak association (p = 0.086) with increasing age trending towards a more positive view (36.1% of the younger group, 55.8% of the middle age group, and 64.0% of the older group).

In Sendai no significant relationships were apparent, however, the younger age group generally felt it was both possible and safe to do drop-cover-hold more so than the elderly group. Nearly half the younger group (47.9%) thought it was possible to drop-cover-hold, compared to 47.2% of the middle group and 34.7% or the older group. The younger group were also more likely to say it was safe to drop-cover-hold (52.1%) than the older group (36.7%). Large numbers of the middle and older groups said they did not know whether it was safe to drop-cover-hold (45.0% and 46.9% respectively).

Age and providing or receiving assistance

The act of providing or receiving assistance during the earthquake was also compared across age groups. Providing assistance showed no significant relationship using Fisher's exact test with age group in either city, however a significant relationship existed in Sendai between age and receiving assistance - described below.

In Christchurch the elderly age group (40.0%) provided assistance at a slightly higher frequency than the younger group (36.1%), but were less likely to receive assistance (8.0%) than the middle (15.6%) or younger group (16.7%). Similarly, in Sendai the younger age group was nearly twice as likely to provide assistance (23.9%) than the elderly age group (12.2%). However, there was a significant relationship (p = 0.005) with the younger group reporting receiving assistance (12.7%) more than the middle aged (2.8%) and elderly (2.0%) groups.

In both countries, providing assistance was more likely to be reported than receiving assistance. The reasons for this are unclear, but one possible explanation may be a difference in perception regarding what constitutes being a 'helper' versus what constitutes being 'helped'. There may also be a reluctance among some people to report having received help when compared with describing oneself as having given assistance. The topic of 'assistance' is discussed further in the next chapter.

5.3.2. Gender and actions taken

Actions taken during the earthquake were also analysed by gender using contingency tables and the Fisher's exact test.

In Christchurch two actions showed a significant relationship with gender. 'Sheltering under a table' was performed more frequently by females (40.0%) than males (15.0%) (p = 0.011). Similarly, females more frequently reported 'protecting others' (48.9% and 13.5% respectively) (p = 0.001). Twice as many females (10.0%) performed drop-cover-hold than males (5.4%), however this was not a statistically significant difference. Other actions with trends in the data were 'saving personal items' where 18.4% of females reported doing this, but only 8.6% of males. Slightly more females than males reported avoiding objects during the earthquake (60.5% female, 50.0% male). The only case where slightly more males (38.6%) than females (35.0%) took action was 'going outside' during the earthquake, but this was not statistically significant.

In Sendai the only significant relationship between gender and actions taken was with 'to sit or lie down' (p < 0.001). Of those who did this action, 37.0% of the respondents were female and 14.4% were male. In retrospect this survey question does not distinguish between those who chose to sit or lie down as an action in itself, or whether this was part of an attempt to seek shelter.

There were other trends in the data with more females having reported 'sheltering under a table', 22.7% compared to 17.8% of males. Of those who did drop-cover-hold, 42.9% were female, and 33.6% male. The data also shows more females (25.5%) than males (20.0%) went outside during the earthquake, which was the opposite of that found in Christchurch.

In common with other research (Prati *et al.,* 2012), these findings support the notion that females are more likely to take protective actions than males, particularly in terms of seeking shelter and performing drop-cover-hold.

Gender and attitude to drop-cover-hold

Gender was also investigated as a factor in attitudes to drop-cover-hold, and this again used contingency tables and Fisher's exact test.

In Christchurch no significant relationships existed between gender and whether people thought it was possible, or safe, to perform the drop-cover-hold action. Trends in the data indicate that more females though it possible to drop-cover-hold (62.2% female, 53.0% male), however slightly less females than males thought it was actually safe to drop-cover-hold (51.4% female, 54.5% male).

In the Sendai sample, gender did not show any significant relationships with respondents' attitudes to whether it was possible or safe to drop-cover-hold. However, trends in the data indicate that more females thought it possible to drop-cover-hold than males (50.0% female, 40.4% male). Similarly, more females than males also thought it safe to drop-cover-hold (48.1% to 40.4%). This is consistent with the finding above that more females than males actually performed drop-cover-hold or sought shelter under a table.

A large proportion of both genders were unsure whether it would have been safe to drop-cover-hold, with no difference between females (42.2%) and males (42.5%).

Gender and providing or receiving assistance

Gender was explored as a possible factor in whether assistance was provided or received during the earthquake.

The Christchurch sample showed no significant relationship, using Fisher's exact test, for providing assistance during the earthquake, with only slightly more females (40.5%) having provided assistance than males (37.9%). However, a significant relationship was found between gender and receiving assistance during the earthquake ($p = 0.008$), with 23.0% of females saying they received assistance but only 6.1% of males.

In Sendai the results are similar to Christchurch, with no significant relationship being found between the provision of assistance and gender, although more females (18.8%) provided assistance than males (14.4%).

A significant relationship was also found between gender and receiving assistance (p = 0.032), with 7.8% of females receiving assistance, and only 2.1% of males.

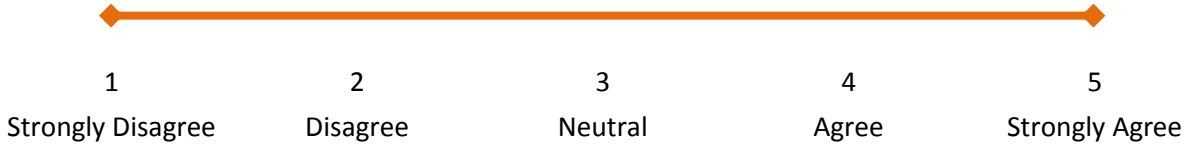
In both Christchurch and Sendai there was no gender difference in providing assistance, but females were more likely to report having received assistance. A speculative explanation is that males may be more reluctant to report having received assistance, although this is not proven by this data.

In summary, females were found to be likely to seek shelter, protect others, or receive assistance during an earthquake. Males do not exhibit a clear bias in gender-based behaviour, although there is a greater tendency for them to exit a building during shaking.

5.3.3. Effect of feelings on actions taken

In order to provide a more complete overview of the relationship between people, preparedness advice and actions taken, the surveys included questions about feelings or emotions. This was to explore how people think and feel in times of sudden stress and how this might affect their behaviour.

Of particular interest to this study are the effects of fear and anxiety on the actions taken during the earthquake. Respondents were asked to rank their response to a particular feeling on a 5-point Likert scale:



The Christchurch sample showed no significant relationships between anxiety and actions taken during the earthquake, using the Mann-Whitney U test. There was a weak association between feeling anxious and sheltering under a table (Md = 4, n = 26), and not sheltering (Md = 4, n = 63), (U = 648, z = -1.369, p = 0.100, r = -0.145).

Respondents who agreed or strongly agreed with the statement ‘I felt anxious’ were nearly five times more likely to get under a table (36.9%) than those who were either neutral, disagreed or strongly disagreed (8.3%). In the same way, this anxious-group was more likely to shelter under a doorway (36.1%) or go outside (45.0%), when compared with those who felt less anxious (26.1% and 20.8% respectively).

In Sendai there were no significant relationships using the Mann-Whitney U test between levels of anxiety and actions taken during the earthquake. Frequencies were similar across all levels of anxiety for people doing drop-cover-hold, going outside, or staying in place during the earthquake.

Levels of fear in Christchurch showed no significant relationship using the Mann-Whitney U test with actions taken during the earthquake. However, there was a weak association with being fearful and sheltering under a table (Md = 4, n = 26) and not sheltering (Md = 4, n = 64), (U = 631, z = -1.881, p = 0.060, r = -0.198).

Respondents who agreed or strongly agreed with the statement 'I felt fearful' were more than twice as likely to get under a table (36.2%) than those who were either neutral, disagreed or strongly disagreed (15.6%). The fearful-group was more likely to shelter under a doorway (37.7%) or go outside (40.0%), when compared with those who felt less anxious (25.0% and 34.3% respectively).

Levels of fear in Sendai showed no significant relationships with actions taken during the earthquake, using the Mann-Whitney U test. There was a weak association between feeling fearful and staying in place (Md = 4, n = 224), and not staying (Md = 5, n = 76), (U = 7371.5, z = -1.869, p = 0.062, r = -0.108). As with anxiety, frequencies were similar across all levels of fear for people doing drop-cover-hold, going outside, or staying in place during the earthquake.

These findings suggest that both anxiety and fear have a limited effect on the actions taken. Respondents in Christchurch who expressed greater fear and anxiety, appeared to take more sheltering actions than those in Sendai, and this may in part have been due to the earthquake activity in Christchurch during the preceding six months.

Fears during the earthquake

The survey also asked, 'what were your greatest fears during the earthquake?', and aimed to explore how people's specific fears might affect the actions they were prepared to take.

In Christchurch no significant relationships were found between fear of 'building collapse' and actions taken during the earthquake, using Fisher's exact test. However, those fearful of 'building collapse' were more likely to go outside (43.6%) than those who did not share this fear (32.6%). The fear of 'being trapped' showed a significant relationship with sheltering under a table (p = 0.039) with 39.5% of those seeking shelter under a table, compared with 19.1% of those who said they were not fearful. Those fearful of 'being trapped' also showed a weak association (p = 0.092) with performing drop-cover-hold more frequently (13.9%) as opposed to those who did not express this fear (2.4%). However, contrary to what night be expected, the fear of being trapped did not appear to influence the action of going outside.

In Sendai no significant relationships were found between a fear of 'building collapse' and actions taken during the earthquake. Trends in the data indicate that fear of 'building collapse' neither increases or decreases the likelihood of a particular action being taken, with near equal frequencies across the actions.

Also, in Sendai the fear of 'being trapped' showed a significant relationship with doing drop-cover-hold (p = 0.045) using Fisher's exact test, with 49.2% of those who feared entrapment performing this action, compared to 35.3% of those who did not express this fear. 'Staying in place' also showed a significant relationship with the fear of being trapped (p = 0.037), with 84.6% of those who were fearful 'staying in place', compared with 71.9% of those without fear. Contrary to what one might expect from these figures, those who said they were afraid of being trapped were less likely to 'go outside' (14.0%) than those who did not express the fear (25.2%).

These results are interesting as they appear to show the opposite of what might be expected where fears of building collapse and entrapment do not appear to motivate people to attempt to escape a building. One possible effect is that increased levels of fear has an immobilising effect on individuals, something that is associated with the fight and flight response, discussed in the next chapter.

5.4. Influences of preparedness advice on actions taken

Of significant interest for this research, when it comes to determining the influences upon actions taken during earthquakes, is whether preparedness advice shapes people's behaviour. Does official guidance have an effect, and if so, in what way? It might be assumed that telling people what to do during an earthquake is an effective way of saving lives, but without evidence, this would be an unwise assumption given how taking the right action may be a life-or-death decision.

This research, therefore, considered whether an awareness of earthquake preparedness advice had an effect on actions taken and five potential areas of influence were considered, namely:

- Does awareness of official advice in general influence protective actions taken?
- Does participation in exercises or drills influence protective actions?
- What actions are taken by people who are aware of the 'drop-cover-hold' procedure?
- Do those who are aware of drop-cover-hold believe that it is effective in terms of being a) possible and b) safe to perform during an earthquake?
- Does awareness of official advice influence the frequency with which people provide assistance to others?

5.4.1. Awareness of official advice and actions taken

The percentage of respondents from the 'aware' of preparedness advice and 'unaware' groups is summarised for various actions in the tables below followed by some observations about this data.

Overall, there was only a single significant relationship between being aware of advice and the actions that were performed during the earthquakes. This was from the Sendai sample and was between awareness of

official guidance and sheltering under a table (p = 0.049). However, contrary to what might be expected, this was an inverse relationship, with those in the 'aware' group being less likely to seek shelter. Such a relationship is the opposite of the intention of the guidance provided, which aims to encourage people to take shelter.

The Christchurch sample showed no significant relationships between awareness of official advice and actions taken, and in general less than half of respondents reported taking any kind of directly protective action, see Table 5.13 below. -

	'Aware' of official advice		**'Unaware' of official advice**	
Action Taken	%	n	%	n
Drop-cover-hold	9.5	6	0.0	0
Sheltered under a table	28.4	21	31.3	5
Stood in a doorway	34.3	24	26.7	4
Go outside	40.0	28	26.7	4
Stayed in place	52.1	38	66.7	12
Personal items	13.6	8	14.3	2

Table 5.13. Christchurch: Actions taken by those who were aware and unaware of official advice

These figures for drop-cover-hold might suggest that guidance is at best having only a small effect on this behaviour, but even this is unclear. Not only were the differences between aware and unaware groups not statistically significant, but it is also possible that those who are unaware, for example, of the term 'drop-cover-hold' are using different terminology with which to describe similar actions.

A trend in Christchurch that may also be of concern was that more respondents in the 'aware' group chose to go outside during the earthquake (40%) than those in the unaware group (26.7%). Unfortunately, from a risk management perspective, this is not only counter-intuitive, but contrary to the advice in both New Zealand and Japan.

Again, with the Sendai data, see Table 5.14, apart from the significant inverse relationship between awareness of advice and sheltering under a table, there is little sign of awareness having an effect on what people do. Some difference was observed between aware (15.1%) and unaware (20.4%) groups for standing in a doorway.

Overall, these findings appear to suggest that awareness of official earthquake advice has a limited effect on protective actions taken during an earthquake. Recommended actions were not frequently performed by respondents, and some actions were taken that were not actually endorsed in the advice, such as standing in a doorway.

	'Aware' of official advice		'Unaware' of official advice	
Action Taken	%	n	%	n
Drop-cover-hold	35.3	36	39.9	79
Sheltered under a table	13.7	14	23.7	47
Stood in a doorway	15.1	13	20.4	37
Go outside	24.4	21	22.1	40
Stayed in place	78.4	80	72.7	144
Personal items	22.5	23	15.2	30

Table 5.14. Sendai: Actions taken by those who were aware and unaware of official advice

A further possible explanation for these apparently counter-intuitive findings may be that people are unable to recall where their knowledge of earthquake advice has come from, and cannot distinguish between what are 'official' and 'unofficial' sources. This may be of concern given that there may be a large amount of, sometimes contradictory or outdated, information available to members of the public from other sources, such as social media and hearsay. This problem is discussed further in chapter seven.

5.4.2. Preparedness exercises and actions taken

Exercises and drills are specific forms of earthquake preparedness advice characterised by active participation in, and practice of, the recommended actions. It is of interest, therefore, to consider whether previously having undertaken this type of training had any effect on the frequency of actions taken during an actual earthquake over and above that caused by awareness advice in general.

The Christchurch results are summarized in Table 5.15 below but no significant relationships were found between experience of exercises or drills and actions taken during the earthquake. Nonetheless, some trends within the data can be seen, for example, fewer of those who had done exercises went outside when compared to those who had not.

	Undertaken exercises or drills		Not undertaken exercises or drills	
Action Taken	%	n	%	n
Drop-cover-hold	11.4	4	4.8	2
Shelter under a table	30.8	12	27.5	14
Stood in a doorway	32.4	12	33.3	16
Go outside	29.7	11	43.8	21
Stayed in place	51.4	19	57.4	31
Personal items	12.1	4	15.0	6

Table 5.15. Christchurch: Actions taken by those with prior experience of practical exercises or drills

These figures suggest that exercises may be having more impact on behaviour than advice on its own, and in the direction that would be desired. Again, however, this is not supported by a statistically significant difference in the number of people performing these actions.

For Sendai, previous participation in exercises showed a significant relationship, using Fisher's exact test, with doing drop-cover-hold during the earthquake (p = 0.006) and this supports the suggestion that doing exercises or drills as part of preparedness activities can influence the actions taken during an earthquake. Of those who had done exercises, 76.5% also did drop-cover-hold, compared to 61.1% of those who had not done exercises, see Table 5.16.

	Undertaken exercises or drills		Not undertaken exercises or drills	
Action Taken	%	n	%	n
Drop-cover-hold	76.5	88	61.1	113
Shelter under a table	22.4	45	16.2	16
Stood in a doorway	18.2	32	19.8	18
Go outside	20.5	36	27.5	25
Stayed in place	76.6	154	70.7	70
Personal items	17.9	36	17.2	17
Avoid objects	24.4	49	34.3	34

Table 5.16. Sendai: Actions taken by those with prior experience of practical exercises or drills

No other actions in the Sendai sample showed a significant relationship with participation in exercises. However, the action sheltering under a table was performed by 22.4% of those who had done exercises, compared with 16.2% of those who had not. A weak association (p = 0.076) was seen with those who had not done an exercise being more likely to have to avoid objects (34.3%) than those who had done an exercise (24.4%).

5.4.3. Awareness of drop-cover-hold and actions taken

Another line of enquiry regarding the relationship between personal knowledge and actions taken was to look at whether awareness of the drop-cover-hold action had an effect on other actions that people take during an earthquake. This question was to check for any unanticipated consequences that learning about drop-cover-hold may have on people's behaviour, for example, does it lead to fewer people leaving a building, or more instances of indecision with people not doing anything at all? As expected, no significant relationships were found between awareness of drop-cover-hold and other actions taken.

However, as has been noted previously, in Christchurch, where 96.5% of respondents said that they were aware of drop-cover-hold, only 8.1% of this group actually did the action during the earthquake, meaning that 91.0% must have chosen to do something else, or nothing at all. Of these others, the majority (54.5%) chose to remain where they were, and 39.0% chose to go outside. See Table 5.17.

Unfortunately, from the perspective of giving advice, these figures suggest that learning about drop-cover-hold as a preparedness action is not, in New Zealand at least, having the effect of encouraging people to take cover when shaking starts. The reason for this somewhat disappointing finding may be due to the

immobilising effect of fear, the impracticality of moving during a strong earthquake or the lack of anywhere convenient to take cover under. These explanations are explored in more depth in chapter 6.

	'Aware' of drop-cover-hold advice		'Unaware' of drop-cover-hold advice
Action Taken	%	n	Owing to the small size of this subset (n=6) – percentages are not included here.
Drop-cover-hold	8.1	6	
Shelter under a table	29.9	26	
Stay in place	54.5	48	
Stood in doorway	34.1	28	
Go outside	39.0	32	
Personal items	14.3	10	

Table 5.17. Christchurch: Actions taken by respondents with awareness of drop-cover-hold

The proportion of respondents in the Sendai sample who took protective actions and were either aware (72.3%) or unaware (27.7%) of drop-cover-hold advice is given in Table 5.18, below:

	'Aware' of drop-cover-hold advice		'Unaware' of drop-cover-hold advice	
Action Taken	%	n	%	n
Drop-cover-hold	40.6	88	32.5	27
Shelter under a table	20.3	44	20.5	17
Stay in place	74.7	162	74.7	62
Stood in doorway	18.2	35	20.0	15
Go outside	20.3	153	29.3	53
Personal items	18.4	40	15.7	13

Table 5.18. Sendai: Actions taken by respondents with awareness of drop-cover-hold

In Sendai, the proportion of those who were aware or unaware of drop-cover-hold and who actually did the action was, in both cases, greater than for Christchurch. The reason for this difference is unclear although one explanation may be the longer duration of the earthquake in Sendai, giving more time for the respondents to take multiple actions. Of interest is the fact that three-quarters of the 'aware' group in Sendai chose to remain where they were (i.e. stay in place) for at least part of the duration of the earthquake, suggesting that in some cases at least, people may have hesitated before performing drop-cover-hold.

Overall, these results lean towards the idea that awareness of drop-cover-hold also encourages people to take that action but, in this study, no significant link could be found.

5.4.4. Awareness of drop-cover-hold and appropriate actions

It is also of interest to look at what those respondents who reported having been aware of 'drop-cover-hold' as an action, actually recommended as the most appropriate action to take in an earthquake after their own

experiences in Christchurch and Sendai. Has having actually survived an earthquake affected how they perceive the value of this guidance?

Findings from Christchurch show that of the 138 (96.5%) people aware of drop-cover-hold, only 34.1% (n=47) recommend the action as appropriate in response to the question 'what would be the best action to take during an earthquake?'. However, other actions were also suggested, and this included nearly a quarter of respondents saying that people should get under items of furniture (24.6%, n=34). The range of actions considered appropriate are show in Table 5.19 below.

	'Aware' of drop-cover-hold advice	
Appropriate action	%	n
Drop-cover-hold	34.1	47
Get under furniture	24.6	34
Get down low next to furniture	7.2	10
Take cover, cover head with hands	4.3	6
Move away from glass, falling objects	16.7	23
Stood in corner / doorway	19.6	27
Stay inside	10.1	14
Go outside	10.1	14

Table 5.19. Christchurch: Appropriate actions suggested by respondents aware of drop-cover-hold

The responses from Sendai are somewhat different. Nearly three quarters (72.3%, n=217) of respondents were aware of drop-cover-hold but only 4.1% (n=9) recommend actually taking this action. However, as with Christchurch, nearly a quarter of respondents (24.4%, n=53) stated that the most appropriate action is to get under furniture, and another 15.7% (n=34) recommended taking cover and covering the head with hands – see Table 5.20.

	'Aware' of drop-cover-hold advice	
Appropriate action	%	n
Drop-cover-hold	4.1	9
Get under furniture	24.4	53
Get down low next to furniture	1.8	4
Take cover, cover head with hands	15.7	34
Move away from glass, falling objects	23.0	50
Stood in corner / doorway	5.5	12
Stay inside	2.8	6
Go outside	11.1	24

Table 5.20. Sendai: Appropriate actions suggested by respondents aware of drop-cover-hold

These findings from the two field studies suggest that of those who are aware of drop-cover-hold, many respondents believe that taking cover in some way is an appropriate action. However, respondents choose

not to use the specific phrase 'drop-cover-hold' when describing what they would recommend people to do. The implications of this mismatch between official advice and peoples' own choice of terms is considered further in chapter 7.

5.4.5. Attitudes towards drop-cover-hold

In order to explore how the efficacy of drop-cover-hold was perceived by respondents, the questionnaire asked whether they believed that it would have been a) possible and b) safe to do this action during the earthquake. The influence of both awareness of advice in general and exercises specifically were considered.

It does appear that, in Christchurch at least, being aware of official guidance increased people's confidence in drop-cover-hold with a significant relationship, using Fisher's exact test, found between an awareness of official guidance and a belief that it was possible to perform the drop-cover-hold action ($p < 0.001$). This was represented by 61.5% of those aware of official guidance believing it was possible to perform drop-cover-hold compared to 38.1% of those who were not aware, see Table 5.21.

	'Aware' of official advice		**'Unaware' of official advice**	
Drop-cover-hold	%	n	%	n
Possible to perform	61.5	75	38.1	8
Safe to perform	57.4	70	23.8	5

Table 5.21. Christchurch: Awareness of official advice and attitudes to drop-cover-hold

A further significant relationship ($p < 0.001$) was found in Christchurch between awareness of official guidance and whether respondents considered it safe to drop-cover-hold, with 57.4% of those aware of the guidance, and 23.8% who were unaware believing that the action was safe to perform.

In Sendai, no significant relationships were found between an awareness of official guidance and whether respondents thought it possible (47.1%), or safe (47.1%), to drop-cover-hold. A related trend in Sendai was that even amongst those who were aware of the advice, a number indicated that they were unsure about the efficacy of the action by selecting 'don't know' with regards the safety (42.2%) of performing the action, see Table 5.22.

	'Aware' of official advice		**'Unaware' of official advice**	
Drop-cover-hold	%	n	%	n
Possible to perform	47.1	48	44.4	88
Safe to perform	47.1	48	42.9	85

Table 5.22. Sendai: Awareness of official advice and attitudes to drop-cover-hold

Of those who had participated in exercises, see Table 5.23, no significant effect was found in Christchurch. Of those that had done exercises, 58.7% thought it was possible to drop-cover-hold, and 57.1% also thought that it was safe to do so. This compares with 57.5% of those who had not done an exercise believing that the action was possible and 48.8% of this group agreeing that it was safe to do so. This suggests that in Christchurch at least, doing exercises does not change people's attitude towards drop-cover-hold.

	Undertaken exercises or drills		**Not undertaken exercises or drills**	
Drop-cover-hold	%	n	%	n
Possible to perform	58.7	37	57.5	46
Safe to perform	57.1	36	48.8	39

Table 5.23. Christchurch: Previous exercise or drill experience and attitudes to drop-cover-hold

By contrast, in Sendai both results showed significant relationships using Fisher's exact test. Of those respondents with exercise experience 52.7% said it was possible to drop-cover-hold compared to those without an exercise (30.3%), ($p < 0.001$), see Table 5.24. This suggest that experience of exercises in Sendai is having a greater influence on attitudes towards drop-cover-hold than in Christchurch. The reason for this difference is unclear.

	Undertaken exercises or drills		**Not undertaken exercises or drills**	
Drop-cover-hold	%	n	%	n
Possible to perform	52.7	106	30.3	30
Safe to perform	50.7	102	31.3	31

Table 5.24. Sendai: Previous exercise or drill experience and attitudes to drop-cover-hold

Similarly, a significant relationship was found in Sendai between having done an exercise previously and believing that it was safe to drop-cover-hold ($p < 0.001$). Of those who had done an exercise 50.7% considered it safe to drop-cover-hold, and of those without exercise experience, only 31.3% considered it safe.

The factors affecting people's confidence in drop-cover-hold appear to be varied with awareness of guidance in general seeming to influence the perceptions of respondents from Christchurch, and experience of exercises being a key influence in Sendai. Further consideration of the issues around 'drop-cover-hold' as a concept are considered in chapter 7.

5.4.6. Providing assistance

This research considered whether providing assistance to someone during the earthquake was affected by either an awareness of advice or having previously done exercises. Neither the New Zealand nor Japanese guidance specifically mention providing assistance to someone during earthquake activity.

Having an awareness of official earthquake advice showed no significant relationship with providing assistance during the earthquake in either city.

In Christchurch, awareness of guidance led to fewer people (38.5%) providing assistance than for those who were unaware (42.9%). Conversely, slightly more of the aware group (19.6%), compared to the unaware group (15.2%), provided assistance in Sendai, see Table 5.25 and Table 5.26.

Assistance	**'Aware' of guidance**		**'Unaware' of guidance**	
	%	n	%	n
Provided assistance	38.5	47	42.9	9

Table 5.25. Christchurch: Awareness of official advice and providing assistance

Assistance	**'Aware of guidance**		**'Unaware' of guidance**	
	%	n	%	n
Provided assistance	19.6	20	15.2	30

Table 5.26. Sendai: Awareness of official advice and providing assistance

In Christchurch of those respondents who had previously done preparedness exercises 41.3% had provided assistance during the earthquake as opposed to 37.5% of those without this experience. In Sendai undertaking earthquake exercises and providing assistance during the earthquake was reported by 18.9% of respondents, see Table 5.27 and Table 5.28.

	Undertaken exercises		**Not undertaken exercises**	
	%	n	%	n
Provided assistance	41.3	26	37.5	30

Table 5.27. Christchurch: Providing assistance with experience of exercises

	Undertaken exercises		**Not undertaken exercises**	
	%	n	%	n
Provided assistance	18.9	38	12.1	12

Table 5.28. Sendai: Providing assistance with experience of exercises

Taking the influence of preparedness advice and exercises as a whole, a clear picture of how these factors affect people's behaviour is not provided by the data. One of the themes that is emerging from this data is that there are numerous influences on behaviour that makes a simple understanding of what people will do and why they do it, illusive. This complexity, and its implications, are considered further in chapter 7.

5.5. Preparedness activities and the effects of age and gender

This research also considered whether there were any effects of age and gender on the three preparedness activities that focus on protective actions – preparedness exercises, awareness of drop-cover-hold, and awareness of earthquake advice.

Of the three activities in the Christchurch sample, there was a significant relationship using Fisher's exact test, between age group and having previously undertaken exercises, with twice the number of 20-39 year group undertaking exercises than the elder group, 60-99 years (p = 0.033).

No significant relationship existed between age group and either awareness of guidance or awareness of drop-cover-hold using Fisher's exact test. However, high levels of awareness existed across all age groups for both activities, with the lowest level of awareness being for the 20-39 age group where only 77.8% were aware of official guidance, this despite their greater participation in exercises. Awareness of drop-cover-hold was high across all age groups, with more than 90% awareness, and 100% of the older age group were aware of the action.

Amongst the Sendai respondents there was a significant relationship between age group and an awareness of drop-cover-hold, with the 60-99 year group (79.6%) more aware than the younger 20-39 year group (59.2%) (p = 0.019). For preparedness exercises, there was a weak association (p = 0.071) with the older group, 60-99 years, who were less likely to have previously done an exercise. This is similar to that found in Christchurch. Awareness of guidance in general showed no relationship with age.

When considering any effects from gender on the three preparedness activities for the Christchurch respondents, no significant relationships were found using Fisher's exact test. The same proportion of females (43.2%) and males (43.9%) had undertaken exercises. Slightly more females (87.8% to 83.3%) were aware of official guidance, and slightly more males (97.0% to 95.9%) were aware of the drop-cover-hold action.

Similarly, for respondents in Sendai when considering gender and the three preparedness activities, (exercises or drills, awareness of drop-cover-hold, and awareness of earthquake advice), no significant relationships were found using Fisher's exact test. For each of these activities, there was little difference in frequency between genders, suggesting that this has no effect on participation in exercises or drills, an awareness of drop-cover-hold, and awareness of earthquake advice.

5.6. Outcomes from protective actions

While the main focus of this research has been to explore the relationship between advice received and actions taken, a logical next step is to consider the consequences of those actions. The two field studies took the opportunity of asking respondents about the outcomes of the actions they took during the earthquake.

This section, therefore, reports on some of the issues arising from taking protective actions, and includes a) whether the person was struck by any objects during shaking, b) any injuries sustained during the earthquake, c) self-described actions to take if a person is trapped, and d) reasons for survival.

5.6.1. Struck by objects

This research found that 14.9% (n=21) of Christchurch respondents and 11.3% (n=34) of those from Sendai reported having been struck by an object during the earthquake. No statistical relationship was found between age, gender, previous exercises, awareness of drop-cover-hold, or awareness of earthquake advice, and the likelihood of being struck by objects. This suggests the chance of being struck is a random event, at least in terms of these variables. Table 5.29 shows the observed frequencies of these variables against being struck by objects.

However, in terms of frequency, younger people in Christchurch and Sendai reported being struck by objects more frequently than older people. As these earthquakes occurred during the daytime, it would be interesting to explore whether this is caused by different work environments across age groups, e.g. more people working in blue-collar roles where there may be a higher number of hazards.

For gender, females in Christchurch reported being struck at a greater frequency than males, however in Sendai it is the opposite, with more males reporting being struck. This is shown in Table 5.29 below.

	Christchurch		**Sendai**	
	Yes - Struck	No	Yes - Struck	No
	n (%)	n (%)	n (%)	n (%)
Age group				
20-39	7 (19.4%)	29 (80.6%)	12 (16.9%)	59 (83.1%)
40-59	13 (17.1%)	63 (82.9%)	18 (10.0%)	162 (90.0%)
60+	1 (4.3%)	22 (95.7%)	4 (8.2%)	45 (91.8%)
Gender				
Male	8 (12.7%)	55 (87.3%)	20 (13.7%)	126 (86.3%)
Female	13 (17.6%)	61 (82.4%)	14 (9.1%)	140 (90.9%)
Aware official advice				
Yes	21 (17.5%)	99 (82.5%)	12 (11.8%)	90 (88.2%)

No	0 (0.0%)	20 (100.0%)	22 (11.1%)	176 (88.9%)
Aware of drop-cover-hold				
Yes	20 (14.8%)	115 (85.2%)	26 (12.0%)	191 (88.0%)
No	1 (20.0%)	4 (80.0%)	8 (9.6%)	75 (90.4%)
Exercises / drills				
Yes	10 (47.6%)	52 (52.4%)	27 (13.4%)	174 (86.6%)
No	11 (43.7%)	67 (56.3%)	7 (7.1%)	92 (92.9%)

Table 5.29. Respondents struck by items during the earthquake

It might be expected that having an awareness of these protective measures (experience of earthquake exercises, awareness of drop-cover-hold, and official earthquake advice), would show a reduction in being struck by objects. However, this is not indicated by the findings where a knowledge of these activities showed a higher frequency of being struck by objects. This raises the question as to whether the movement required of people attempting to perform drop-cover-hold, for example, is actually exposing them to more risk.

5.6.2. Injuries received during earthquake activity

Being struck by objects or debris is one way that people can become injured during an earthquake. This section describes the findings relating to injury type, cause and location. The number of injured respondents in both Christchurch and Sendai samples was small, meaning that inferences should be treated with caution. Nonetheless, the results relating to injuries are included here for completeness.

Christchurch

Only ten (7.0%) respondents reported injuries, of these eight were injured during the earthquake, and nine were injured inside a building. The main types of injury sustained during the earthquake were bruising to three respondents, strains or sprains for two others, and one laceration. Non-specified injuries were reported by one respondent.

The actions being taken at the time of injury included evacuating a building, drop-cover-hold, and 'protecting themselves', each reported by two respondents. The remaining four injured respondents did not specify an activity. The reported causes of the injuries included falling objects to two respondents, debris and glass to one, slipped or tripped to four, and 'other causes' accounted for three respondents. All the injuries were described as minor and the respondents were all still able to walk. Of those injured, nine respondents either self-treated their injuries or sought no medical assistance at all.

Sendai

A small number of injuries were reported by the Sendai sample (5.0%, n=15). Of those injured, seven reported that the injury occurred during the earthquake, and four stated that it occurred afterwards. A

further three said they were injured in an aftershock. Injury occurred inside a building in all but one of the 15 cases.

The most common injury sites were the legs and feet (n=10), and arms and hands (n = 8). The most frequently reported injuries were minor lacerations and abrasions. Injury severity was reported as minor, walking but injured (n=14), and moderate for those unable to walk but still conscious, (n=1). No one was seriously injured. Most respondents (n=11) reported they were in a room in a building when they were injured, and one was on the stairs in a building. The remainder were either outside (n=1), or in 'another location' (n=2).

Three respondents listed the actions being taken at the time of injury as either evacuating a building, doing drop-cover-hold, or protecting themselves. A further respondent was injured protecting property, and five others were undertaking actions not specified. As with Christchurch, the most frequent causes of injury were falling objects (n=6) and slips and trips (n=6). Debris and glass were responsible for three injuries, and both falling masonry and dust were each responsible for causing one injury.

Two respondents in Sendai reported being trapped following the earthquake, and both reported being rescued by bystanders. Each received medical assistance, one at hospital, the other at a first aid post.

Age group and injury

In Christchurch, younger respondents were more frequently injured than older age groups. Similarly, in Sendai it was predominantly younger people who were injured, and this group was also most likely to suffer injury while leaving a building, while the middle age group was most likely to be injured while 'protecting themselves' (33.3%) or doing drop-cover-hold (16.7%). Possible explanations and implications of this age difference are discussed in the next chapter.

Gender and injury

In Christchurch more females (n=8) than males (n=2) reported being injured. Of the females half reported being injured while seeking protection (n=4), whereas, no males reported being injured in this way.

In Sendai eight males were injured and seven females. There was little difference between genders for the actions being taken at the time of injury. Slightly more females (n=5) reported being injured than males (n=3), seeking protection, and this is a similar to that from Christchurch.

Preparedness exercises and injury

In the Christchurch sample, respondents were more likely to be injured if they had done preparedness exercises (n=6) than if they had not done so (n=4). However as mentioned above, the sample sizes are too small to draw conclusions from this.

In Sendai, no difference was shown between those who had undertaken preparedness exercises and the probability of injury. However, of those who were injured and had done exercises, six out of ten were injured undertaking the protective actions of drop-cover-hold or 'protecting oneself'.

5.6.3. Actions to take if trapped

Within the Christchurch sample, no one reported being trapped as a result of the earthquake, while in Sendai two (0.7%) people reported being trapped and then rescued with help from bystanders. As part of this research, all respondents were asked to describe what they thought would be appropriate actions to take if trapped by debris during an earthquake.

In Christchurch, shout for help (44.4%, n=64) was the most frequently suggested action, closely followed by using a mobile phone (35.4%, n=51), and keep calm (27.1%, n=39). Other less frequently mentioned actions included assessing the situation and making an escape plan (18.8%, n=22). In Sendai, the most frequent action described by respondents was shouting or calling for help (42.7%, n=128). Lying still and waiting for help were also suggested as actions (16.7%, n=50 and 15.7%, n=47 respectively). Use of the mobile phone was lower than in Christchurch at only 8.3% (n=25). The frequency of actions recommended by respondents is shown in Figure 5.14. The implications of these actions are discussed further in chapter 6.

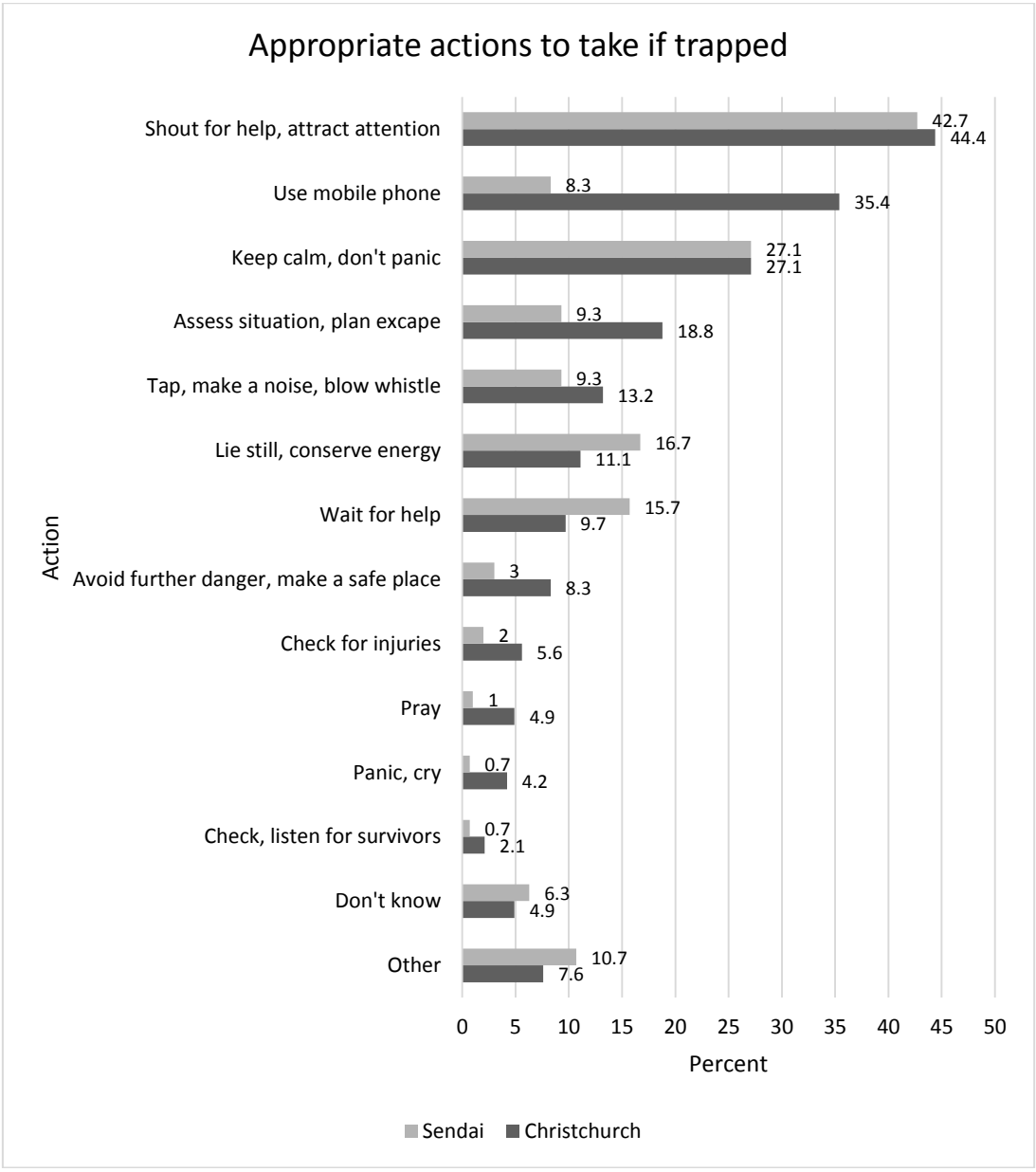


Figure 5.14. Appropriate actions to take if trapped by debris during an earthquake (%)

5.6.4. Reasons attributed to survival

Respondents were also asked why they thought they survived the earthquake. Most responses had some connection with the buildings (see Figure 5.15). Respondents in Christchurch mentioned building strength (60.8%, n=62), and not being near or in a building (11.8%, n=12). Reasons for survival that relate to protective actions taken during the earthquake (stayed inside, drop-cover-hold, and took shelter) were given by just five (4.9%) of the Christchurch sample.

In Sendai 68.0% (n=204) stated that building strength was an important factor. Remaining indoors (24.0%, n=72) and doing the drop-over-hold action (22.3%, n=67) were also frequently mentioned. Considerably more respondents in Sendai felt that protective actions contributed to their survival (54.0%, n=162), when compared to Christchurch (4.9%).

What is clear is that people consider building strength to be the primary factor in their survival, rather than any actions they may take. This may reflect building standards in New Zealand and Japan, and may have implications for people's attitudes to preparedness advice. This is discussed further in chapter 6.

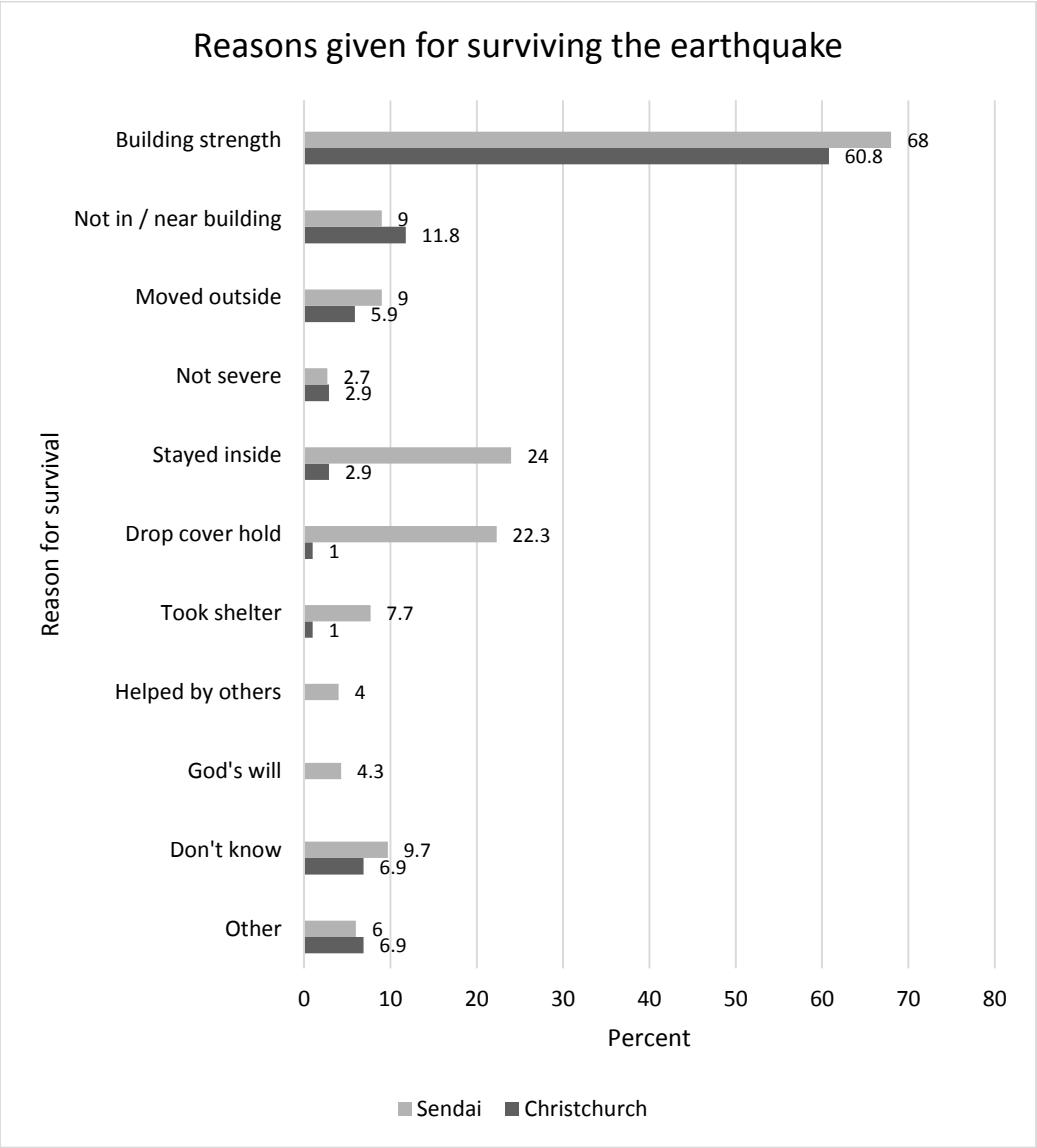


Figure 5.15. Reasons given for surviving the earthquake

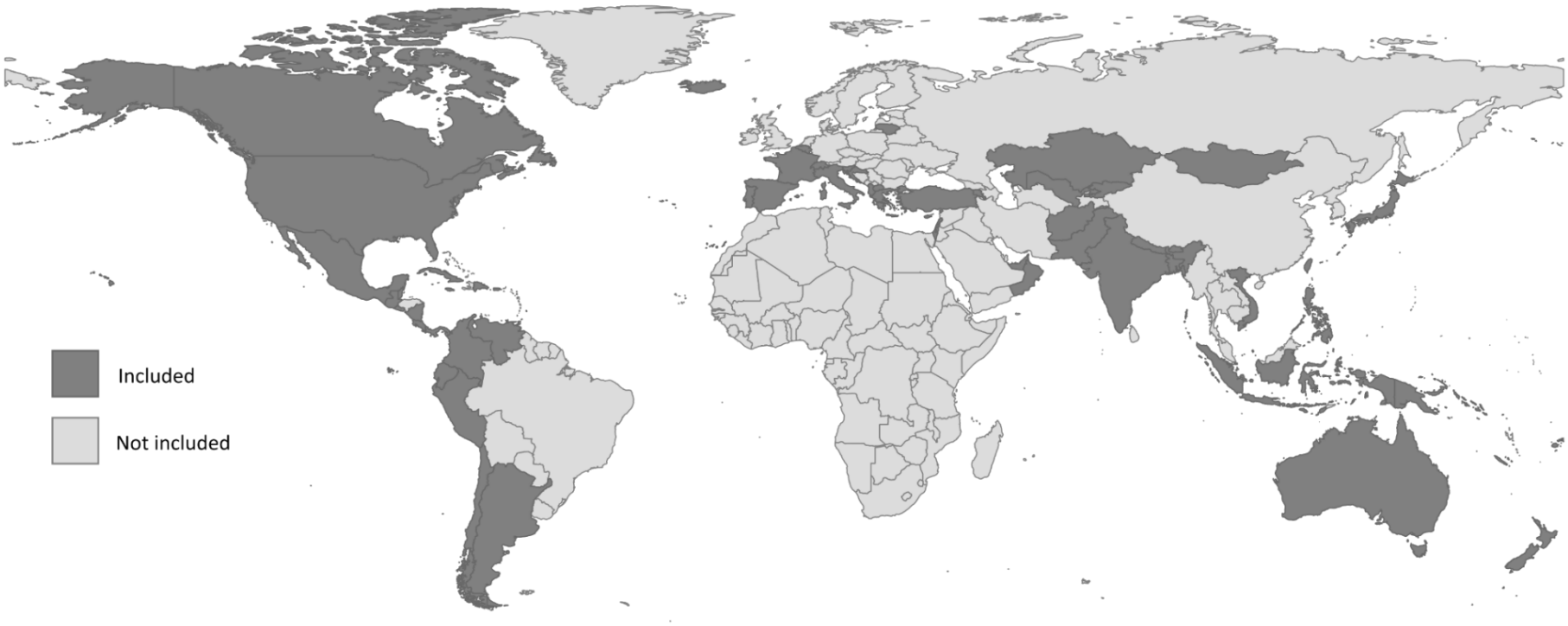
5.7. National earthquake preparedness advice

In addition to the surveys undertaken for the two field studies, a third part of this research has been to examine publicly available earthquake preparedness advice more generally, i.e., from a number of different countries and territories around the world. In particular, this aspect of the research looked at the advice given to protect oneself during actual shaking. This was done in part to see if the findings from the field studies could inform the provision of preparedness advice more generally, which is discussed in chapter seven.

This section describes the results from the content analysis of these online documents, and includes, for greater clarity, examples of actual text. The example text is uncorrected for grammatical errors, if any were present.

5.7.1. Countries included in the analysis

The web-based review of earthquake preparedness advice identified a total of 74 countries and territories for inclusion in the study, according to the criteria described in the previous chapter on methodology. Of these countries, seven were excluded owing to broken hyperlinks that prevented the information being accessed, even after additional online searching. In total, therefore, 67 countries with relevant and accessible information were included in the final sample, shown in Figure 5.16 below. A list of the countries sampled, the date when documents were accessed, and the relevant URL can be found in Appendix 7.0.



Afghanistan	Belize	Dominican Rep	Israel	Mexico	Papua New Guinea	Trinidad Tobago
Albania	Bhutan	Ecuador	Italy	Mongolia	Peru	Turkey
Antigua Barbuda	Canada	El Salvador	Jamaica	Nepal	Philippines	U.A.E.
Argentina	Cayman Islands	Fiji	Japan	New Caledonia	Portugal	U.S.A.
Armenia	Chile	France	Kazakhstan	New Zealand	Puerto Rico	Uzbekistan
Australia	Colombia	Greece	Kyrgyzstan	Nicaragua	Slovenia	Venezuela
Azores	Costa Rica	Guatemala	Lebanon	Oman	Solomon Islands	Vietnam
Bangladesh	Croatia	Iceland	Lithuania	Pakistan	Spain	
Barbados	Cuba	India	Macedonia	Palestine	Switzerland	
Belgium	Cyprus	Indonesia	Madeira	Panama	Taiwan	

Figure 5.16. Countries and territories included in the document analysis

The 67 countries included in the study had national earthquake preparedness advice documents that were analysed for content across the eight categories described in the previous chapter, namely:

- The format of the information
- Whether reference is made to emotions
- Advice specific to indoor situations
    - General
    - Protective
- Advice specific to outdoor situations
    - General
    - Protective
- Advice on hazard reduction
- Advice for specific situations
- Advice for groups in the community
- Advice relating to entrapment

As part of the analysis process the categories relating to indoor and outdoor situations, are further divided into general and protective advice. General advice includes instructions which do not directly advise active protective measures, an example being to avoid falling debris. Protective advice, therefore, refers to those actions which advocate active protective measures, such as drop-cover-hold.

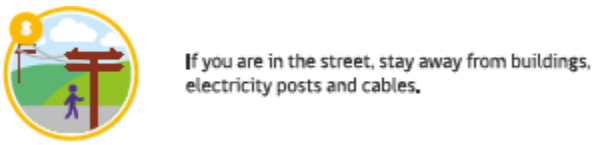
5.7.2. The format of the information

This category focuses on the layout and format of the advice and whether the document contained the following three sections with headings, or similar, to those below:

- what to do before an earthquake
- what to do during an earthquake
- what to do after an earthquake

Of the 67 countries included in the analysis, 89.6% (n=60) produced earthquake preparedness and response advice in this format. This implies that there is general acceptance amongst those involved in disaster management that actions to take during shaking, the focus of this research, can be considered distinct from either preparations made before, or actions to take after, the earthquake. The remaining countries did not follow this structure, meaning their advice was either in one continuous block of text or collated under a single heading.

Pictures were included by 24 countries (35.8%), and assisted with explaining some or all of the actions described in the advice. Examples of pictures relevant to the advice are shown below in Figure 5.17



(Chile)

(Philippines)

Figure 5.17. Pictures and advice in documents from Chile and the Philippines

It is interesting that less than half of countries included pictures in their advice given current knowledge about how people learn and absorb information. This is considered further in a later chapter.

5.7.3. Reference to emotions

Emotional advice relating to taking protective actions was categorised as either being positive, where the person was directed towards a desired mental state, by using the phrase 'stay calm', or negative, by advising against certain feelings, such as 'don't panic'.

The positive advice 'stay calm' was used more than twice as frequently (43.3%, n=29) than the negative advice, 'don't panic', (20.9%, n=14). The use of both types of phrase together occurred in only 10.4% (n=7) of countries, and many countries provided no emotional advice at all (40.3%, n=27). There is some evidence that positive advice can be more effective than negative language, such as 'don't do this', and this is discussed further in chapter 7.

A small group of countries (5.9%, n=4) included references that could be categorised as either positive or negative, as shown by examples from the Dominican Republic and Kazakhstan.

'…master your nerves and fears. Thinking clearly is the most important thing at the moment.'

(Dominican Republic)

'The most important thing is to try to calm fears. … Should not be chaotic actions, because there is a fear here.'

(Kazakhstan)

5.7.4. Actions to take inside a building – general

At least one general action to take when inside a building during an earthquake was included by 95.5% (n=64) of countries. The most frequent action was to avoid glass or loose and falling objects, mentioned by 71.6% (n=48) of countries. Typical advice found in the documents is similar to that shown below from Costa Rica and Iceland.

'Keep away from windows, mirrors, and glass items that may crack.'
(Costa Rica)

'Those who are indoors when a large earthquake occurs should especially avoid.... objects that may fall from shelves and cabinets (especially in kitchens).'
(Iceland)

Figure 5.18 shows the range and frequency of general indoor advice found in the documents.

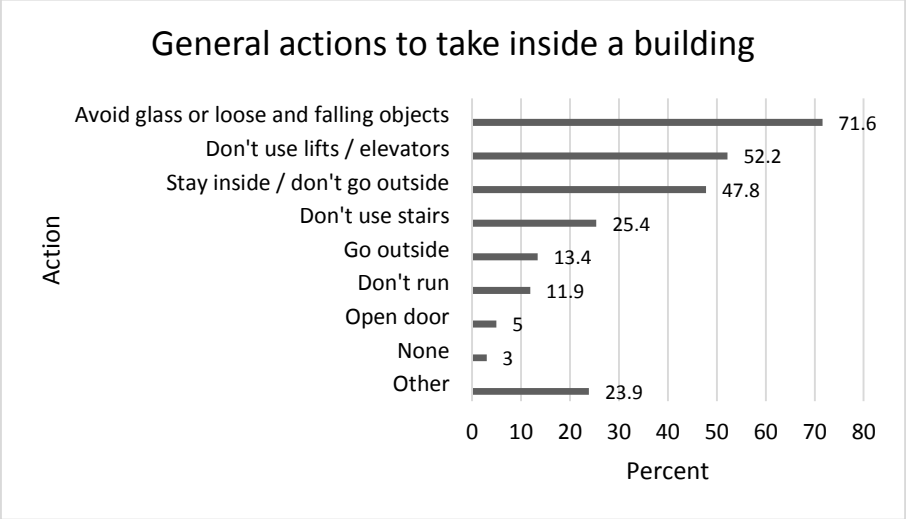


Figure 5.18. General actions to take inside a building

Guidance to avoid using lifts or elevators was included by 52.2% (n=35) of countries, and in many cases was also linked to avoiding the use of stairs (25.4%, n=17), as the examples below from Albania and Italy show.

'It is best to avoid using the elevator. May be blocked or damaged'
(Albania)

'Pay attention to the stairs: in general they are not very resistant and can be damaged.'
(Italy)

Nearly half the countries (47.8%, n=32) recommended people to stay indoors and not to go outside during the shaking, as the advice below from Dominican Republic and Indonesia shows.

'If….inside a building, stay there, do not go out'
(Dominican Republic)

'Stay inside a room until the shaking stops, and go out when it is safe.'

(Indonesia)

However, 13.4% (n=9) of countries did advise people to go outside during an earthquake.

Nearly a quarter of countries provided advice that was unique to their general guidance (23.9%, n=16). This included advice specific to the society, but also some more unusual actions, such as that provided by Lithuania below.

'Do not jump through a window if you are above the ground floor. Do not jump through closed windows! If the need arises, knock out the glass with a stool or other object, or in an extreme situation use your back.'

(Lithuania)

'Move to ….previously identified internal security zones'

(Peru)

'If you are indoors when an earthquake strikes, quickly go to a safe place….Go to the reinforced security room (mamad). Leave the mamad door open.'

(Israel)

5.7.5. Actions to take inside a building – protective

Protective actions to take inside a building were included in the advice by all but one country (98.5%, n=66) in the study. The most frequently included action was to seek shelter under solid furniture, advised by 68.7% (n=46) of countries. Frequency of different types of advice is given in Figure 5.19 below.

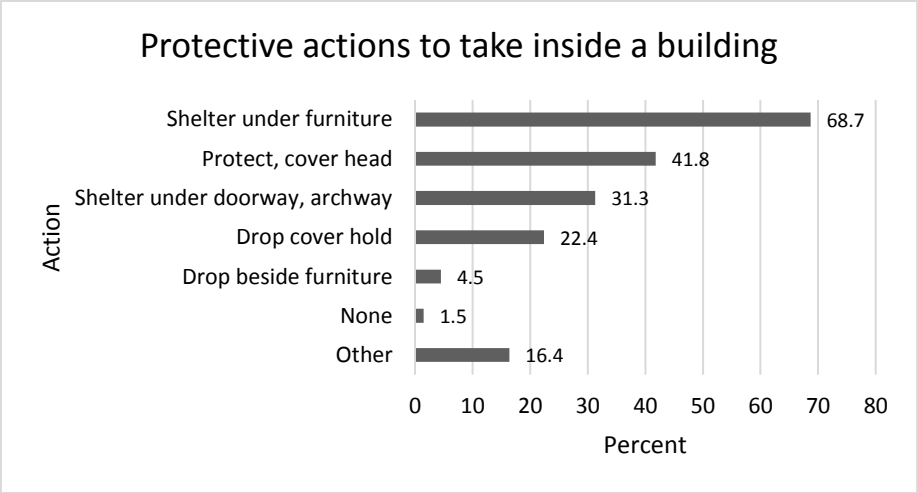


Figure 5.19. Protective actions to take inside a building

Text typical of this advice is shown below by examples from Trinidad and Tobago, Palestine and Nepal.

'Get under a sturdy desk, table or bed, protect head and eyes and hold on to the desk / table.'

(Trinidad and Tobago)

'…under one of the tables or under the bed to guarantee you protection from falling objects…'

(Palestine)

'Take shelter (if it is close) under strong furniture (tables, beds) close to walls under door frame.'

(Nepal)

Advice to protect or cover the head was included by 41.8% (n=28) countries.

'Cover your head with both hands, placing it between your knees or in the fetal position, covering your head.'

(Argentina)

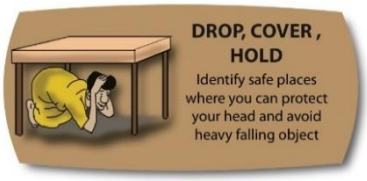
'Become a "ball", hugging yourself in a corner; If possible, protect the head with a cushion or blanket.'

(Mexico)

Separately to protecting the head, drop-cover-hold was advised by 22.4% of countries (n=15).

'Ducking under a table, covering the head and holding onto a table leg'.

(Iceland)



'Drop, cover, hold. Identify safe places where you can protect your head and avoid heavy falling objects.'

(Solomon Islands)

Advice to seek shelter under an archway or doorway was included by 31.3 % (n=21) of countries, as shown by examples from India and New Caledonia.

'Use a doorway for shelter only if it is in close proximity to you and if you know it is a strongly supported, load bearing doorway.

(India)

'Shelter and protect your head… along a carrying column, in the passage of a door'

(New Caledonia)

The action drop beside furniture was only mentioned by 4.5% (n=3) of countries. In Chile, this was mentioned in conjunction with the more frequently included advice to seek cover. No country in this study recommended undertaking the triangle of life action.

Protect yourself and get underneath a solid element. If this is not possible, place yourself next to such an element.

'Protect yourself and get underneath a solid element. If this is not possible, place yourself next to such an element.'

(Chile)

Some countries (16.4%, n=11) included advice that was not found elsewhere, i.e. unique to a single country. Examples of these actions include:

'If you cannot shelter under furniture, move against an interior wall if you are indoors...'

(Cayman Islands)

'Try to go to the kitchen or bathroom: the furniture is firmly anchored and you will find water that can help you survive in case of destruction.'

(Belgium)

5.7.6. Actions to take outside a building – general

General actions recommended by authorities that apply when a person is outside a building frequently mentioned two pieces of advice, namely a) to keep clear of buildings and tall structures (77.6%, n=52), and b) to keep clear of powerlines (76.1%, n=51). The examples below are indicative of much of the advice covered by these two categories.

'Move to open area cautiously away from power lines, poles, trees, high building, and walls.'

(Bhutan)

'Stay away from buildings, trees, poles and power lines and telephone lines, as they may fall and cause damage.'

(Ecuador)

'…if possible find a clear area away from buildings, trees, streetlights and power lines, as these may fall causing injuries during an earthquake.'

(New Zealand)

Three other pieces of advice appeared in more than 20% of the sample. Advice to stay outside buildings and not to go inside during earthquake activity was mentioned by 23.9% (n=16) of countries, and is summed up by the phrase, 'stay outside if you are outside', that comes from Turkey.

Avoidance of riverbanks and beaches was also included by 20.9% (n=14) of countries, and often linked to the possibility of a tsunami, as these examples from the Philippines and Japan show:

'Move away from steep slopes which may be affected by landslides.'
'If you're near the shore and feel an earthquake, especially if it's too strong, move quickly to higher grounds. Tsunami (giant sea waves) might follow.'

(Philippines)

'The biggest earthquake danger facing you at the seaside is a tidal wave (tsunami). Move to higher ground or an evacuation site immediately, without waiting for instructions or evacuation advice.'

(Japan)

Avoiding glass and loose or falling objects, or similar, was also mentioned (22.4%, n=15), as the examples below from Italy and the Cayman Islands show.

'Move away from buildings… you could be struck by vases, tiles and other materials that can fall.'

(Italy)

'Move away from buildings, utility wires, glass, hanging signs and other objects which may fall and cause injury.'

(Cayman Islands)

The frequencies of individual actions are summarised in Figure 5.20.

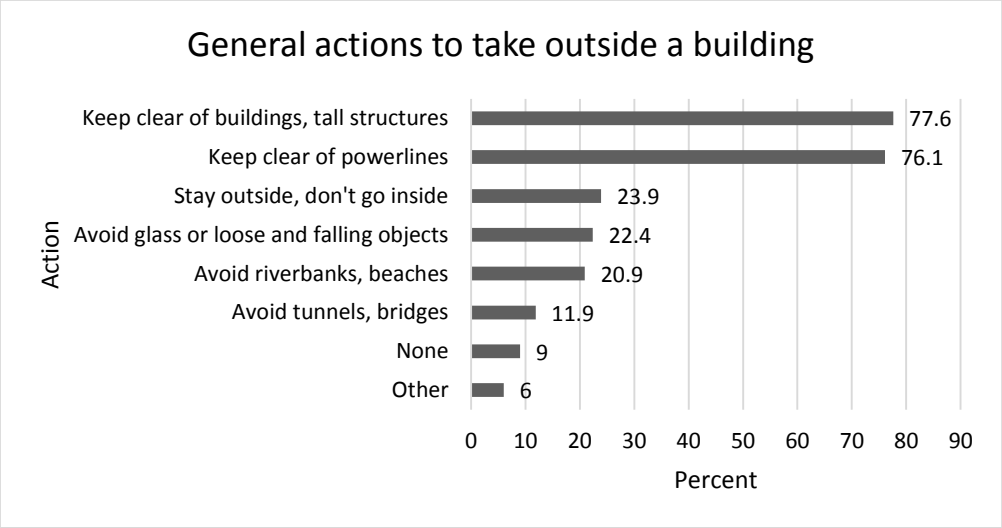


Figure 5.20. General actions to take outside a building (%)

5.7.7. Actions to take outside a building – protective

Actions to take that provide protection when outdoors was less well covered by authorities, with more than half the countries (55.2%, n=37) not offering any protective advice. Of those countries that did give advice, 31.3% (n=21) advised people to seek open spaces, such as the following examples.

'If you are outside then take shelter in an open space far from a tree, high-rise building and/or electric pole.'

(Bangladesh)

'If on the street, move into an open area, away from buildings.'
(Trinidad and Tobago)

Only 7.5% (n=5) of countries mentioned protecting the body when outside. The example from Belize covers both open spaces and protection of body areas.

'If you are outside, go to an open area. Always protect your head and face.'
(Belize)

Some countries (4.5%, n=3) advised to take shelter under a doorway or archway, and others advised to do drop-cover-hold (3.0%, n=2), or go inside (1.5%, n=1). These actions appear to be at odds with advice given by the majority of countries.

The frequencies of individual actions are shown in Figure 5.21.

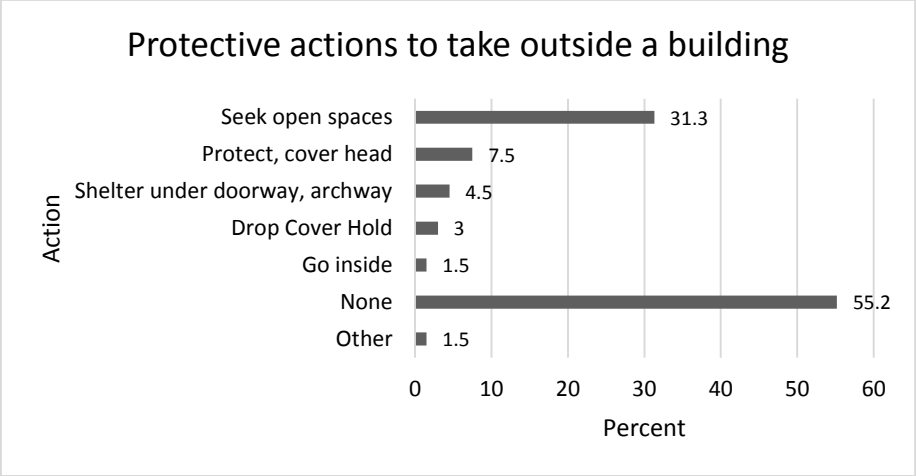


Figure 5.21. Protective actions to take when outside a building (%)

5.7.8. Advice on hazard reduction

The hazard reduction category included advice where positive actions were mentioned that could result in minimising a secondary hazard such as fire or gas release. These actions are not directly protective, but aim to mitigate further damage occurring.

Two thirds of countries (67.2%, n=45) did not mention hazard reduction as part of actions to take during earthquake shaking. Hazard reduction actions for most countries were more commonly contained in actions to take immediately after an earthquake, as might be expected, but which is outside the scope of this research. However, when it was included in the during shaking advice, the most frequently provided guidance was to turn off utilities such as gas, electricity or water, being provided by eight countries (11.9%).

'If possible, turn off the gas switches and disconnect the power supply.'
'Avoid lighting matches or any fire source.'
(Mexico)

A further four (6.0%) countries mentioned switching off ovens and appliances, and five countries (7.5%) recommended not using open flames. Other miscellaneous advice was given by six countries, including this example:

'Get away from hot things like coffee pots, pots, and kitchens'
(El Salvador)

5.7.9. Advice for specific situations

Situational advice refers to advice where specific reference was made to a particular place where people might find themselves at the time of the earthquake. Nine types of location were identified within the situational advice category, and shown in Figure 5.22

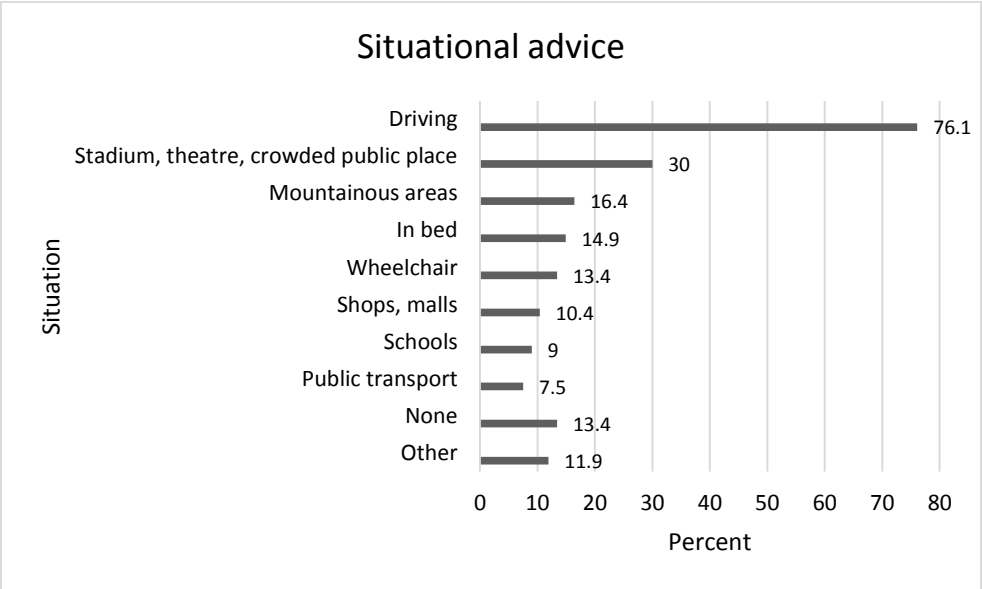


Figure 5.22. Countries that included advice for specific situations (%)

The most frequently mentioned situation was 'driving', i.e. in a vehicle, and this was included in advice by 76.1% (n=51) of countries, for example as with Guatemala and Turkey.

'If you are in your vehicle, park it as soon as possible in a safe place and stay inside it.'
(Guatemala)

'If you are in a car during an earthquake, stop the car at a place away from the gates, bridges, and do not go out until the tremor is over.'
(Turkey)

The second most frequently included piece of advice was for people located in stadiums, theatres or other crowded public places, excluding shops and malls, and was included by 30.0% (n=20) of countries. Examples are given below.

If you are in a crowded public place, stay calm and remain where you are. Protect your head and neck with your arms. Follow the instructions given by security staff.

(Chile)

'When in crowded places (shops, cinema theaters, schools, institutes, railway stations) do not succumb to general panic, stay close to bearing walls and away from hanging objects– chandeliers, ventilators, billboards.

(Kyrgyzstan)

'If you are in a garment factory, hospital, market or cinema hall then do not rush towards leaving the spot rather sit down where you are and try to protect your head with your hands.'

(Bangladesh)

Actions to take in mountainous areas was included by 16.4% (n=11) of countries, and mentioned falling rocks and landslides, for example:

'Mountainous areas or near unstable slopes or cliffs: be alert for falling rocks and other debris that could be loosened by the earthquake. Earthquakes can trigger landslides.'

(New Zealand)

'If you live in mountainous careful collapse rocks'

(Mongolia)

Advice for actions whilst in bed was provided by 14.9% (n=10) of countries, and this generally recommended people to stay in bed and protect their head, for example:

'Stay in bed if you are there when the earthquake strikes. Hold on and protect your head with a pillow, unless you are under a heavy light fixture that could fall. In that case, move to the nearest safe place.'

(India)

Advice for those in wheelchairs was similar across all countries that included it (13.4%, n=9).

'If you are in a wheelchair and indoors, place yourself under a beam, next to a column or in a corner. Then brake the wheels and cover your head with your arms.'

(Cuba)

Perhaps, not surprisingly, advice varied between countries and some of this variation may be due to physical differences between the locations, such as the likelihood of landslides or the strength and resilience of buildings. Whilst driving was a common situation for inclusion, there was variation in the acknowledgement of specific sub-groups, such as wheelchair users, and any needs they may have, with many countries providing only generic information intended to meet the needs of all people.

5.7.10. Advice for groups in the community

Some groups in the community, such as the elderly or people with disabilities, may require extra assistance, or alternative instructions. The majority of the actions contained in earthquake preparedness advice were generic, and did not target any particular community group. Most countries (80.1%, n=54) did not mention or highlight any specific advice for more vulnerable groups in the community.

The group most frequently mentioned was people with disabilities (7.5%, n=5), for example:

'Remember those who are physically challenged may need assistance more than in normal circumstances.'

(Antigua and Barbuda)

'People who use wheelchairs or other mobility devices should lock their wheels and remain seated until the shaking stops. Protect your head and neck with your arms, a pillow, a book, or whatever is available.'

(USA)

The elderly and children as groups were mentioned by only two (3.0%) and three countries (4.5%) respectively.

'If you are elderly or have limited mobility, remain where you are, bracing yourself in place against the shaking.'

(New Zealand)

'Think about the welfare of children and elderly people (some of them may have difficulty moving).'

(Kazakhstan)

5.7.11. Advice relating to entrapment

As with advice for hazard reduction, advice for people trapped under debris was most commonly seen in the 'after' section of earthquake preparedness documents. However, nine countries (13.4%) included advice about entrapment as part of the 'during' section of their guidance.

Nearly all of the advice regarding actions to take included tapping on a pipe or wall (88.9%, n=8). Other common phrases in the advice included:

'Cover your mouth with a handkerchief or clothing.'

(Afghanistan)

'Tap on a pipe or wall so rescuers can locate you'

(Afghanistan)

'….therefore not recommended to light a match or cigarette lighter'

(Macedonia)

'Yelling is the last thing to do, but it can cause dust inhalation.'

(Indonesia)

Other common actions included not shouting (66.7%, n=6), not kicking up dust (66.7%, n=6), and not lighting a match (55.6%, n=5).

5.7.12. National advice - protective actions summary

The results above have highlighted the variety of protective actions contained in earthquake preparedness advice around the world.

Taken as a whole, the most frequently provided advice can be observed from the ten categories used to analyse the document contents. Three categories did not refer to action-based advice (i.e. format of documents, community groups, and entrapment). The top-ranked action in each of the remaining seven categories are shown in Table 5.30 below:

Category	Action
Emotions	Stay calm
Indoors – general	Avoid glass or loose and falling objects
Indoors – protective	Shelter under furniture
Outdoors – general	Keep clear of buildings and tall structures
Outdoors – protective	Seek open spaces
Hazard reduction	Shut off utilities
Specific situations	Driving advice

Table 5.30. Top ranked actions by category

When information from these categories is combined, the most frequently provided advice can be determined. The most frequently included actions, appearing in the advice from more than two thirds of countries, are:

- Keep clear of buildings and tall structures (n=52)
- Keep clear of powerlines (n=51)
- Advice related to driving (n=51)
- Avoid glass or loose and falling objects (inside) (n=48)
- Shelter under furniture (inside) (n=46)

The first three items of advice in this list all relate to outdoor situations, this is surprising given the increased risks from being indoors during an earthquake. However, this may be a reflection of the fact that a greater variety of terms are used to describe actions to take while indoors, compared to those used for outdoor situations.

Other advice that appears in 40-60% of country guidance are:

- Don’t use lifts or elevators (n=35)
- Stay inside, don’t go outside (n=32)
- Stay calm (n=29)
- Protect or cover head (n=28)

The graph below (Figure 5.23) provides a summary of advice, in terms of frequency of occurrence, given in the documents across each of the seven action-related categories. The relevance of this advice is discussed further in chapter 7.

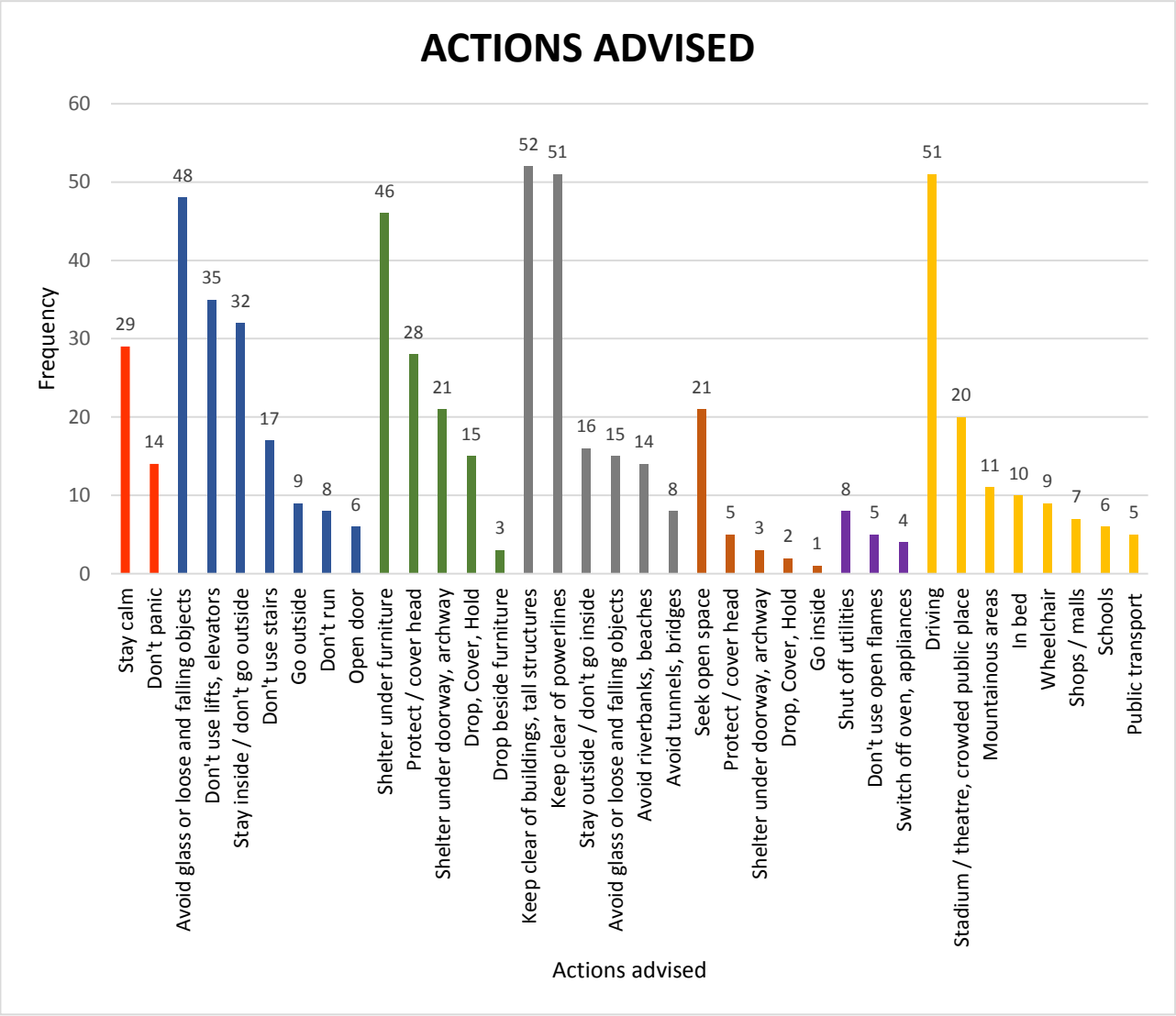


Figure 5.23. Combined actions to take during an earthquake from all countries

5.8. Summary

This chapter has explored the results from two samples of respondents that experienced earthquakes in Christchurch and Sendai. The underlying characteristics, demographics, earthquake preparedness activities and locations of the respondents during the earthquake were described. The actions taken, the reasons given for those actions and feelings experienced during the earthquake as described by the respondents were

also detailed. Comparisons were made between the results from Christchurch and Sendai. Possible influences on the actions taken, both people-centred and preparedness-centred were considered as were outcomes from the consequences of taking those actions. Finally, a description of the results of the document analysis of national earthquake advice from around the world was given.

This research is unusual in that it compares the actions taken by people across two earthquake events in different countries using the same survey tool. This has been done in only a few previous studies (e.g. Lindell *et al.*, 2016; Goltz & Bourque, 2017). The results of this research allow for comparison to be made between the two field studies in terms of the experienced intensity of the earthquakes, and also demographically, with age and gender ranges being similar in both samples.

The next two chapters discuss the implications of many of these results in more depth, and compare and contrast the findings with other similar research in this field.

Chapter 6: Protective actions during the 2011 earthquakes

This is the first of two chapters that explore in-depth the data gathered as part of this research. This chapter focuses on the field surveys undertaken in Christchurch and Sendai. The next chapter will look at the wider implications of the survey results along with the document analysis of national advice.

This chapter initially considers the demographic influences on actions taken, along with feelings experienced at the time of shaking. Respondent's own explanations for taking the actions are also reviewed. Personal items saved during shaking are also explored as well as whether assistance was provided or received during the earthquake. The remainder of the chapter is devoted to discussing the consequences of taking protective actions, including entrapment and reasons for surviving the earthquake.

6.1. Protective actions during earthquakes

During the 2011 earthquakes, respondents from both Christchurch and Sendai reported taking a variety of actions, such as sheltering under furniture, avoiding objects, protecting others, going outside and drop-cover-hold.

Among this variety of behaviours, some can be seen as direct attempts to improve the individual's level of protection, such as sheltering under a table or drop-cover-hold. Other actions provide indirect protection, such as avoiding existing hazards (e.g. falling debris), but do not otherwise improve the individual's level of safety. Finally, there are actions that may only appear to be indirectly related to safety, such as retrieving personal items. In the following discussion, directly-protective actions are considered before discussing other types of behaviour.

6.1.1. Directly-protective actions

The directly-protective actions identified from the surveys were a) sheltering under furniture, b) drop-cover-hold, and c) standing in a doorway. In both New Zealand and Japan, seeking shelter and the drop-cover-hold type actions are core components of the guidance on actions to take during earthquakes. The action of standing in a doorway is not actively promoted in either country, but was commonly reported by respondents in both countries and can be regarded as an attempt to seek protection even if it is based on erroneous knowledge about its effectiveness.

The action of sheltering under a desk or table was performed at similar frequencies in both Christchurch (28.6%) and Sendai (20.3%), whereas only 7.7% reported doing drop-cover-hold in Christchurch, in contrast to 38.3% in Sendai. These differences between the two cities may be due to the longer duration of the earthquake in Sendai which would allow more time for people to remember and enact the drop-cover-hold manoeuvre.

In order to compare findings from this research with other studies, two actions, seeking shelter under a table and drop-cover-hold, can be considered together to understand how many people in total took a protective action that involved generally taking cover. Doing so gives a combined taking cover result of 35.3% in Christchurch and 58.6% in Sendai.

Other studies have also attempted to quantify the frequency of sheltering actions taken at the time of an earthquake. The study by Lindell *et al.* (2016) found that in the same Christchurch earthquake only 17.1% of their sample described 'taking cover' of some kind. This variation in levels of sheltering actions with the current study, may have been due to differences in the sample groups where Lindell *et al.*'s study included a higher proportion of both elderly and female subjects. Lower levels of taking cover are also supported by analysis of video footage in Christchurch hospital during the 2011 earthquake that found no one did all the drop-cover-hold actions, but those near a desk, chair or doorframe did seek shelter (Lambie *et al.*, 2017).

From the point of view of this research, which explores the influence of protective advice on actions, a question of interest is what level of activity would constitute a successful public information programme. In New Zealand the government conducts an annual survey of people's knowledge and awareness of advice which asks, amongst other things, what they would do during an earthquake (Colmar Brunton, 2019). In the 2010 survey prior to the Christchurch earthquake, 58% of respondents said that they would take shelter. However, the results of this research and that of Lindell *et al.*'s (2016) indicate that less than half of that number actually took the action. This highlights the problem of relying on reported intentions to gauge people's activity during earthquakes rather than retrospectively assessing what they actually did. Some researchers have chosen to equate intention with actual actions (e.g. Shapira *et al.*, 2018; Paton, 2003), and it may be that this kind of extrapolation is unreliable.

Higher levels of sheltering actions were found in Sendai (58.6%) during this current study, which contrasts with Lindell *et al.*'s study (2016) in Hitachi for the same earthquake, where only 7.2% of respondents took cover. These differences in the frequencies in Japan may partly be explained by the use of a different city, as Hitachi was further south from the epicentre of the earthquake, however there was little difference in the reported intensity of the earthquakes at these locations (USGS, 2011).

Findings from other research indicates that the incidence of those seeking shelter or taking cover rarely rises above 40% of respondents in post-earthquake surveys. For example, the combined action of seeking shelter was performed more frequently in Christchurch and Sendai than in the Umbria-Marche earthquake in Italy in 1997, where only 12% reported seeking shelter (Prati *et al.*, 2012), and the Emilia-Romagna earthquake in Italy in 2012 where only 1.7% sought shelter under a table (Prati *et al.*, 2013). During the Mexico City earthquake in 2017, only 13.7% reported seeking shelter (Santos-Reyes & Gouzeva, 2020). Those seeking shelter during the Californian earthquakes at Loma Prieta (32.8%), Whittier Narrows (39.0%), and Northridge

(26.6%) (Goltz & Bourque, 2017) are more in line with those in Christchurch, but still below the frequency seen in Sendai. In the Off-Urakawa earthquake in 1982, only 7.3% of respondents attempted to protect themselves (Archea & Kobayashi, 1984), but not all were successful. During the Imperial Valley earthquake in 1979, 36% of respondents sought shelter under a desk (Arnold *et al.*, 1982).

Results of a study of actions taken in Iceland following two earthquakes in 2000 showed that people's attempts to escape from inside a building by trying to hold on to something, get under tables or move to doorframes or the corners of rooms were considered too difficult or dangerous at intensities approaching MMVIII (Akason *et al.*, 2006). Both the Christchurch and Great Eastern Japan earthquakes had greater intensities than this, at MMX in Christchurch and MMIX in Sendai, and as such the expectation, therefore, would be that few people would achieve seeking shelter at these shaking intensities.

Akason *et al.*'s (2006) study above might suggest that protective advice and guidance are recommending actions that may not be achievable during high intensity earthquakes, and thereby creating a false expectation amongst the public of what is possible. Similarly, it may be that people know about seeking shelter but either cannot or will not do the actions for reasons such as having no place to seek shelter, physically not being able to shelter, attempts to assist others, and even fear or embarrassment. This might explain the apparent low levels of sheltering action reported from different parts of the world. The practicality of seeking shelter and attitudes to drop-cover-hold are discussed further in the next chapter.

Another directly-protective action that people reported doing during the earthquakes was to move to or stand in a doorway, with slightly more of the Christchurch respondents (19.4%) taking it when compared to those in Sendai (16,7%) but the reason for this is unclear. However, this action is no longer included in official earthquake advice in either Japan or New Zealand. Of the national earthquake preparedness actions analysed (see Chapter 5), 29.9% of countries recommend seeking shelter under a doorway or archway. Nevertheless, it can be argued that standing in a doorway still represents an attempt to seek shelter, and this was the meaning used by Prati *et al.*, (2012) to describe actions in the Umbria-Marche earthquake, where 12% sought shelter in this way. This term was also used by Goltz and Bourque (2017) for the three Californian earthquakes, where a combination of actions (stood in doorway, ducked under furniture and avoided hazards) are included under the collective term 'took cover'. For the Emilia-Romagna night-time earthquake, seeking shelter in a doorway was the choice of 14.1% of people (Prati *et al.*, 2013). These frequencies are all lower than that found in this research. In Lindell *et al.*'s (2016) comparison of the Christchurch and Hitachi earthquakes, no mention was made of taking shelter in doorways, but instead they collectively group actions as 'took cover' without further defining these. This highlights another limitation of some earthquake research that uses broad categories to define behaviour, thereby limiting the insights that can be gained.

Seeking shelter in a doorway is no longer recommended in many countries, partly due to the potential danger of being injured by a swinging open door, and in modern buildings doorframes are often no stronger than other parts of the building (CDEM, 2015). However, this research shows that many people are still performing this action, particularly in Christchurch. A reason for this may be that people pass through doors as they move towards an exit, and the action of standing in a doorway during shaking may be instinctive or feel sensible as part of a route out of the building. This finding means that those providing advice should not simply ignore the fact that people do choose to stand in doorways even if it is not considered the best action. Either the advice needs to be clarified or consideration needs to be given to the possibility that, even with its limitations, standing in a doorway may be safer than remaining in the middle of a room, in which case, doorways could be strengthened to accommodate this action. This notion is supported by findings from Mora *et al.* (2015) who used analysis of Twitter feeds and focus groups after the Christchurch 2011 earthquake, and found that the provision of safe exits from buildings was important for participants when they were deciding whether or not a building was 'safe'.

To attempt to explain the similarities and differences between these findings and other research also requires comparison of the differences in the nature of the earthquakes, the demographics of the sample, and most importantly, studies that compare the same actions defined using similar terms. As seen here, definitions of directly-protective actions vary across studies, such as those by Santos-Reyes and Gouzeva (2020), Lindell *et al.* (2016), Goltz and Bourque (2017), Prati *et al.*, (2012), Prati *et al.* (2013) and others. This is also demonstrated by the lack of definitions provided for protective actions found in the literature and summarised in Chapter 2. Ideally, consensus is required surrounding the definitions used for sheltering actions, as well as the level of detail involved, so that findings can be more easily compared.

6.1.2. Indirectly protective actions

Indirectly protective actions tend to involve interaction with the surrounding environment, such as avoiding falling debris, going outside, and retrieving personal property. These actions are not directly protective in themselves since they do not involve the act of positively seeking some form of physical protection but rather, they include acts of attempting to avoid danger.

<u>Avoiding falling objects or debris</u>

Advice to avoid falling objects or debris is included in both New Zealand and Japanese guidance. Findings from this research showed that of the Christchurch respondents, just over a third (35.3%) avoided falling objects, but in Sendai this fell to just over a quarter (27.7%). These frequencies are higher than other research has reported, and may, in Christchurch, be due to the fact that residents may not have secured items in buildings, particularly as the area was not considered a high-risk location until the 2010-2011 series of earthquakes. Both earthquakes had a high intensity of shaking, and therefore an increased risk of items and debris falling. These findings compare with the Imperial Valley earthquake (California 1979), where 8%

'dodged to avoid falling objects' (Arnold *et al.*, 1982), and the Off-Urakawa earthquake where very few respondents (12.5%) reported attempting to protect themselves from falling objects, mostly due to protecting property (Archea & Kobayashi, 1984). More recent studies do not mention avoiding objects or debris during earthquakes; although Goltz and Bourque (2017) collected a small amount of data on those who caught or braced objects, but did not discuss this particular action.

Attempts to avoid falling objects, and even to seek shelter, may be affected by the items surrounding people at the time of an earthquake. In Christchurch, respondents listed the presence of items such as a table, desk, computer equipment, shelving unit, chairs, sofas and storage cabinet, in more than 40% of cases. Similarly, for Sendai, a table, desk, computer equipment, chairs, sofas, television, storage cabinet or bookcase were also present in more than 40% of rooms. The greatest difference between the two locations was the presence of televisions and bookcases, with half of Sendai rooms having these items, but in Christchurch this reduced to a quarter of rooms. Unless anchored to a solid part of the building, furniture and other items such as these can create hazards for people moving around the room to seek shelter, attempting to perform drop-cover-hold or avoid falling debris.

Advising sheltering as a behaviour also implies the presence of a suitable place to take cover. Whilst 64.6% of rooms in Christchurch and 80.4% of rooms in Sendai contained a table or desk, it is not known whether these were suitable places to shelter. As Archea and Kobayashi (1984) have reported, many people in their study could not find suitable pieces of furniture to shelter under, and some moved to the next room to find such a location, thereby increasing the risk of injury by moving. In some cases, the distance moved indoors to find a place to seek shelter was further than going directly outside (Archea & Kobayashi, 1984).

This points to another potential problem with making sheltering under furniture a central theme of guidance in that while people may understand the action, the absence of suitable protection at the time of an earthquake may make the advice impossible to implement.

<u>Stayed in place</u>

The action 'stayed in place', or 'stayed where I was' was mentioned by twice as many of the respondents in Sendai (74.7%) as in Christchurch (34.7%), and was the most often reported action in Sendai, and second most frequent in Christchurch. These differences may depend on how respondents interpreted the option 'stayed where I was', such as being taken literally to mean staying in one place and not doing anything else, or may have been taken to mean staying in the similar location and undertake other actions. In both cities, a number of respondents reported staying in place and doing only that action (6.9%, n=10 in Christchurch, and 9.7%, n=29 in Sendai), whilst the remainder took multiple actions during the earthquake.

Other studies have suggested that 'staying in place' could also be due to initially freezing in position when the earthquake begins, or that people were able to take an action without moving from their position (Lindell

et al., 2016; Goltz & Bourque, 2017). The force of the shaking may also have meant that people stayed in the same place as the shaking was too great to move to another location. Duration of the earthquake may also be a factor in determining how many actions people take, if any.

The proportion of people who reported staying in place in this research is somewhat higher than from other earthquake studies, particularly in Sendai. Lindell *et al.* (2016) found that 37.7% in Christchurch 'froze in place', as did 31.6% in Hitachi. They also found small numbers of people (2.7% Christchurch, 2.1% Hitachi) continued what they were doing just before the earthquake started, which may also equate to staying in the same place (Lindell *et al.*, 2016). Findings from the Umbria-Marche earthquake showed 22% froze, and 10% had no reaction (Prati *et al.*, 2012), however, in the Mexico City earthquake, only 1.8% reported freezing and 2.4% had no reaction (Santos-Reyes & Gouzeva, 2020). The Whittier Narrows earthquake saw 35.7% stay the same, and 33.3% in Loma Prieta (Goltz & Bourque, 2017). In research from the Emilia-Romagna earthquake (Prati *et al.*, 2013) that happened at night, the action 'I waited in my bed' (32.9%) could also be regarded as staying in place. Similar results to Emilia-Romagna were found in the Northridge earthquake that also occurred at night, where remaining in bed was the action of 38.6% of respondents (Goltz & Bourque, 2017).

A possible explanation for the high number of respondents staying where they were in Sendai could stem from the earthquake lasting for a long time with high intensity. This may have meant people were less likely to be able to move freely even if they had wanted to. However, this does not fully explain the other actions that were also reported during the shaking. It may be this situation was similar to that reported by Archea and Kobayashi (1984) where 31.7% of respondents in the Off-Urakawa earthquake stayed where they were until the severity of the earthquake was determined, and then undertook other actions, with only 14.6% remaining in the same place for the entire earthquake.

As this and other research has shown, taking more than one action during an earthquake is not uncommon, particularly if the earthquake is long. Some researchers have focused on the main action taken by people (Lindell *et al.*, 2016) however, this approach may miss important responses to earthquakes. People may report staying in one place even if they undertook additional actions during part or all of an earthquake. Future research that focuses on the multiple actions taken during an earthquake and the reasons for these actions may go some way to understanding people's behaviour. In the meantime, earthquake advice might reasonably state that people should only attempt an action if it is feasible to do so, thereby acknowledging that staying where they are is among several possible options.

<u>Go outside</u>

Going outside during an earthquake to escape the building is a commonly reported action, but is not recommended in either New Zealand or Japan. However, findings from this research show that this is still a

commonly undertaken action. In both cities, a number of respondents reported that they went outside the building during earthquake shaking, including nearly a quarter of the Christchurch (22.9%) and a fifth of Sendai respondents (20.3%). Again, there are differences between these results and those found in Lindell *et al.* (2016), where they reported that 10.5% in Christchurch and 27.7% in Hitachi evacuated the building immediately. However, in the analysis of CCTV footage of actions taken in Christchurch hospital, only 0.9% of the sample were observed to evacuate the building during shaking (Lambie *et al.*, 2017). In the Off-Urakawa earthquake 24.4% of people exited the building during the earthquake (Archea & Kobayashi, 1984). There are also low numbers of people exiting the building in the three Californian earthquakes, 8.8% Whittier Narrows, 8.3% Loma Prieta, and 8.4% in Northridge (Goltz & Bourque, 2017). In the Italian earthquakes there are higher numbers exiting buildings during shaking, with 35.6% leaving during the Emilia-Romagna earthquake (Prati *et al.*, 2013), and 38% leaving during the Umbria-Marche earthquake (Prati *et al.*, 2012). There were considerably higher numbers (52.5%) that escaped the building during the Mexico City earthquake (Santos-Reyes & Gouzeva, 2020).

Whilst the low number of people exiting the Christchurch hospital building during shaking might be explained by many of the subjects' professional responsibilities (Lambie *et al.*, 2017), this cannot necessarily be said for other situations and buildings. Results from analysis of the national earthquake advice show that 46.3% of countries recommended staying indoors during shaking and 13.4% recommended going outside. As GeoHazards International (2015) have reported, most fatalities in earthquakes result from building collapse and the subsequent crushing or striking by building debris and asphyxiation from dust. Some types of buildings are more likely to collapse than others, and to collapse in a particular manner that can directly affect the chances of survival. In spite of advice to the contrary, deciding to evacuate a building can sometimes be a life-saving decision. Accounts from the Royal Commission Inquiry into the Christchurch earthquake include one person on the ground floor who ran from the CTV seven-storey building as it collapsed, and was the only survivor from that floor and the floor above (Royal Commission, 2012).

To attempt to explain the high numbers of people leaving buildings during an earthquake when this goes against established advice involves considering a number of contributing factors. This might include building design, such as multi-storey workplaces, apartments, and single-level dwellings; demographic factors, such as age and gender; and emotional factors such as levels of fear and accepted risk. This study found that males were slightly more likely than females to leave a building, and previous studies have linked going outside to levels of fear experienced (Lindell *et al.*, 2016; Goltz & Bourque, 2017; Prati *et al.*, 2012; Prati *et al.*, 2013). The roles of gender and fear are discussed further in section 6.2 of this chapter.

Sit or lie down

This research also considered the action of sitting or lying down during an earthquake, an action not specifically identified in earthquake advice, but which does involve the 'drop' component of drop-cover-hold.

This action is not considered directly-protective as it does not include covering or protecting the head, but was undertaken by more people in Sendai (26.0%) than in Christchurch (9.0%).

Explanations as to why someone would choose to get down to the ground include attempting to find shelter but not being able to find a suitable location, or not being able to move due to the intensity of shaking. Whilst a high number of respondents reported their locations had a table or desk, it is not known whether it was possible to get under these items of furniture. Other studies have not identified or included this action as one that people have taken, and in future it may be worth considering this type of action and whether people have attempted to either drop-cover-hold or seek shelter but not achieved it. Getting down to the ground may also be a protective action for those who may be vulnerable to injury from a fall, such as the elderly, and this is discussed further below.

Protecting others

This research also looked at the prevalence of attempts to protect others during the earthquake. Whilst the findings do not define who was protected, 20.1% of Christchurch respondents and 21.3% in Sendai reported protecting others during shaking. These frequencies are somewhat higher than those reported in Prati *et al.* (2012) where only 7% reported protecting others. Lindell *et al.* (2016) also found lower frequencies of protecting others with 10.1% in Christchurch and 6.3% in Hitachi undertaking this action. Goltz and Bourque (2017) found that of those going to others at home, the majority were parents going to dependent children, but that overall, this action was less prevalent than seeking shelter.

By attempting to protect others during an earthquake, a person may be increasing their own risk of injury, for example by moving greater distances during the shaking, or by being at greater risk from falling debris, and not seeking shelter. Advice in New Zealand and Japan focuses on the individual and no advice exists on protecting or helping other people during an earthquake. Whilst it may be intentional to focus on personal safety, people may have other responsibilities or be with people less able to help themselves. Including advice for this situation may be appropriate as it appears from these findings that during an earthquake some people will still attempt to respond to the needs of others. This advice might be along similar lines to that used on aircraft, where people are told to ensure their own safety first before assisting other people.

Move away from buildings

The action of moving away from a building was reported by slightly more people in Christchurch (20.1%) than in Sendai (18.7%). This action includes those who were outside a building as well as those inside who exited the building and moved away from it during the earthquake. Both countries advise people to move away from buildings and tall structures if outside during an earthquake. As Christchurch is generally less intensely built up than Sendai, these respondents may have had more outdoor space to move to. Respondents in Sendai reported more substantial and severe damage to buildings than Christchurch, however, in

Christchurch more respondents reported complete building destruction. This may also have impacted on the numbers of those who moved away from buildings. Other studies (Lindell *et al.*, 2016; Goltz & Bourque, 2017; Prati *et al.*, 2012; Prati *et al.*, 2013; Archea & Kobayashi, 1984; Arnold *et al.*, 1982) have not reported on the movement of people outside, as studies tend to focus on indoor actions.

6.1.3. Personal items saved during the earthquake

Official advice regarding actions to take during earthquakes from both New Zealand and Japan does not include advice on saving or protecting property. However, a number of respondents indicated they saved various items during the two earthquakes. Findings from this research show that 6.9% of respondents in Christchurch saved a personal item during the earthquake, and this rose to 17.7% for respondents in Sendai.

There are similarities between Christchurch and Sendai regarding the type of items that respondents said they saved or attempted to save during the earthquake. The most common item to be saved, by a quarter of respondents in both cities, was the mobile phone. In Sendai, other popular items to save were computers, and wallets or handbags, mentioned by less than a fifth of respondents. Results from Lindell *et al.* (2016) did not break down the types of property protected, but in Christchurch they found 5.1% tried to protect property, and in Hitachi this rose to 9.9%. Recovery of personal belongings was included in a study of the Umbria-Marche earthquake; however, this was a mixed category with saving personal items and continuing daily activities combined (Prati *et al.*, 2012), making comparison unreliable. In the Off-Urakawa earthquake in 1982, 39.0% of subjects attempted to protect furniture and to stop it from falling, and a further 17.1% reported holding on to other objects to stop them falling or breaking (Archea & Kobayashi, 1984). This action was not reported in literature regarding the Emilia-Romagna earthquake (Prati *et al.*, 2013), or for the three California earthquakes between 1987 and 1994 (Goltz & Bourque, 2017), however ownership of mobile phones and computers was not as common when those earthquakes occurred as in 2011.

Saving small items such as a mobile phone, wallet or handbag may be relatively easy to do during shaking if the item is nearby. The implications of attempting to save property or collect various items together during an earthquake might imply that an individual is less focused on protecting themselves, thereby increasing the risk of injury. In Sendai 18.3% of people mentioned saving their computer. However, it is possible that even collecting a laptop computer or attempting to gather other personal belongings could slow down a person's ability to take protective action. Despite this, information from global earthquake advice documents makes little or no reference to the merits of saving or protecting property (see Chapter 7).

<u>Mobile phones</u>

An unexpected finding from this research was the importance placed on mobile phones as a means of support and providing assistance during and after an earthquake. Of those people who saved personal items during the earthquake, a quarter of respondents in Christchurch and Sendai reported that they saved their mobile

phone. This action may in part be explained by the fact that these devices are frequently more than simply a telephone, and are nowadays often used as a source of information, a storage place for personal data, and to access on-line accounts. They may also contain personal mementos such as photographs.

There appears to be limited research into people's attitudes to mobile phones during an earthquake, however a study by Rosoff *et al.* (2011) found that 100% of respondents planned to use their mobile phone in the immediate aftermath of an earthquake, and research by Jia *et al.* (2017) found that after experiencing a high intensity earthquake, there was increased mobile communications and use of apps. In this current research many people said they would use a mobile phone to check on the well-being of friends and family or call for help. Mobile phones also commonly include a torch and radio, two items recommended in a survival kit.

Mobile phones have also been used to call for help whilst trapped under debris (e.g. Royal Commission, 2012). When asked what they would most likely do if they became trapped following an earthquake, a third of Christchurch respondents indicated they would use their mobile phone to call for assistance from their location. Of course, mobile phones have their limitations and in many large earthquakes, communications are frequently lost for a period of time and it may not be possible to use a mobile phone from within a collapsed or damaged building. There are also limitations on battery life and the capacity of the mobile network to cope with demand, particularly if damage has occurred to infrastructure. These limitations regarding the use of mobile phones in disasters are also noted by Toya and Skidmore (2018). These authors concluded that increasing use of mobile phones may be connected to a reduction in fatalities related to disasters, however, this conclusion cannot be relied upon as it appears to have confounded correlation with causality, and there are many other factors that may have contributed to this fall in overall deaths.

Of the global national advice and guidance accessed for this research, no references were found regarding the use of mobile phones during an earthquake, however there was some advice about their limitations in the immediate aftermath of an earthquake. This research has highlighted a gap in the public advice around the limitations and use of mobile phones by the public during an earthquake disaster. To reflect the importance of this technology in people's lives, consideration might be given to including information about mobile phone use in national earthquake preparedness advice. However, the potential high personal value of these devices may mean that it is ineffective to simply advise people against retrieving their mobile phone during an earthquake.

6.1.4. Assistance provided and received

In addition to the action of protecting others discussed earlier, actively providing assistance to, or receiving assistance from, others may have impacted on the actions people took. There are differences in the meaning associated with protecting someone and providing assistance, for example protecting someone may involve

picking up and hugging a child, and providing assistance may be assisting someone to get down under an item of furniture for shelter. Receiving assistance can include actions such as being helped to get under furniture, or being told to drop-cover-hold.

More than a third (39.2%) of Christchurch respondents indicated that they provided assistance to someone during the earthquake, and 14.7% received assistance, mostly from colleagues. In Sendai the reported frequencies were less, with only 16.7% of respondents providing assistance and 5.0% receiving assistance during the earthquake. Generally, there were higher levels of people providing assistance than receiving it. This difference may partially be explained by how people interpret what constitutes providing and receiving assistance, and how their actions towards another person are interpreted.

Earthquake guidance for New Zealand and Japan does not specifically mention providing assistance to someone during an earthquake, although some studies do show that people go to others during shaking. This research found that in both Christchurch and Sendai there were higher levels of providing assistance than those found by Lindell *et al.* (2016), where only 10.1% of Christchurch respondents tried to protect people, and 6.3% in Hitachi. Their study refers to protecting people nearby, rather than providing assistance. Goltz and Bourque (2017) included giving assistance in a broader category of 'going towards others', and found this was less likely to happen in the workplace than at home. In the Umbria-Marche earthquake, Prati *et al.*, (2012) found only 7% reached and protected significant others. Using the same descriptor, this contrasted with the Mexico City earthquake, where 17.1% reached and protected others (Santos-Reyes & Gouzeva, 2020).

As part of this research, the possible effects of age and gender on providing and receiving assistance were considered, and two significant relationships were found for gender. From the Christchurch sample, females were more likely to report receiving assistance than males (p = 0.008), and there was a slightly less strong relationship for the Sendai sample, where females also reported receiving assistance more than males (p = 0.032). These findings indicate that females are more likely to report receiving assistance than males. From the information obtained, it is not possible to identify whether the females requested assistance, or whether it was provided unsolicited.

Regarding age, Christchurch respondents generally showed higher levels of both providing and receiving assistance than Sendai, with the frequencies being similar across the three groups. In the Sendai sample however, a greater number of younger people provided assistance (23.9%) than the older group (12.2%), but the younger group also reported receiving assistance more frequently (12.7%) than the older group (2.0%), a relationship that was significant (p = 0.005). Considering the younger group are aged between 20 and 39 years and the older group are aged 60 years and over, it would perhaps be expected that the older group would require more assistance, however, this was not supported by the data.

This study contrasts with that by Goltz and Bourque (2017), who considered those providing assistance during the Northridge earthquake, and found that gender and age were both factors in going to others. Lindell *et al.* (2016) also found that those with children were more likely to protect others. Findings from this research suggest that in Christchurch, of those who provided and received assistance, this was from colleagues or strangers, suggesting that it is not only the presence of a person's own children that encourages people to provide assistance during earthquakes.

This research does not specify the type of assistance provided or received during the earthquake, or whether assistance was provided at the expense of taking protective actions. In future it would be useful to clarify this, as the act of providing assistance to someone may hinder one's chances of survival or minimising injury. Analogies can be drawn to the situation during an aircraft emergency, where people are instructed to put on their own oxygen mask and ensure their safety first before helping someone else. Similar actions might be considered to reduce the likelihood of injury in earthquakes, where seeking shelter is done first, and helping others is secondary.

Finally, a further recommendation for future research would be to provide clearer definitions of the terms 'providing' and 'receiving' assistance. The issue of inconsistency in terms of definitions and categories used is a consistent problem in earthquake research, and is discussed in the final chapter.

6.2. Age, gender and emotional influences on protective actions

The possible influences of demographic and emotional factors on protective actions are discussed in this section. The protective actions included in the survey were sheltering under furniture, drop-cover-hold, standing in a doorway, going outside, avoiding objects, and staying in place. Protective actions are typically the focus of earthquake advice, and if differences are found in responses between age groups or gender, etc., then the advice may need to be tailored to the needs of each group. Similar influences on saving personal items, and protecting others, actions that are generally not included in the advice, have already been discussed above.

6.2.1. Age

The results reported in Chapter 5 show that for the Christchurch sample there was no influence of age on seeking shelter under furniture or doing drop-cover-hold. There was also no age-related effect when these two actions were combined to represent any kind of sheltering behaviour. However, in Sendai, age had a strong influence on seeking shelter under furniture, with the younger group three times more likely to seek shelter in this way than the older group (p = 0.009). Also, in Sendai, a weak association was found with age and drop-cover-hold with younger people taking this action more often than older people (p = 0.077). Differences in the findings between Christchurch and Sendai may partially be explained by the duration of

shaking in Sendai that gave people more time to seek shelter. Nonetheless, the effects of age on drop-cover-hold behaviour might be worth further investigation.

Standing in a doorway is not a recommended action in either New Zealand or Japan, however, the action was frequently reported by respondents (19.4% in Christchurch, 16.7% in Sendai). Little difference was found between the age groups for this action, although it was performed by slightly more of those in the middle and older age groups in Christchurch (18.5% young, 40.5% middle, and 35.7% older age groups). This may be due to the fact that standing in a doorway was recommended in the past and older age groups might therefore have learnt this behaviour previously and still remember the advice. Similarly, the younger group may have had more exposure, perhaps at school, to the drop-cover-hold message which would account for the higher number of younger respondents taking this action as described above. Other factors that may affect whether or not people take these actions are mobility and physical fitness. Whilst the samples in this research reported very low levels of mobility issues, in general the older group may be more reluctant to get down to floor level, meaning that standing in a doorway may be a preferable action.

Other studies also report differences in actions taken due to age. Lindell *et al.* (2016) found that those who were young were more likely to take cover. Goltz and Bourque (2017) reported that age was significantly associated with taking cover at home in the Whittier Narrows earthquake, with younger people of 39 years of age and younger being most likely to seek shelter, however, they found no association with age and seeking shelter in the Loma Prieta and Northridge earthquakes. In contrast, Santos-Reyes and Gouzeva (2020) found that people aged 34 years and over were more likely to seek shelter than younger people, though the frequencies are small.

For actions considered indirectly protective (avoiding objects, going outside, and staying in place), it might be expected that younger people would be more likely to take evasive action and avoid debris than older people due to their advantages in terms of physical mobility. However, no strongly significant relationships were found between age groups for these actions in either Christchurch or Sendai. Nonetheless, weak associations were found for other actions where more middle-aged respondents chose to go outside (p = 0.074) and more elderly respondents stayed in place (p = 0.094) in the Christchurch sample.

In other research, Goltz and Bourque (2017) found no significant effect of age on going outside during the three Californian earthquakes studied, and Lindell *et al.* (2016) also found that age did not have a significant effect in either Christchurch or Hitachi. Santos-Reyes and Gouzeva (2020) showed that during the Mexico City earthquake, slightly more of the younger group (22 years or less) escaped the building than those aged 34 years or more.

For staying in place, Goltz and Bourque (2017) found a significant association between age (≥40 years) and remaining in the same place during the earthquake with those under 40 years more likely to stay where they

were. In the night-time Emilia-Romagna earthquakes, Prati *et al.* (2013) found that those who waited in bed, or stayed in place, were likely to be younger. Lindell *et al.* (2016) did not report on the effects of age and staying in place during the earthquake.

Effects due to age are not always easy to compare between different studies, as age intervals for groupings vary significantly. Santos-Reyes and Gouzeva (2020) used three age groups, 22 years and under, 23-33 years, and 34 years and over. In the Lindell *et al.* study (2016), ages were not broken down into groups, but given as a mean value. Goltz and Bourque (2017) only used two age groups, 39 years and younger verses 40 years and older. In one study by Prati *et al.*, (2012), age groups were not reported, and in a second study (Prati *et al.* 2013) intervals of roughly 10 years were used. Earlier studies by Arnold *et al.* (1982) and Archea and Kobayashi (1984) did not include age information for their samples. Similarly, whilst Roces *et al.* (1992) included the overall age range for their study into actions and injury in the Philippines (3 months to 92 years), the findings were not broken down by age.

The two field studies in this research used the same age intervals for both surveys allowing for comparisons to be made between the samples. For wider comparisons to be made and to better understand whether age has any influence on protective actions taken, the age groups used in studies more generally, would ideally need to be comparable. Future studies could consider how age data is collected and grouped, and what the implications of this are for comparison with existing research.

6.2.2. Gender

Previous studies have looked at the relationship between gender and earthquakes (Alexander, 2013), and this research specifically considers whether there is any effect of gender on the actions taken during earthquake activity.

This research found a significant relationship in the Christchurch sample between gender and sheltering under a table (p = 0.011), with females (40.0%) more than twice as likely as males (15.5%) to do this action. This relationship was not found to be significant in Sendai, though females were still more likely to seek shelter. This research supports the findings from other studies that found females were more likely to seek shelter during earthquakes. Goltz and Bourque (2017) found that females were more likely to seek shelter than males during the three Californian earthquakes, albeit alongside other factors including avoiding objects. This type of protective behaviour is similar to that found by Prati *et al.* (2013), where women appeared to take less risky behaviour - i.e. sheltering rather than evacuating. However, for the same earthquakes (Christchurch and Tohoku) Lindell *et al.* (2016) did not report any relationship between gender and seeking shelter for people in Christchurch and Hitachi. Similarly, Santos-Reyes and Gouzeva (2020) did not report any difference between gender and seeking shelter in the Mexico City earthquake.

The findings from this research suggest that females in Christchurch were more prepared to seek shelter than males, and at a greater rate than people in Sendai, implying that females may be more likely to seek protection indoors. Females in both cities were also found to do the action drop-cover-hold more than males, however this was not significant in either case. No difference was found between males and females for seeking shelter in a doorway during the earthquake in either city.

In both New Zealand and Japan seeking shelter under furniture is an advised action. However, in many studies females have also been shown to be more likely to be injured or affected in earthquakes (Alexander & Magni, 2013). Whilst the tendency of females to seek shelter might suggest they are more aware of, and able to recall the appropriate actions to take, it raises the question about whether females are becoming injured or disadvantaged through undertaking these protective actions.

One possible reason why females are more likely to be injured, is that they are also more likely to provide protection to other people, thereby exposing themselves to greater danger. For Christchurch the relationship between gender and protecting others was highly significant (p = 0.001). This outcome is in line with other findings and papers that suggest this may be part of the 'caring nature' of females to protect and assist others. It may also be that females often work in roles with contact to other people, such as nurses and care-givers. Goltz and Bourque (2017) found that the majority of people engaged in this action were parents going to their children, with females predominantly displaying the behaviour in all three of the earthquakes studied. Lindell *et al.* (2016) found that those with children did try to protect them, but any difference by gender was not reported. Johnston *et al.* (2014) found that females are more likely to report injuries during earthquakes, but without providing a reason. Injury outcomes are discussed later in section 6.5 of this chapter.

Going outside or evacuating a building during an earthquake are not actions recommended in New Zealand or Japan, but findings from this research show that, nonetheless, people frequently do leave buildings at the time of shaking (Christchurch 36.9%, Sendai 22.8%). However, there was no significant relationship between genders in either city for this action, although in Christchurch males were more likely to go outside, while in Sendai it was females who were more likely to take this action. Similarly, Lindell *et al.* (2016) did not find any correlation between gender and leaving the building. However, Goltz and Bourque (2017) did find that significantly more males ran outside than females during the Loma Prieta and Northridge earthquakes but not in the Whittier Narrows event. The findings from Prati *et al.* (2013) also found that more males exited the building during the earthquake than females, and that generally females showed less risky behaviour than males. Prati *et al.* (2013) also drew links between going outside and levels of fear experienced and there may be a link between this emotional factor and the decision to stay in and seek shelter or, to leave a building and go outside. This is discussed further in section 6.2.3 below. These findings suggest a link between females staying in and seeking shelter, and males going outdoors during earthquakes. Further research into why this might be, and the possible outcomes, are important to understand why females are apparently

disproportionately affected by earthquakes, as reported by, for example, Johnston, *et al*., 2014 and Alexander and Magni, 2013.

The action of protecting others during earthquake shaking was the second action that showed a significant relationship in Christchurch ($p = 0.001$). Females were more than three times likely to protect others during the earthquake than males (48.9% and 13.5% respectively). This effect was not seen in Sendai, though a slightly higher number of females did report the action. The specific actions taken to protect someone and the type of person being protected were not defined in this research. This is the opposite of that found by Santos-Reyes and Gouzeva (2020) in the Mexico City earthquake, where slightly more males performed this action, although it was not significant.

The action of sitting or lying down showed a significant relationship in the Sendai sample ($p < 0.001$), with more females performing this action than males (37.0% and 14.4% respectively). This particular action could arguably be seen as a failed attempt to shelter under furniture, or drop-cover-hold, as it does not include protecting or covering the head from falling debris. This action would then be consistent with the finding that more females generally attempt to seek shelter.

No difference was found between males and females in either location when it came to avoiding falling debris. Other research does not routinely consider the avoidance of objects or falling debris by gender.

In summary therefore, if a gender theme can be extrapolated from this data, it is that females are more likely to follow official advice during earthquakes, by remaining indoors and seeking shelter.

6.2.3. Feelings

This research considered whether peoples' feelings had an effect on actions taken during the earthquake and the findings suggest that fear and anxiety may at times influence the actions taken.

In Christchurch, weak associations were found between anxiety and sheltering under a table ($U = 648$, $z = -1.369$, $p = 0.100$, $r = -0.145$) using the Mann-Whitney U test, and fear and sheltering under a table ($U = 631$, $z = -1.881$, $p = 0.060$, $r = -0.198$). In Sendai, a weak association was also found between fear and staying in place ($U = 7371.5$, $z = -1.869$, $p = 0.062$, $r = -0.108$) using the Mann-Whitney U test. This indicates that in Christchurch, fear and anxiety are associated with seeking shelter, and in Sendai fear was more closely related to staying in the one place rather than moving.

These associations between fear, anxiety and actions would suggest that these emotions may be a motivation for people to do something during an earthquake, although which protective action they choose is harder to say.

In other studies, such as Goltz and Bourque (2017) and the three Californian earthquakes, where levels of fear were reported as either low or high, only the Whittier Narrows event showed a significant association with fear and taking shelter or going outside. Lindell *et al.* (2016), in Christchurch and Hitachi, also found that fear was positively related to leaving the building immediately. By contrast, an absence of fear may mean that people are less likely to act – Lindell *et al.* (2016) found that those with lower levels of fear continued with their previous activities. However, the evidence is not entirely clear, as Prati *et al.* (2013) found that seeking shelter was generally associated with lower levels of fear.

Another factor impacting on the decision to follow the advice to remain indoors, seek shelter or drop-cover-hold may be the 'fight-or-flight' response and how this impacts on people's decision making (Leach, 2004). In essence, a person's instinct may be to flee the apparent danger of the building. A typical outcome of fear is to want to escape the situation (Prati *et al.*, 2012), and escape is a frequent response to earthquakes.

The fight-or-flight response, first described by Walter Cannon in 1915, is a physiological reaction that occurs in the body in response to a threat, stressor or harmful event (Kozlowska *et al.*, 2015). The person reacts to a threat by either preparing to stay and fight, or to flee (Kozlowska *et al.*, 2015). At intense levels, the fight or flight response may interfere with people's ability to make decisions, making it difficult to follow advice that may be contrary to one's own survival instincts. However, Leach (2004) reported that a complex cognitive operation that normally takes 8-10 seconds can be reduced to one or two seconds with practice, training and experience in advance of the situation arising. This might suggest that advice alone is not going to be as effective as exercises or drills in influencing people's protective behaviours.

Fight and flight is sometimes extended to fight, flight and freeze (Leach, 2004), which includes the tendency of many species to become immobile in the face of danger. This may account for the high number of people who do nothing when an earthquake strikes, and stay in place, although it is not clear whether this is an instinctive action or a deliberate choice. This is discussed further in the next chapter. Future research might explore this issue further.

6.3. Reasons given for taking actions

This research also captured the reasons that respondents gave for their actions during the earthquake. Whilst there was a variation in the level of detail collected from the Christchurch and Sendai samples, as described in Chapter 4, the mean findings are comparable.

The most common reason given in Christchurch to explain taking an action was 'instinctive behaviour', followed by 'seeming sensible', and having done the action previously in exercises. In Sendai the most common reasons given for actions taken were 'seeming sensible' followed by 'instinctive behaviour', and the third most common reason was 'learnt from previous experience'. Reference to instinctive behaviour would

appear to support the idea that actions may sometime be as a result of a physiological reactions, such as the fight or flight response.

In Sendai more details were obtained from the survey regarding the individual actions and motivations behind them. In particular, participating in exercises was given by some respondents as a reason why they 'sheltered under a table' (21.3%) and did ''drop-cover-hold' (9.6%). As sheltering under a table is an advised action in Japan, this indicates that exercises can be useful to reinforce the desired behaviours, and this is supported by results from the ShakeOut exercises or drills (Vinnell *et al.*, 2020; Showstack, 2013; and others). The use of exercises, drills and practical activities to reinforce behaviour is discussed further in Chapter 7.

The action 'go outside' is not recommended in Japanese guidance, however of those that did do that action, half said it 'seemed sensible', and one third said it was 'instinctive behaviour'. No respondent reported learning this action from previous exercises, and very few from previous experience, indicating that this is possibly an untaught, spontaneous action. It also appears that respondents are aware it is not official advice, as the action of going outside or running for the exit during an earthquake was reported elsewhere in the survey as an inappropriate action to take by just over half of the Sendai sample.

It is difficult to compare these findings with those of other studies as there is little previous research that documents people's reasons for their actions. In the Imperial Valley earthquake, 31% said they took the action because it seemed sensible, 39% because they had done previous drills, and a further 25% had prior experience of earthquakes (Arnold *et al.*, 1982). The frequencies of these reasons are mostly higher than those found from both the Christchurch and Sendai respondents, the exception being in Sendai where a greater number gave 'seemed sensible' (40.0%) as the reasons for their actions.

This research found that gender and age had little effect on the reasons given for taking actions. The findings from Christchurch indicate that across the three age groups, 'instinctive behaviour' was the reason given by half of each age group for taking their actions. The Christchurch sample also indicated that 'instinctive behaviour' was the reason given equally by both males and females, however the 'seemed sensible' option was also selected by males nearly twice that of females. Females were twice as likely as males to report that previous experience and having done exercises were the reasons for undertaking an action. This supports findings from this research that more females do drop-cover-hold and seek shelter than males during earthquakes, both actions that are predominantly taught through exercises. In Sendai, females were more likely than males to give 'instinctive behaviour', 'seemed sensible' and previous exercises as reasons for doing drop-cover-hold and seeking shelter under a table.

The general lack of research into the reasons people take the actions they do highlights a gap in knowledge. The findings from this research indicate that people are predominantly acting on instinct or what 'seems sensible' rather than basing their decisions on exercises or education. A greater understanding of why people

do what they do during emergencies might help to improve the effectiveness of preparedness advice and training. This is discussed further in the next chapter.

6.4. Other influences on actions

The previous sections have outlined the direct influences on protective actions during earthquakes. However, there are a number of other factors considered as part of this research that also have the potential to influence actions. These include demographic variables such as household size, religion and level of education, and others such as a person's position in the building at the time of shaking.

Unfortunately, when the samples were broken down into these subgroups, little meaningful analysis of the data could be undertaken as the resulting group sizes were too small. Nevertheless, for completeness, some relevant observations are worth noting.

Household size

This research considered household size rather than marital status as an indicator of the number of people more closely associated with the respondent. Previous social earthquake research has used marital status as a variable (Lindell *et al.*, 2016; Goltz & Bourque, 2017), but this does not always take into account other people the respondent is living with and to whom they may have strong bonds. In this research households in Christchurch and Sendai ranged from 1 to 5 people, however as the majority of people in both cities were not with family members when the earthquake struck, it is hard to say how the relationships may have impacted on actions taken.

This research was undertaken in countries where family sizes are small to medium, however future research in countries with more complex family units and communities could be done to take into account the possible effects of household and community on actions taken during an earthquake.

Education level

Levels of education are widely reported as having an influence on people's preparedness (Goltz & Bourque, 2017; Lindell *et al.*, 2016; Shapira *et al.*, 2018) and vulnerability during disasters (Park *et al.,* 2019). The samples in this research mostly included those with high school and tertiary levels of education. No relationship was found to exist between education levels and actions taken during the earthquakes in either Christchurch or Sendai. In both Japan and New Zealand earthquake drills are conducted at all levels of schooling, so for these countries the relevance of education level may show less of an influence on actions taken during earthquakes. However, Goltz and Bourque (2017) in their research on three earthquakes in California did find that a higher level of education was one variable of many that resulted in actions being taken that generally followed accepted public advice.

Mobility and disability

This research asked respondents if they had mobility difficulties at the time of the earthquake, in order to determine whether this impacted on their ability to undertake protective actions such as drop-cover-hold or seeking cover and protecting the head. In this research only small numbers within the samples reported any level of disability or mobility problem (1.4% in Christchurch, 5.3% in Sendai), and it was not possible to identify any effect of mobility and disability on actions taken. This research excluded people with cognitive impairment, which can also impact on a person's ability to understand instructions.

Physical disability in disasters has been widely discussed, with outcomes for people with disabilities somewhat reduced when compared with those without such issues (e.g. Rahimi, 1993; Rahimi, 1994; Park *et al*., 2019; Tatsuki, 2013). Findings from this research show that the inclusion of relevant advice and earthquake protective actions for people with physical disability or mobility problems in wider national advice documents was low, with only 7.5% of the 67 countries included in this research containing such advice. This suggests that the needs of these sections of society are not be being addressed in public awareness and education campaigns. Of those countries that do include advice for this group, much of it is centred on people in wheelchairs, however, there are many other instances where people may have mobility difficulties, such as those using walking aids, or women who are heavily pregnant. Future research into the advice and actions of people with mobility issues therefore needs to also consider the requirements of this group, including those who are not registered as or considered disabled, to ensure that advice is suitable for as many people as possible.

Ethnicity and religion

The samples from Christchurch and Sendai were both strongly skewed towards one religion and one ethnicity, meaning that it was not possible to evaluate the impact of these factors on actions taken by comparing different subgroups within them. Other research has indicated that ethnicity may have an influence on increased levels of fear and doing more risky movements (Goltz & Bourque, 2017). Further research in other countries may highlight differences in protective actions during earthquakes where religions and ethnic make-ups are more diverse than the samples used in this research.

Floor of the building

In this research, most people in Christchurch reported they were on the ground, first or second floor of a building, as might be expected. In Sendai however, most people were on either the ground, first or curiously, the fifth floor or higher – the cause of this distribution is unknown. Analysis of the data showed that the level, or floor, of the building that people were on during an earthquake did not appear to have an effect on the actions that people took during shaking. This is in line with a study by Arnold *et al.* (1982), where occupants of a six-storey building during an earthquake did not demonstrate any differences in protective actions attributable to the floor of the building they were on. New Zealand and Japan building codes are

generally considered high, and further research may reveal an effect of floor levels on protective actions in buildings that are less able to withstand earthquakes, such as those without reinforcement.

6.5. Consequences of protective actions

This research attempts to find a link between protective actions, the influences on those actions, and the outcomes, or consequences, of those actions. The aim of taking a protective action is to reduce the likelihood of injury or death, and to increase the chance of survival from the earthquake. Understanding the outcomes of protective actions will assist in developing relevant and appropriate earthquake preparedness messaging. Studies into behaviour and actions taken during earthquakes have not routinely considered outcomes (e.g. Santos-Reyes & Gouzeva, 2020; Goltz & Bourque, 2017, Prati *et al.*, 2012, Lindell *et al.*, 2016, Prati *et al.*, 2013). Shapira *et al.* (2018) have modelled behaviour and risk of injury and death during an earthquake, however this was a simulation-based study with people expressing their intentions about what they would do if experiencing an earthquake.

6.5.1. Respondent description of entrapment actions

De Bruycker *et al.* (1983) defined entrapment as being when a person 'had been buried underneath debris or been locked into an enclosed space and needed help from outside to be freed'. Entrapment, due to a collapsed building or falling debris, is a risk for anyone caught in an earthquake or its aftershocks. However, guidance for protective actions during earthquakes in Japan and New Zealand does not currently contain advice on what to do if a person becomes trapped as a result of the event.

This research asked respondents to describe the actions they would take if they became trapped during or as a result of an earthquake. This is a question that is rarely, if ever, asked of respondents. Nearly half of responses in both Christchurch and Sendai included shouting for help or calling to attract attention. A further quarter of all respondents said they would keep calm. However, in general the results indicate that the Christchurch sample would take a more active approach to being trapped, by using a mobile phone to call for help, assessing the options for escape and tapping or making a noise to attract attention. In Sendai the approach appears more passive, with suggestions including to lie still, conserve energy, and wait for help. Proposed mobile phone use was four times higher in Christchurch than Sendai (35.4% and 8.3% respectively).

Other than entrapment advice issued by some countries, there is sparse mention in the wider literature of the preferred actions to take if trapped. Analysis of earthquake advice documents during this research indicated few countries include advice about what to do if trapped. Of the nine countries that did so, the contents were similar in nature, and the most common advice was to tap on a pipe or similar, followed by not shouting or kicking up dust. The Christchurch sample suggested actions more closely related to this advice with their active approach than respondents from Sendai, however for both samples, a wider knowledge of trapped actions was generally lacking.

Being trapped during an earthquake has an adverse effect on outcome, with the longer someone is trapped making it less likely they are to survive (de Bruycker *et al.*, 1983). Understanding how people might respond whilst trapped can assist in the search and rescue phase in the aftermath of a destructive earthquake. Currently, skilled search and rescue teams are taught to listen for people tapping, and if the public are not aware of this action, location of trapped survivors may be delayed. Large amounts of time and effort are spent on search and rescue in the first hours and days post-earthquake, therefore ensuring that people know how to behave if trapped may assist in increasing survival rates. In the 1980 southern Italy earthquake 9% of trapped people reportedly shouted for help but died before being rescued (de Bruycker *et al.*, 1983).

The high number of people expecting to rely on using a mobile phone is of concern, as not only may mobile phones not work after an earthquake, battery life of the device may be short. Information contained in the coroner's report into deaths from Christchurch shows that several of the trapped people were using their mobile phones to make calls before they subsequently died (Matenga, 2014). Nonetheless, it cannot be denied that mobile phones may be useful for calling for help in the immediate aftermath of an earthquake.

This research proposes that entrapment advice should be included as part of the actions to take during an earthquake, as damaging earthquakes are frequently followed by aftershocks, and those who remain trapped will need to act from such a position. The wide range in actions suggested by respondents in this research indicates that there is a lack of consistent advice about what to do in this situation, and that whilst these events are rare, information ought to be made available to the public.

Developing advice for entrapment situations ideally needs to be done in conjunction with technical input from search and rescue experts who will ultimately be searching for the most complex entrapments. Further work is required to better identify the most appropriate actions to recommend to the public for this situation, and to ensure these are contained in preparedness advice documents as part of actions to take during an earthquake.

This leaves two unanswered questions about entrapment for future investigation. How much is being trapped during an earthquake an outcome of poor actions and how much is due to poor building design and strength? This is therefore closely related to the question of how building design influences the actions that people do take.

6.5.2. Injuries and being struck by debris

Injuries and being struck by debris are possible consequences of an earthquake and this research also considered whether respondents were injured during shaking. In both Christchurch and Sendai, the proportion of respondents reporting injuries was low (7% and 5% respectively), and therefore statistical analysis is inappropriate. Despite this, it is still worth discussing the findings, albeit briefly.

In Christchurch, 80% of injuries were caused during the earthquake, but only 47% in Sendai. Nearly all injuries in both cities took place inside a building, and the severity of the injury was described as 'injured and able to walk' for all but one injury that was 'injured and unable to walk'.

The actions undertaken at the time of the injury being sustained were similar across both cities, where 60.0% of those injured were trying to protect themselves, including evacuating the building (20.0%), doing drop-cover-hold (20.0%), and protecting oneself (20.0%) at the time of injury. Despite the small numbers, this is a relatively high proportion of injuries caused whilst trying to undertake a protective action. In contrast, the study by Johnston *et al.* (2014) into injury during the Christchurch earthquakes showed those who moved during the earthquake, a potentially avoidable action, totalled only 18.0% of those injured.

In this research the causes of these injuries were predominantly slips and trips (40.0% in Christchurch and Sendai), along with falling objects (Christchurch 20.0%, Sendai 40.0%), and debris or glass (Christchurch 10.0%, Sendai 20.0%). Although care must be taken with the small number of injured persons in the samples when making comparisons, the frequencies in this research are comparable to that found by Johnston *et al.* (2014) where trips and falls were the cause of 26.1% of injuries, projectiles 15.3%, glass and masonry 5.1%. However, the Johnston *et al*. study is not clear about the action being taken when the injury occurred. Petal's (2004) study of the 1999 Kocaeli earthquake in Turkey found somewhat different causes and frequencies for injuries with the most common cause cited as being struck by, or caught under, objects. The study found that 83.5% of injuries were caused during the earthquake.

Findings from injuries sustained in the 2016 Kaikoura earthquake in New Zealand indicated that injuries were most likely to be caused by loss of stability during the earthquake (36.8%), due to falls or 'being thrown' (Horspool *et al*., 2020). This raises the question of whether following advised actions might increase a person's chance of injury when compared to staying where they are. Horspool *et al*.'s study reported that 13.1% of injuries occurred while attempting to take cover and another 13.8% while getting out of bed. However, advice from New Zealand does appear to consider this possibility when suggesting that in the event of a night time earthquake, people should remain in bed until the shaking stops.

Numerous other studies exist that focus on injury causes and patterns following earthquakes (e.g. Gunn, 1992; Johnston *et al.*, 2014), and found that the majority of trauma from earthquakes is due to building collapse, entrapment, flying debris and falls. Further research is required, with larger sample sizes, to better understand whether there is a link between taking a particular protective action and sustaining an injury.

<u>Being struck by objects or debris</u>

One of the ways people can become injured during earthquakes is through being struck by loose objects or debris, such as falling ceiling tiles and glass. In Christchurch, 14.9% of respondents reported being struck by objects. In Sendai this was lower at 11.3%. These results are slightly higher than those from Arnold *et al.*

(1982) in their study on occupant behaviour following an earthquake where 8% of building occupants dodged to avoid falling objects as their first action. Whilst not precisely the same as being struck by an object or debris, it gives an indication of the proportion of people that might be affected by debris-related hazards.

Findings from the national earthquake document analysis indicate that instruction to avoid glass or loose and falling objects was included by more than two thirds of countries in the review, and was one of the top five actions included. Advice to secure such items is frequently contained in preparedness advice, of which a third to a half of respondents in both cities reported they were aware.

The findings for both cities show younger people (age 20-39 years) were more likely to be struck by an object or debris than older people (60+ years). This may be due to the younger group being more agile and able to move during earthquake activity, thereby putting themselves more at risk of being struck. However, the counter argument might be that the elderly group would be more at risk due to lower physical ability and therefore being less able to move out of the way of debris. Data was not collected as to the type of object the person was struck by.

Specific advice for the elderly about actions during an earthquake was rarely included in national guidance documents, however New Zealand advice for the elderly is to remain in place and brace themselves. The above finding might suggest that this could be applied to all age groups rather than suggesting that other people attempt to move towards shelter. Further research with larger samples that considers the frequency with which elderly and younger people are struck by objects and the level of injury sustained, if any, may be useful to determine whether remaining in place and bracing against furniture or walls is safer than moving to another location in order to perform, for example, drop-cover-hold.

Whilst the findings indicated a difference due to age, there was no consistent difference with gender and being struck by objects. In Christchurch, more females were affected, but in Sendai this reversed and more males were struck by objects.

Earthquake preparedness advice from both New Zealand and Japan advises that people avoid falling debris or moving objects in the room during an earthquake. Findings from this research indicate that there was no significant effect of an awareness of preparedness advice such as drop-cover-hold and avoiding being struck by objects during the earthquake.

Fatalities

This research excluded the actions of those who were deceased as a result of the earthquake, however being killed is one possible outcome. Much has been written about fatalities during earthquakes, focusing on demographics of the deceased (Alexander & Magni, 2013), but there is less written about the actions that the deceased took in the moments before they were killed. Information regarding actions of the deceased

prior to death may be challenging to investigate, nevertheless, such research might provide an insight into why some people die and some survive. In New Zealand, the Royal Commission of Inquiry into the Christchurch earthquake did explore the actions of some of those who would later die in the earthquake (Royal Commission, 2012), however it is beyond the scope of this research to describe the findings here.

6.5.3. Reasons for surviving the earthquake

This research sought to understand the reasons why people thought they survived the earthquake, and whether they believed that their actions contributed to this. Considering that the actions an individual takes during an earthquake may impact on their chances of survival, two thirds of residents of both Christchurch (60.8%) and Sendai (68.0%) stated building strength as the main reason for their survival. However, differences in other reasons exist for survival between the two cities, particularly in Sendai, where 24.0% of respondents also thought that staying inside during the earthquake was a factor in their survival, but in Christchurch this fell to 2.9%. This may reflect levels of confidence in building strength and that the building will withstand the earthquake long enough for people to subsequently evacuate. In Sendai, the combined protective actions of drop-cover-hold and taking shelter were mentioned by nearly a third of respondents (30.0%) as a reason for survival, but in Christchurch these actions ranked significantly lower with a total of only 2.0%.

These findings suggest that respondents believe the main cause of their survival in both cities is building strength. This is not unexpected considering both countries have strongly enforced and rigid codes for building construction (Egbelakin & WIlkinson, 2010; Egbelakin *et al.*, 2013), and this may give people confidence and a sense of safety to seek shelter and remain indoors during an earthquake. However, in Christchurch, where staying inside scored low as a reason, two large central city buildings collapsed during the earthquake causing most of the fatalities, and this may have impacted retrospectively on the Christchurch sample's attitudes towards staying inside a building.

If, as suggested, people choose to remain inside a building during an earthquake, then the actions taken inside become important to improve survival and reduce injury. As mentioned above, in buildings where people spend large amounts of their time, particularly if there are likely to be no items of furniture that can be sheltered under, it may be possible to provide reinforced areas for people to use when taking shelter, although movement during an earthquake is often more difficult than people anticipate (Akason *et al.*, 2006).

6.5.4. Protective actions and their outcomes

As previously discussed, there are a range of protective actions taken during an earthquake and a number of variables that potentially influence these actions. The consequences of taking these measures in human terms can be seen in whether the individual survives the earthquake and whether they are injured.

Therefore, in the most simplistic terms, outcomes regarding protective actions and survival can be classified as:

- Not injured
- Injured
- Dead (fatally injured)

In the immediate aftermath of an earthquake each of these outcomes may also involve entrapment in or under a building. Therefore, the range of possible outcomes can be categorised as:

- Trapped, or not trapped, and not injured
- Trapped, or not trapped, and injured
- Trapped, or not trapped, and died

These consequences of actions taken can be portrayed in a 'Protective Action Outcomes Diagram', as shown in Figure 6.1 below.

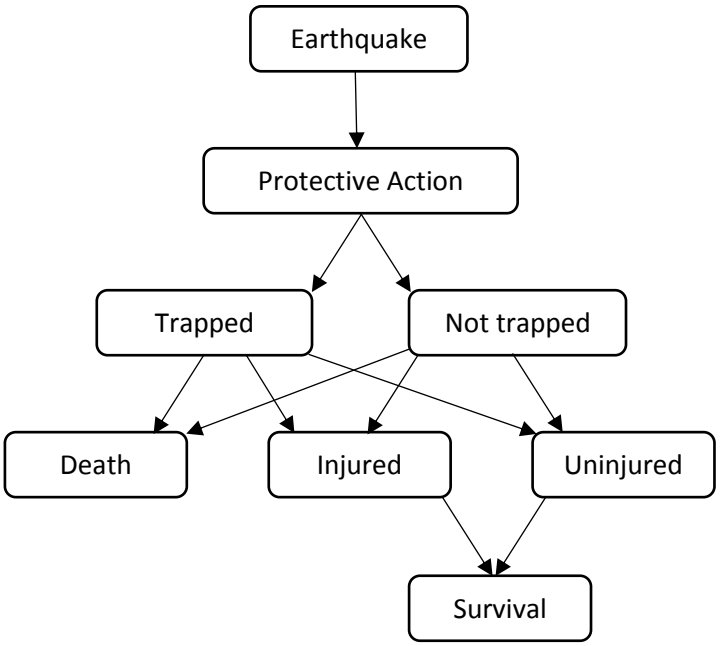


Figure 6.1. Protective action outcomes diagram

The diagram depicts these outcomes starting with the earthquake occurring and the individual taking a protective action. Whilst the diagram does not include external influences on actions, such as age and gender, it does show in a simple manner, the various outcomes, including for those who are trapped or injured. Survival reflects an outcome of the earthquake, and could be used as a positive indicator of actions taken. This schema might also be used as a framework for classifying outcomes of actions during earthquakes in order to evaluate their efficacy.

The challenge, however, in determining behaviours that enhance survivability is the complex interaction of variables that influence actions taken. For example, these actions may be influenced by preparatory measures taken hours, days or years before an event, and it is these preparedness activities and their influences that will be discussed in the next chapter.

6.6. Summary

This chapter has highlighted and discussed the findings from the two field surveys in Christchurch and Sendai concerning the actions that people take during earthquakes, including the reasons for these actions and the outcomes. Taken as a whole, these findings have shown that individual decisions about protective actions to take during an earthquake are affected by a variety of influences, and this presents a challenge when trying to evaluate the content and effectiveness of public advice.

The directly protective actions of seeking shelter either by getting under furniture, drop-cover-hold, or standing in a doorway were commonly performed actions reported by more than half the respondents in both cities, suggesting that respondents believe that these actions have benefits in terms of protecting themselves during an earthquake. However other actions such as staying in place, going outside, avoiding falling objects, protecting and assisting others, and saving personal property, were also undertaken, and some of these actions are not advised.

This research has shown that the effect of demographic variables of age and gender, had no significant effect on actions taken, except for seeking shelter and drop-cover-hold, where more females undertook this action, along with younger people in Sendai. Feelings of anxiety and fear showed only a weak link with taking actions, particularly sheltering under furniture.

The reasons people gave for doing their actions are predominantly ‘instinctive behaviour’ and ‘seeming sensible’, with exercises and previous experience less likely to have an effect. However, preparedness exercises were linked to seeking shelter and drop-cover-hold, with implications for drills such as ShakeOut - this is discussed further in the next chapter.

Factors including household size, ethnicity, religion, disability and position in a building showed no significant effect on the protective actions taken during the earthquake. This was partly due to the homogenous nature of the two samples in this respect. Future research with larger and more diverse samples will be needed to further investigate the effects of these variables.

Consequences, or outcomes, of taking protective actions during an earthquake include entrapment, being struck by objects, and injury. Whilst avoiding falling objects and debris is included in earthquake advice, information on actions if trapped is generally not present, and awareness of actions in this situation were

low. Finally, the protective action outcome diagram suggests a way to categorise the outcomes related to actions taken.

Overall, therefore, this chapter has shown that there are many personal factors, such as age, gender and mobility, that influence people's choice of actions during earthquakes, and it is not possible to say that any one of these factors is more important than another. The question that remains to be answered is, does earthquake preparedness advice also shape people's behaviour, and if so, in what way?

Chapter 7: The role of preparedness advice in behaviour

The previous chapter considered the influence of age, gender and other individual factors, such as emotional state on the actions that people take during an earthquake. Preparedness advice was also considered in the context of these factors, and the aim of this chapter is to further explore and develop the understanding of the role and effectiveness of official advice in shaping people's behaviour.

A key question for this research is how aware are people of the advice provided, and does awareness translate into action? Within this, attitudes towards drop-cover-hold and how the relevant effectiveness of passive advice, such as written or spoken materials, compares with activities such as exercises and emergency drills, is also of interest.

A broader overview of the nature and value of protective advice is further provided by exploring the results of the document analysis of advice from 67 countries in more depth.

7.1. Preparedness advice and its influence on protective actions

Given the significant resources that are put into providing preparedness advice, there is surprisingly little research into its effectiveness on shaping behaviour specifically at the time of shaking. A central focus for this thesis has been to explore that question and to see whether there is any evidence to show if, and how, advice from governments and their agencies is understood and acted upon by people in event of an earthquake.

7.1.1. Awareness of preparedness advice

Authorities in New Zealand and Japan issue earthquake advice that includes actions to take during an earthquake (see Chapter 3). This research has shown that differences exist between Christchurch and Sendai in the levels of awareness of this advice. Christchurch respondents were more than twice as likely to be aware of official earthquake advice as in Sendai (85.3% versus 34.0%). This is similar to that reported by Lindell *et al.* (2016), who found a similar difference existed between Christchurch and Hitachi. As they point out, these differences may be due to Christchurch having experienced a large, but less damaging, earthquake on 4 September 2010 that was also followed by six months of aftershocks (Lindell *et al.*, 2016). This may have caused the population to take greater interest in the advice that was available when compared to Japan, and the New Zealand authorities may also have increased the frequency and extent of public awareness campaigns at this time.

Accepting that the aim of preparedness advice is to encourage people to take recommended actions during an earthquake, with a single exception, no significant relationship was found between a general awareness of official advice and the frequency of actions taken, and this was the case in both Christchurch and Sendai.

The one exception was in Sendai where there was a significant relationship with sheltering under a table ($p = 0.049$).

These findings are similar to those reported by Audru *et al.* (2013) after the Martinique earthquake in 2007, where they found that whilst instructions given by authorities were known, they were rarely acted upon. Audru *et al.* (2013) speculated that people's knowledge of what to do during the earthquake was affected by surprise, fear and panic that prevented them from following advice. As Leach (2004) has commented, 'human responses to unfolding emergencies and the tendency to freeze can be understood in terms of neurocognitive function and the time required to process the several steps between perception and appropriate action'. This may go part-way to explaining why, despite knowing what to do, some people are not able to recall and undertake previously learnt lifesaving actions during an earthquake.

However, identifying the reason for this apparent gap between knowledge and action is difficult as there may be several explanations. One possibility is that being able to recall awareness advice while completing a questionnaire is very different to trying to remember the same information in the middle of an earthquake or other real emergency. Vogel and Schwabe (2016), for example, stated that 'stress markedly impairs memory retrieval'. Alternatively, while people may be aware of the official advice, they may choose not to act upon it, either because they do not trust the advice or, as mentioned in the previous chapter, the shaking prevents them from being able to complete the action.

As well as not undertaking recommended actions, respondents were no less likely to avoid actions that were advised against. In fact, in Christchurch, 34.3% of respondents who indicated they were aware of advice chose to stand in a doorway, which is half as many again as those who were unaware of the advice (26.7%). This might suggest that people are remembering the actions described in advice, but not recalling which ones are recommended and which are advised against.

Finally, no relationship was found between age or gender and having an awareness of official guidance in either city. Overall, therefore, this indicates that basic demographic factors appear not to predict an awareness or otherwise of preparedness advice.

It would be useful to be able to compare these findings with other research, however there has been a tendency for researchers either to conflate the elements of preparedness under a single heading, (Goltz & Bourque, 2017), or to focus on advice relating to mitigation measures to take before an earthquake such as preparing additional food and water supplies, emergency kit, and a radio (Lindell *et al.*, 2016). Unfortunately, this does not show how official advice may, or may not, be influencing behaviour at the time of shaking.

What would you do during an earthquake?

Given the absence of significant evidence linking advice to behaviours taken, it is pertinent to ask what people themselves would recommend as appropriate and inappropriate actions to take during an earthquake. One thing to be considered however, is that in the case of the Christchurch and Sendai samples, the responses have come from people who have actually endured an earthquake and so may be different to those who have not had that experience.

Content analysis of the respondent's descriptions of the most appropriate actions during an earthquake revealed a variety of responses, however both cities showed similarities for the five most frequently selected actions as shown below.

Christchurch:

1. Drop-cover-hold
2. Get under strong or solid structure
3. Stand in corner of room, doorway, reinforced area
4. Move away from glass, windows, tall items, machinery
5. Run outside, to open area, get out fast

Sendai:

1. Get under strong or solid structure
2. Move away from glass, windows, tall items, machinery
3. Take cover, cover head with hands
4. Run outside, to open area, get out fast
5. Stay calm

These responses suggest some understanding of the preparedness advice issued by authorities in both countries, as most of the actions suggested reflect those recommended in the respective official advice. However, the option of going outside also features in the top five suggestions. The presence of this option may again suggest that while people remember actions included in preparedness advice, they are less able to recall whether those actions are recommended or discouraged. In cases such as avoiding falling objects, the intention of the advice is clear, but when it comes to standing in a doorway, the merits of the action are less apparent as there is no overt reason why it would be either a good or a bad choice. In this case it may be preferable to mention only recommended actions, and omit from the advice actions that are to be discouraged.

This last suggestion finds support in clinical settings where warning statements surrounding drug administration use affirmative rather than negative instructions to ensure clinicians understand the meaning of a warning, focusing on the action that is needed to be completed, rather than that to be avoided (Grissinger, 2014). Instructions may be more effective if they only describe desired actions, and avoid mentioning undesirable ones altogether. As Sutton (2015) noted in his book on process risk and writing procedures, 'instructions are more likely to be understood and followed if they are written in a positive manner'. Applied to earthquake advice, this could mean including actions such as 'stay indoors' rather than 'don't go outside', and 'stay calm' rather than 'don't panic'.

Actions considered inappropriate during an earthquake

Analysis of the actions that respondents felt were inappropriate to take during an earthquake showed less variation than for the appropriate actions. Respondents from both cities listed the highest ranked inappropriate action as going outside or running for the exit (59.7% Christchurch, 55.0% Sendai). This was followed by panicking or being hysterical. The third ranked inappropriate action was to stand near anything heavy, likely to collapse or flying objects. This suggests that people are aware of some of the dangers that exist during earthquakes, and some actions that should be avoided.

Despite the respondents reporting that running or going outside and panicking were the most inappropriate actions to take, in Christchurch nearly a quarter (22.9%) reported actually going outside during shaking, along with a fifth (20.3%) in Sendai. These findings suggest that although people are aware of an action being inappropriate, they may still take it, in contrast to appropriate actions that people may be aware of, and yet fail to take. The implications of this are that people are likely to continue to do inappropriate actions during earthquakes. This raises the question as to whether people are driven more by instinct than learning. As previously noted, many respondents cited instinct as a reason for the actions they undertook. Savage (2019) has argued that an individuals' instincts in relation to disaster response are either fight or flight, or survival, and that this type of 'instinct' can influence behaviour and decision-making processes.

In the previous chapter, the outcomes of protective actions were discussed, and these included entrapment, injury or death. Therefore, considering the inappropriate actions listed by participants, it would be expected that undertaking these actions might result in an increase in these negative outcomes. Unfortunately, injury data from this research was too small to be meaningfully analysed, and a study by Johnston *et al.* (2014) that looked at injury causes from the Christchurch earthquake does not provide sufficient detail to ascertain whether injuries were caused by inappropriate actions during the earthquake. Further research into the types of protective actions taken during earthquakes and whether inappropriate actions result in increased injury is required.

7.1.2. Drop-Cover-Hold

'Drop-cover-hold' is a term used to describe a key sheltering action in the preparedness advice of many countries and includes getting down and under a strong piece of furniture, then holding on whilst protecting one's head. The term is widely used in the international ShakeOut exercise programme (Great Earthquake ShakeOut Drills, 2015) and specifically mentioned in official advice in New Zealand. In Japan, drop-cover-hold is widely disseminated in advice provided by government authorities, such as those in Sendai and Tokushima (SIRA, 2013; TOPIA, 2014), and through ShakeOut exercises held in the country each year.

This research explored both the levels of awareness of drop-cover-hold and respondents' beliefs about the practicality and safety of performing the action as a result of their earthquake experiences.

Awareness of drop-cover-hold

In Christchurch, respondents had a very high awareness (96.5%) of the drop-cover-hold action. Among those who were aware of official earthquake advice in general, this rose slightly to 97.5% of respondents. In Sendai, around three-quarters of respondents (72.3%) reported being aware of drop-cover-hold, rising to 81.4% of those who were also aware of official advice.

The high rates of familiarity in New Zealand with the action may be expected given that the action is strongly advocated in earthquake preparedness messaging, and is advised for nearly every earthquake situation indoors and outdoors. A further factor in the high rates of awareness seen in Christchurch may have been due to the ongoing aftershocks following the September 2010 earthquake that caused people to give more attention to current guidance. In Japan, the FDMA advice often takes a more directly descriptive approach (see Appendix 2.0), advising actions such as 'seeking shelter under furniture', and this may explain the relatively lower familiarity of respondents to the term.

In both Christchurch and Sendai, the levels of awareness of drop-cover-hold were not reflected in the numbers of people doing the action during the earthquake, and no significant relationships between awareness of, and doing the action were found. As previously discussed in Chapter 6, even when accounting for those respondents who described their actions as 'sheltering under a table' rather than specifically referring to drop-cover-hold, the number of people seeking shelter remained low.

As already highlighted, an awareness of drop-cover-hold does not appear to result in this action being taken during an earthquake. Furthermore, both of the field studies found that among those who were aware of the term 'drop-cover-hold', this was not the language they chose to use when describing what they considered appropriate actions to take, even after their experience of an actual earthquake. This suggests that there is little connection, at least linguistically, between the use of the term and either what people do, or what they think they should do during an earthquake. This raises the possibility that drop-cover-hold is learnt more as a catchphrase than a tool for shaping behaviour. In Christchurch, for example, reported levels

of awareness of drop-cover-hold may be due to a conditioned response, in the sense that respondents are simply 'parroting' a term they have heard due to having been frequently exposed to the term through public messaging.

This disconnect between awareness of the term 'drop-cover-hold' and, both beliefs about appropriate behaviour and actual actions taken, may point to a possible need for preparedness information to use different phrasing, such as 'seek shelter under furniture', similar to that used by people to describe their actions. The phrase 'drop-cover-hold' does not appear to connect with their behaviour. This is discussed in more detail later in this chapter. Further research is required to ensure that disaster management authorities are delivering the most appropriate and effective safety message to citizens, rather than relying on a phrase that is commonly used among professionals but whose efficacy with the public is yet to be proven.

Attitudes towards drop-cover-hold

Among the possible explanations for this lack of a relationship between awareness and behaviour for drop-cover-hold is that, at the time of shaking, it may prove physically difficult to perform the action under this condition, that there is nowhere to shelter, or that respondents are not convinced that it is the safest course of action.

With regard to these explanations, around half of Christchurch (58.3%), and Sendai (45.3%) respondents thought that drop-cover-hold was possible to perform during the earthquake. A significant relationship with awareness of official advice was found in Christchurch ($p < 0.001$) with nearly two thirds of those aware believing that drop-cover hold was also possible. In Sendai, a significant relationship was found between the possibility of doing drop-cover-hold and having previously undertaken earthquake exercises ($p < 0.001$). This difference may be due to the official advice from Japan favouring direct instructions such as mentioned above, rather than the abbreviated version that 'drop-cover-hold' represents.

With regards to opinions about the 'safety' of performing drop-cover-hold, respondents were less sure that this was an effective action to take. In Christchurch 52.1% of respondents had doubts about safety as did 44.3% of those in Sendai. These findings are similar to those reported by Petal (2004) from the 1999 Kocaeli, Turkey earthquake, where perception of the possibility of performing various drop-cover-hold options ranged from 47.1% to 69.2%, and perceived safety of the action ranged from 36.1% to 46.6%.

However, in Christchurch there was a significant relationship between awareness of official advice and a belief that drop-cover-hold was safe to perform ($p < 0.001$) during the earthquake (57.4% aware and 23.8% unaware of advice). These findings suggest that, in New Zealand at least, those who learn of drop-cover-hold through official guidance have more confidence in the action than those who hear about the procedure from elsewhere, suggesting that an awareness of advice may be linked to an increased belief in the efficacy of the action.

In Sendai, a positive relationship was not found between safety of drop-cover-hold and awareness of guidance, but instead existed among those who had previously undertaken earthquake exercises ($p < 0.001$) with 50.7% believing that the action was safe to perform if they had previously done an exercise compared with 31.3% of those who had not. Again, the style of Japanese advice may be behind this relationship being limited to exercises in Sendai, although it is by no means clear. Nonetheless, activities to improve awareness of drop-cover-hold through exercises might improve confidence in the action, as well as providing further information on the rationale of staying indoors and seeking shelter.

The availability of shelter may also contribute to explaining some people's doubts about drop-cover-hold. For example, office workers and school children may have desks to shelter under, but many other people do not reside or work in situations where suitable cover is always available. Additionally, venues such as shopping malls, cinemas and theatres, stadiums and night-clubs, only offer limited opportunities for sheltering.

In addition to the reasons above, Vinnell *et al*. (2020) suggested that social pressure or feelings of embarrassment may be further reasons why people hesitate to perform drop-cover-hold. In another study of Icelandic earthquakes, Akason *et al.* (2006) found that seeking safety inside buildings at intensities MMVII or greater is often perceived as dangerous or impossible. Presumably, the point at which movement becomes impractical is further reduced for those who have mobility problems. For some vulnerable people, such as the elderly, there may be an increased risk of injury when trying to perform drop-cover-hold when compared to, for example, bracing themselves against a wall or other secure object, and this issue has been noted by other researchers such as Tuohy *et al.*, (2014).

Therefore, while drop-cover-hold is the preferred protective action of authorities in both New Zealand and Japan, there are many possible reasons why the public may have doubts about the possibility and safety of performing this action. Given that respondent's views in this study were based upon real life experience rather than simply expressing future intentions, there is clearly some way to go to persuade people of the benefits of drop-cover-hold, even after they have survived an earthquake. Without this acceptance the guidance is unlikely to be very effective in terms of influencing people's behaviour, although as noted for Sendai above, exercises do appear to have some effect on people's attitudes to drop-cover-hold.

Recent work by Vinnell *et al.* (2020), showed that participation in New Zealand ShakeOut exercises resulted in an increase in knowledge of how to perform drop-cover-hold. However, they did not seek to evaluate people's opinions about the efficacy of the action, and focused instead on whether official guidance was followed during what were exercises and not actual earthquake events.

Attitudes towards drop-cover-hold: age and gender

Little difference between age groups or gender, and attitudes towards drop-cover-hold were found in this research, with only a weak association appearing between age and safety of the action in the Christchurch sample (p = 0.086). In this case, confidence in the safety of drop-cover-hold increased with age. However, as noted above, age does not predict the likelihood of people actually doing drop-cover-hold. A possible reason for this is given by Tuohy *et al.* (2014) who suggested that increased fear among the elderly population about being injured through falling, such as sustaining a fractured hip, would make it less likely for the elderly group to want to perform an action such as this.

While no significant difference was found between the proportion of males and females who understood drop-cover-hold in either Christchurch or Sendai, in both cases females more frequently performed the action. Additionally, more females in both locations reported seeking shelter under furniture or doing drop-cover-hold (50.0% female, 20.4% male in Christchurch, and 65.6% female, 51.4% male in Sendai). There are a number of possible, speculative, reasons for these differences, among them being gender differences in types of employment leading to females being closer to a suitable piece of furniture for taking cover under when at work. This might partially explain why more females than males also perceive the action as being possible. As discussed earlier, females may also consider that taking shelter or doing drop-cover-hold, is the less risky action, as opposed to leaving the room or building. These differences could be further researched with larger sample sizes and an emphasis on understanding people's motives and confidence in either drop-cover-hold or seeking shelter advice, as well as further exploring whether this advice actually influences subsequent behaviour.

Drop-cover-hold as a catchphrase

The failure of people to enact the drop-cover-hold advice, even when they are aware of it, naturally raises the question as to why the advice is failing to influence behaviour. This is an important question given that the use of drop-cover-hold as a catchphrase has become widely used in many earthquake-prone countries, particularly those with strong, enforced building codes, such as New Zealand, the USA, Japan and others. It is also widely used as part of the ShakeOut programme (Great Earthquake ShakeOut Drills, 2015), originating in the USA and copied elsewhere, that advocates practicing the drop-cover-hold action at least once a year as part of a structured exercise programme.

This research suggests that in Christchurch, few people associated the actions they took with drop-cover-hold, and instead described their actions during shaking as seeking shelter under a table or furniture. This is despite nearly half the sample retrospectively reporting that drop-cover-hold was the most appropriate action to take. This suggests that people remember the term, but that it has little meaning for them.

The catchphrase and action drop-cover-hold originated during the cold war and focused on school children taking protective actions against a nuclear blast wave by getting under their desks (Preston, 2015). This was then extrapolated to earthquakes where similar forces can be experienced, and has been adopted in countries with high building standards as the preferred action to take. However, the situation in which this action is now being used is somewhat different from cold war America, and this research shows that re-evaluation of the effectiveness of the drop-cover-hold message is required to ensure people routinely perform safe protective actions during an earthquake.

One danger of using a single catchphrase, such as drop-cover-hold, is that by simplifying the message to three words, much of the detail and intention of the action is lost. Individually, the three words 'drop', 'cover' and 'hold' do not in themselves describe a specific action, rather an abstract notion. 'Drop' does not say what, or who, to drop. It is not a command or order, such as 'get down'. 'Cover' is not specific in telling the individual to cover their head, and protect it from falling debris. It is not informative in the way of phrases such as 'seek shelter' or 'cover or protect your head'. 'Hold' does not identify what to hold on to, or how. The words and phrasing used need to connect to a defined action, as referred to earlier, and instructions such as 'get down, seek shelter, protect or cover your head' may be a more informative way to get across the message that during an earthquake it is important to protect oneself from falling debris to prevent injury. Interestingly, a review by GeoHazards International (2015) considered that the statement 'get under a sturdy object' would be more effective than drop-cover-hold.

Another criticism of drop-cover-hold could be that the phrase does not reflect the language that most people would use to describe this type of behaviour. In Christchurch people were far more likely to describe 'seeking-shelter' than were to use the term drop-cover-hold, although for Sendai this difference was less marked. It could be argued that it does not matter how people describe their actions, as long as they take cover, however, using the same language as the audience itself would choose, might be a recommendation for emergency managers.

Another problem with drop-cover-hold is that not every situation is suited to performing the action. The danger of a single phrase such as drop-cover-hold, does not provide alternatives when the instructions cannot be carried out, for example when suitable shelter is not available. It may take more than a simple catchphrase to capture the variety of information that is required to persuade the public to act in the desired manner. For example, in Japan there is also advice on moving away from aisles in supermarkets and department stores to avoid being struck by falling merchandise, something which contradicts the order to drop-cover-hold.

Similarly, 'shelter' might consist of getting down beside a piece of furniture, if it is not possible to use it for cover. In many rooms or situations, there may not be any suitable furniture available, or there may be more

people present than space available, so seeking protection beside a solid item, similar to part of the 'triangle of life' action, highlighted in Chapter 2, may be an alternative – although this research does not explore the efficacy of the 'triangle of life' model itself, and acknowledges the controversy surrounding the idea. This additional option might be communicated with an instruction such as 'get down, take shelter under or near a solid piece of furniture', which is not as catchy as 'drop-cover-hold', but hardly more difficult to remember.

7.1.3. Turning advice into practice – the use of exercises

The above discussion raises the question of how to encourage people to follow advice that is intended to help them remain safe during an earthquake. Perhaps an answer lies with looking at advice provided for other hazard situations. For example, fire emergency preparedness actions are long-established in many countries, and include activities such as drills, and creating a 'helpful' environment such as with the use of illuminated exit signs and accessible positioning of fire extinguishers (Kobes *et al.*, (2010). This might be considered as a basis for behaviour changes regarding earthquake actions. Preparedness in the workplace could include similar relevant practices such as earthquake drills, action signs and providing clutter-free exit routes from the building.

Other possible ways of increasing the influence of advice have already been touched on such as using only positive directions to steer people towards the desired actions. Similarly, using plain, unambiguous language that is familiar to the audience concerned might also add to the potency of the messaging. However, an issue already raised is that under pressure many people revert to 'instinctive' behaviour and may not be able to recall advice that they have been given, that is to say, there may be a strong element of reflexive, or at least partially involuntary, response during earthquakes. In this case, there is evidence to suggest that exercises may be a more effective way of encouraging appropriate behaviour than advice alone. As Leach, (2004) remarked, the ability to make a decision in a very short time requires the brain to be trained to take that life-saving decision through prior practice. The number of people undertaking a task can be improved through training, exercises, drills, and experience. Having learned a response, performing it again does not require the same level of higher order reasoning (Morgenstern, 2017).

<u>Exercises and drills</u>

The use of exercises and drills is well established in disaster risk reduction programmes, and these terms imply a more active type of learning, with people actually practicing the behaviours they are meant to perform, when compared to other more passive methods of providing advice or education. Coffield *et al.* (2004), in a comprehensive study of learning theories, showed that learning was enhanced if a variety of approaches to learning were employed. Incorporating exercises and drills into disaster preparedness programmes would therefore complement and reinforce advice provided through other means.

In the Christchurch sample, 44.1% mentioned that at some stage in their life they had undertaken an earthquake exercise. In Sendai, the figure is higher, with 67.0% of respondents saying they had engaged in earthquake exercises. Nearly half of the Christchurch sample (44.1%) mentioned they had done these exercises whilst at school, which in a survey of adults suggests that for some respondents, the exercises were last done some years previously. A quarter of respondents in both cities reported undertaking exercises or drills in the workplace. A strong significant relationship between doing an exercise and an action was found in Sendai with drop-cover-hold (p = 0.006).

The issue of whether exercises can have an effect on behaviour at the time of an earthquake is therefore in need of further research. However, there is evidence to show that people learn more effectively when, for at least some of the learning, they are actively doing rather than passively receiving information (Leach, 2004; Vinnell *et al.*, 2020; Wilson, 2000), and an implication of this for earthquake preparedness is that people benefit from participating in exercises and drills. Ideas from other disciplines also suggest that exercises can be valuable. This approach reinforces behaviours through practical application of skills (Vinnell *et al.*, 2020), and allows people to practice drop-cover-hold and other sheltering and protective manoeuvres, rather than having to do this for the first time during an earthquake.

As practical application of skills helps embed knowledge, exercises and drills are important methods to enable people to learn and understand the relevant earthquake protective actions. The ShakeOut programme is one such recognised international scheme that encourages communities and countries to practically implement and exercise their earthquake response activities (Great Earthquake ShakeOut Drills, 2015; Rosoff *et al.*, 2011; Vinnell *et al.*, 2020). In the study by Vinnell *et al.* (2020), they found that just over half of those undertaking a ShakeOut earthquake exercise were able to state the correct actions to take indoors during an earthquake. ShakeOut exercises emphasise the drop-cover-hold action, however, as this research has shown, it is not always possible to perform this action, therefore it would seem sensible to add additional protective methods for seeking shelter to this exercise regime.

A perhaps not unsurprising finding was that age and participation in exercises have an association. In Christchurch, younger people were significantly more likely to have done exercises than older people (p = 0.033), and a similar but weak relationship was found in Sendai (p = 0.071). This may be because older people had less opportunity in the past to undertake exercises, but it is unfortunate because with increasing age comes increasing vulnerability to disasters (Tuohy *et al.*, 2014). This is exacerbated by living alone, poorer health and reduced physical abilities. This lack of exercise experience is reinforced by the general lack of guidance for the elderly found in earthquake preparedness advice - this research found that only two countries out of 67 included advice specifically for the elderly. To encourage wider participation, consideration could be given to holding preparedness exercises at community events that this older age

group may be involved with. They may also benefit from having the information tailored towards their specific needs.

For those people with mobility issues, which may include but is not exclusively the elderly, the opportunity to exercise and practice responses to an earthquake prior to an event may enable them to identify the actions that they can or cannot achieve, and, where necessary, explore suitable alternatives. In much of the national preparedness advice that is issued globally, there is little mention of specific actions for those who are physically unable to drop-cover-hold or seek shelter. For those with mental health or learning challenges, the chance to practice such actions may also be beneficial. Further research is required in this area to identify the most suitable methods for learning and the best actions to take to provide protection.

One potential argument against exercises or drills is that the increased realism of the training might create more anxiety for participants as they become aware of the hazards they might be exposed to during an earthquake. However, this research found that for both Christchurch and Sendai, prior participation in exercises or drills, had no significant effect on levels of anxiety or fear during the earthquake. This finding is similar to Prati *et al.* (2013) who found that previously undertaking exercises had no effect on levels of fear experienced during an earthquake.

Whilst not conclusive, the various points discussed here suggest that exercises could form a very important part of earthquake preparedness, particularly where the exercises are targeted towards different groups in the community, and focus on the variety of locations people might find themselves in when an earthquake strikes. At the very least, the value of this method of delivery is worthy of further investigation.

7.2. National earthquake preparedness advice

A third and final element of this research which is yet to be fully described is the document analysis of national earthquake advice from around the world. The reason for including this work alongside the two field studies, in addition to providing a profile of international advice, was to see if what has been learnt from Christchurch and Sendai has any lessons for earthquake advice more generally.

As mentioned in Chapter 4, during the coding process of the international advice, a number of categories were identified by which the many different types of advice available could be described. These were: reference to emotions, protective and general actions inside, protective and general actions outside, hazard reduction, specific situations, groups in the community, and entrapment situations. These are used to frame the discussion around international advice below.

The majority of national earthquake preparedness advice documents contained information in the format ‘before, during, and after’ an earthquake. This is in line with that found by Verucci *et al.* (2016), and would

seem a sensible method to assist people with prioritising preparedness activities, and highlighting specific protective actions that can be taken at each phase.

Several countries included pictures or pictograms as part of their overall advice. These were predominantly used to clarify the action being referred to in associated text. The use of pictures has the advantage of reaching those who are either unable to read or who prefer to learn in other ways.

More generally, and as argued above, earthquake preparedness advice needs to be relevant, accessible and available in a variety of formats that can be understood by a range of audiences as this may assist in ensuring that the most appropriate protective actions are taken during an earthquake.

Some countries shared the same advice to the point where even the wording was identical. This was not simply due to socio-political connections, and occurred between countries that appeared to be quite different in culture, society and development. In the case of a country with limited resources for emergency management, it may be that they wish to use existing materials from elsewhere to reduce costs, on the other hand countries offering international assistance may also fail to adapt their resources to the needs of those they are trying to help.

7.2.1. Reference to emotions and feelings

Analysis showed that 'stay calm' or 'don't panic' were mentioned by less than half the countries in this study. This is in contrast to results from Verucci *et al.* (2016), where nearly all the websites reviewed contained the words 'stay calm'. Unfortunately, sufficient information was not provided with this 2016 study to be able to follow up on the sources of their data, and so it is impossible to say why this difference exists.

Much research has looked at whether people panic during an earthquake (Alexander, 1995; Clarke, 2002, Quarantelli, 2008). It is generally considered that people do not panic, but attempt to deal with the situation they are faced with. Goltz and Bourque (2017) reported findings from studies of the Californian earthquakes that showed panic was not a factor, but rather people showed fear, and this was linked with seeking shelter.

In an international collaboration, GeoHazards International (2015) developed a set of recommendations for developing messages for protective actions during earthquakes, but did not include reference to people's emotions or feelings. In the context of 'positive messaging' described previously in this chapter, a more nuanced approach might be to recommend that people 'stay calm', while avoiding mention of panic, even in the phrase 'don't panic'.

Findings from the field studies, showed that respondents in Sendai included advice to stay calm as one of their top five recommendations for appropriate actions during an earthquake (see section 5.2.4). This also suggests that making some reference to emotions in preparedness advice is desirable.

7.2.2. Advice for indoor situations

For indoor situations, the directly protective actions most commonly used in the documents were to shelter under furniture, and protect or cover the head. Other protective actions that were mentioned less frequently included, to shelter under a doorway or archway, and drop-cover-hold. These actions focus on sheltering and protecting part or all of the body. Respondents in Christchurch and Sendai reported doing all these protective actions at some point during the earthquakes.

The inclusion of drop-cover-hold by 22.4% of countries in this research is in contrast with Verucci *et al.* (2016), who found that 95% of the websites they reviewed included drop-cover-hold. This also differs to the review by Geohazards International (2015), where they found that 49% of agencies involved in the review recommended drop-cover-hold. Again, no insight exists into why this difference occurs and is possibly due to a lack of available information provided by the other studies. One speculative reason for these differences maybe in the sampling approach. Arguably, samples that include predominantly developed nations, may, by default also be selecting those places where higher building codes and building strength mean that remaining inside and performing drop-cover-hold is a suitable action to recommend, when compared to areas where buildings are more likely to collapse during an earthquake. Countries included in this research are listed in Chapter 5, and Appendix 7.0 contains URL links to the advice.

For those indoors, the three indirectly protective actions most frequently recommended in the preparedness documents were a) avoid glass or loose and falling objects, b) don't use lifts or elevators, and c) stay inside, don't go outside. Information contained in the advice differs between countries, with nearly half of countries sampled advising to stay indoors, but several also advise to go outside. Differences between countries may be due to a number of reasons, such as variations in building strength and codes.

A large number of countries advise people to stay indoors, however, as this and other research has shown, some people will choose to go outside. For those countries that can afford it, instead of relying on advice alone, consideration could be given to constructing buildings and structures that allow for evacuation during earthquakes, such as strengthened internal corridors, awnings to catch debris at exits, and strengthening glass windows. Similar strengthening and construction of safe emergency exits was suggested by de Bruycker *et al.* (1985) following the 1980 southern Italy earthquake where people exited buildings during shaking. This is supported by Ambraseys and Bilham (2011) who commented that 'the wealthiest of nations affected by earthquakes can afford both to educate their populations and to purchase good quality building materials'.

A further difference between this and other studies, showed that only three of the countries included in the document analysis referred to getting down beside furniture, rather than under it, and no country advised doing the 'triangle of life' action. A single country specifically advised against taking this action. These

findings contrast with the GeoHazards International (2015) review of earthquake advice which found that 12% of agencies reported using the triangle of life as a protective measure.

7.2.3. Advice for outdoor situations

The actions advised for when outside were found to be less complex and less detailed than for indoor situations. Three actions appeared in more than two thirds of all advice, a) keep clear of buildings or tall structures, b) keep clear of powerlines, and c) to pull over and stop driving when in a vehicle.

A few countries, including New Zealand, also utilised the drop-cover-hold message for use outside. The practicality of this advice is questionable as the drop-cover-hold action requires an object to shelter under, and a person in the open may be at less risk of falling objects than if they were to move under cover. There is no indication in the guidance from providers as to how the drop-cover-hold actions may be taken outdoors. A number of countries included advice to protect or cover the head and this may be a more realistic approach. GeoHazards International (2015) have also recommended to drop to the ground and protect the head and neck, as well as moving to a safe location away from buildings, overhead wires and falling debris.

7.2.4. Advice on hazard reduction

Hazard reduction, in the context of this research, refers to those actions that attempt to mitigate the effects of secondary dangers such as fire. Several countries in this study included some form of hazard reduction as part of their advice, in particular shutting off utilities and not using naked flames. These countries were predominantly in Latin America and the Middle East, which suggests that this form of advice may reflect the culture and living circumstances of people, although this is not certain. New Zealand and Japan do not contain advice on hazard reduction during an earthquake, but instead include it in the 'after' advice section.

Undertaking additional actions, such as those described to reduce hazards, would likely require moving towards the source of the hazard during shaking, which may not be possible and may result in injury by attempting the action. The question is whether people should protect themselves first, and wait for the shaking to stop before managing such issues as utility supplies, as is recommended in Japan.

GeoHazards International (2015) suggested that a protective action is taken during shaking, and then linked to a further action that relates to the secondary hazard once shaking has stopped. Secondary hazards were also considered by GeoHazards International, including tsunami evacuation and preventing building fires, but they state that any messaging associated with these secondary hazards should not be included with the primary earthquake protective actions to take during shaking (GeoHazards International, 2015).

7.2.5. Advice for specific situations

Challenges exist when it comes to providing simple, accurate and effective messages for each situation that people might find themselves in during an earthquake. In general, countries take a generic approach to

messaging that is applicable to most people in most situations, for example using 'seek shelter and protect your head' rather than 'drop-cover-hold'. However, it is not uncommon for some specific locations to be mentioned.

The most common advice for specific situations was for driving a vehicle (76.1%), and the advice provided was similar and consistent across countries – see outdoor situations above. In many cases, advice when driving was also included as part of the general actions to take when outdoors, and is similar to that reported by GeoHazards International (2015).

What to do when in bed is another example of a specific situation, and the advice found was to stay put, possibly covering one's head with a pillow to add protection. GeoHazards International (2015) and Verrucci *et al.* (2016) also found that using a pillow as protection was advised in most guidance, though getting out of bed and crouching near it while protecting the head and neck might also be suitable (GeoHazards International, 2015). However, this advice is not without problems as it can be argued that in the event of being covered by debris, the person could be suffocated by the pillow.

The study by Horspool *et al.* (2020) into the 2016 night-time Kaikoura earthquake found that of those people injured by taking an action, 27% were caused by getting out of bed, and a further 18% were injured moving to a place of safety. Findings from Prati *et al.* (2013) showed that those who experienced more fear were less likely to stay in bed during an earthquake, and this suggests that providing appropriate advice for night-time earthquakes might be required. Further research into actions to take if in bed is required, not only for earthquakes at night, but also for those people who are bed-ridden or in hospital, in order to test the efficacy of using a pillow for protection, or getting out and crouching beside the bed.

Challenges also exist when providing advice for crowded public places, such as shopping malls, arenas, or theatres. GeoHazards International (2015) have suggested that crowd behaviour is a concern in these situations, and modelling studies have been undertaken that review crowd behaviour during earthquakes and evacuation (Cimellaro *et al.*, 2017). Knowing how the actions taken in smaller buildings, such as homes and workplaces, differ to official advice might also be considered when developing messages for places with larger numbers of people. The types of building and density of people may make seeking shelter difficult, so actions such as drop-cover-hold may be less applicable, and an alternative recommendation needs to be provided.

7.2.6. Advice for groups in the community

This analysis of national preparedness advice also considered whether specific community groups were included, such as people with disabilities, the elderly and children, and found there was limited specific protective information provided, with most countries (80.1%) not providing any information. This study found somewhat lower references to specific groups than by Verucci *et al.* (2016) who found that 8% of

websites they studied had information for the elderly, 9% for people with disabilities, and 9% for children. This suggests that national authorities may not be considering groups in the community with specific needs.

New Zealand was one of only two countries in this research to include advice for the elderly, such as 'remain where you are and brace yourself in place' (CDEM, 2015). The other reference was from Kazakhstan and consisted of a prompt to 'think about the welfare of elderly people'.

This research found that elderly people as a group were less likely to be exposed to earthquake preparedness drills, and awareness activities conducted through traditional routes such as the workplace and schools, as they are often retired and do not frequent those locations. Developing a specific communication and messaging strategy for this group of people is important. In many societies, the concept and tradition of living in an extended family is changing, and many elderly people may live alone or without support, others may be in care homes. It is important to ensure messages are communicated to this group and that they are encouraged to practice and prepare for disasters, including earthquakes. Further research is required to ascertain the most appropriate actions for elderly people to take during earthquakes. Following the Christchurch earthquake, studies also showed that for the elderly, advice to drop-cover-hold was not always appropriate due to reduced mobility (Tuohy *et al.*, 2014). This group may also be confined to bed, or have a reduced mental capacity to understand what is happening. Providing carers and staff in residential care homes with relevant advice is, therefore, also important.

Only two countries mentioned children specifically in the generic guidance produced by national authorities, and this was simply advice to think about their welfare. However, it is not uncommon for separate earthquake advice to be provided within the education system, although this was not part of this research. As children are also part of the family unit and not always at school, generic earthquake advice should perhaps also take into account the needs of children at home. Verrucci *et al.* (2016) found no mention of actions that related to children, and GeoHazards International (2015) highlighted the challenges around ensuring safe school buildings and managing large numbers of children, but made no mention of protective actions for children in the home. There appears to be a gap in the advice for this group that includes a range of physical and mental capabilities and dependencies. The needs of pre-school children are different to those of older children, particularly when it comes to reliance on parents.

People with disabilities were the most frequently mentioned community group in the preparedness advice documents. However, even then, only a few countries provided protective action advice. This may indicate that the specific needs of this group within the community are not being recognised and met. Most advice centred on actions for people using a wheelchair. However, this is a broad category that might also include those with less severe mobility issues, and those with visual or hearing impairments. The study by Rahimi (1993) that considered the behaviours of people with disabilities during the Loma Prieta earthquake reported

on the actions taken, but not how these related to official advice, if indeed there was any at the time, that specifically focused on the needs of people with disabilities.

7.2.7. Advice relating to entrapment

As entrapment caused by debris from collapsed buildings is the most common cause of death from earthquakes (Gunn, 1995), it is an issue that cannot be ignored. In Chapter 6, the issue of entrapment was explored as a consequence of actions, and respondents in Christchurch and Sendai showed low levels of awareness of actions they would take if in this situation. From the document analysis, 13.4% of countries included entrapment action advice, with much of the text and phrases found to be similar across the documents, as if sourced from a single parent document.

Advice common to most countries was to:

1. Tap on a pipe or wall so rescuers can hear you
2. Avoid kicking up dust
3. Do not shout
4. Avoid inhaling dust
5. Do not light a match

No reference was made to the fact it might take many hours before rescue, it will likely be dark, the person may be injured, and that mobile phones might not work. Feelings of tension, fear and loneliness have been reported in trapped survivors (Hu *et al*., 2010).

In the analysis of preparedness websites by Verucci *et al.* (2016), no report was made of actions to take if trapped, either during or after an earthquake. Similarly, in the GeoHazards international (2015) review for developing messages for protective actions, no reference was made to actions to take if trapped. Along with a lack of information in preparedness advice, findings from this research also indicate that the public are generally unaware of appropriate actions, with many relying on mobile phones to call for help. Kang *et al.* (*2017*) found that knowing how to help or rescue oneself and others was the main reason trapped survivors managed to free themselves following the Lushan earthquake. Further research is required around the general lack of information regarding knowledge of actions when trapped.

7.2.8. Observations on global earthquake advice

Taken together, the evidence from Christchurch and Sendai, along with the review of national earthquake advice, some broad conclusions might be drawn and suggestions made for areas where further investigations about the value and efficacy of elements of preparedness advice might focus.

What then is the most common advice given around the world for actions to take during an earthquake? The most common advice found in the document analysis, mentioned by more than two thirds of countries, is given below:

1. Keep clear of buildings, tall structures (77.6%)
2. Keep clear of powerlines (76.1%)
3. Pull over and stop when driving (76.1%)
4. Avoid glass or loose and falling objects (71.6%)
5. Shelter under furniture (68.7%)

Other actions that also appeared frequently are:

1. Stay calm (43.3%)
2. Don't use lifts or elevators (52.2%)
3. Stay inside, don't go outside (47.8%)
4. Protect or cover head (41.8%)

Further detail about the frequencies of actions advised for each category used in the analysis is depicted in figure 5.23.

Evaluating the merits of protective advice is not the direct aim of this research. However, along with other observations made about the field studies in Christchurch and Sendai, some broad conclusions can be made about how information is shared and where there are opportunities for development, this includes:

- Protective actions and preparedness messaging should be positive
  Research has shown that when giving instructions it is best to focus on what people should do rather than what they should avoid doing.
- Exercises are likely to influence behaviour more than advice on its own.
  In view of the fact that many people feel their actions at the time of shaking are 'instinctive', experiential learning, i.e. exercise and drills, may have a significant role to play in shaping behaviour.
- Groups with specific needs are mostly overlooked.
  The elderly, children and disabled, are generally overlooked in national advice and this may result in more injuries or deaths in these groups unless greater attention is given to their specific needs.
- Advice for specific situations could be provided.
  A single piece of guidance, such as 'drop-cover-hold', is unlikely to cover all situations, and perhaps not even most circumstances. Over-simplifying messages may mean that people in a number of

different settings, as well as with different needs as mentioned above, may not be getting the best, clearest, or most applicable information.

- Advice for entrapment situations.
  A general lack of information and awareness in this area means that further research to provide clarity on the types of actions to take is needed.
- Even general advice needs to be relevant to its broad context.
  When developing advice, care should be taken not to transpose guidance that is relevant to one region or country onto another location without first ensuring that it still remains relevant.

7.3. Public messaging

The observations immediately above can also be related back to more general theories about communication, and about public messaging in particular, some of these were noted in Chapter 2. This raises the question of how can the success, or otherwise of preparedness advice, in its broadest sense, be evaluated? Various studies have tried to answer this question, some asked people's intentions (Shapira *et al.*, 2018b), others looked at what happened at the time of a disaster (Lambie *et al.*, 2017), and still others surveyed survivors after the event (Lindell *et al.*, 2016; Santos-Reyes & Gouzeva, 2020). It might be hoped that there would be some consistency in these answers, however, this research has found that this is not the case. Even the same respondent is inconsistent in reporting their actions versus what they felt would be appropriate during an earthquake, and both of these are different again from what is considered appropriate in general earthquake advice. This can be seen in Table 7.1 below, which compares the top three reported actions taken in Christchurch and Sendai alongside the 'appropriate' and 'recommended' actions suggested by the same respondents. The final column shows the top action from the national advice documents.

Rank	Christchurch actions	Sendai actions	Appropriate actions – self-described	National advice indoor actions
1	Avoid objects	Stay in place	Drop-cover-hold	Avoid glass, falling objects
2	Stay in place	Drop-cover-hold	Seek shelter under furniture	Shelter under furniture
3	Go outside	Avoid objects	Move away from glass, tall items	Don't use lifts or elevators

Table 7.1. Top three actions from each group

Missing from this collection is a description of what people intended to do before the earthquake. However, this information is provided in part by Shapira *et al.*, (2018b) who reported that anticipated behaviour in Israel was in line with guidelines issued by the authorities, including exiting the building and seeking shelter indoors. However, Paton (2003) also found that people often did not actually carry out their stated intentions

when it comes to preparing for a disaster, suggesting that expressed intentions are of limited value as an indicator of actual behaviour.

This inconsistency between a) what people say they will do, b) what people do, c) what they say is appropriate, and d) earthquake advice, suggests that the messaging has a limited effect on people's actions during an earthquake. If guidance was influencing both people's intentions and behaviours, then a greater alignment between these elements would be expected.

What then are we to conclude about the behaviour of people during earthquakes and the benefits or otherwise of preparedness advice? This is the subject of the concluding chapter of this thesis.

Chapter 8: Conclusions

The aim of this research, as stated in chapter 1, has been to investigate the protective actions that people take during earthquakes, and the effect of earthquake preparedness advice, and other variables, on these actions. This research had four main topics of investigation, also detailed in Chapter 1, namely: what actions do people take during earthquakes, what influences these actions, what are the outcomes, and what is recommended in earthquake preparedness advice?

This chapter provides comment and conclusions on these themes. It also explores the scope and constraints of the study, considers the implications for earthquake preparedness advice, and finally offers some suggestions for future research.

8.1. What protective actions do people take during earthquakes?

The case studies in Christchurch and Sendai have shown that people will pursue a variety of different actions when the ground is shaking beneath their feet due to earthquake activity. Some of these actions are in line with what is generally advised by emergency management agencies, but others are not.

In broad terms, actions taken will consist of one or more of the following:

- Attempting to seek shelter under or beside an object of furniture
- Standing in a doorway
- Remaining in the same place
- Attempting to leave a building

These behaviours may be unsurprising, however further actions were taken that are rarely mentioned in the guidance include attempting to retrieve or save possessions, and providing assistance to others. Some of the actions are specifically advised against, such as standing in a doorway, or going outside.

8.2. What influences the actions taken during earthquakes?

Perhaps one of the more surprising results of this research is how little people's actions appear to reflect the advice they are provided with. This difference is sometimes in terms of how they choose to describe their actions, and sometimes it is actually contrary to what the guidance recommends.

In Christchurch, for example, the population has been exposed to the 'drop-cover-hold message for many years and yet the respondents in this research appear to prefer to describe their behaviour in terms of 'seeking shelter' or similar phraseology. This is not to say that people are unaware of the term 'drop-cover-hold' but that it does not connect with what they experience in themselves or the situation they find themselves in.

Standing in a doorway was another common action even though it is specifically advised against in New Zealand and not mentioned in the advice from Japan. This raises the question of why people think that the action is a good idea. Two possible explanations that were discussed are that either people still recall outdated information that does not reflect changes in building techniques, or that including advice against doing an action is having the opposite effect.

Another common action that people will do in spite of advice to the contrary is to try and leave a building during the earthquake. It was proposed that some actions may be the product of fear rather than reasoning, with the implication that many are more afraid of being trapped in a building than they are of being struck by falling objects while trying to escape. However, perhaps even this implies a level of conscious decision making that is beyond the individual when they are gripped by a 'fight or flight' response.

Contradicting the above, are the group of people who choose to offer assistance to others rather than solely thinking of their own safety. This 'pro-social' behaviour implies a degree of deliberate intention in people's action that is contrary to that suggested by the physiologically centred fight or flight response. Clearly, attempting to explain people's actions in terms of the choices they make or the 'instincts' that drive them, is fraught with complexity, and may also be overly simplistic.

An alternative focus for potential influences on behaviour was explored by looking at the effects of age and gender on the actions people take. The research concludes that age has little effect on the protective actions taken during earthquakes, and this supports the findings of previous studies. However, in coming to this conclusion it is noted that the variations in age groups used by different studies makes comparison across these studies difficult. When comparing the two samples in this research using the same parameters, no effect from age was found.

Regarding the influence of gender, this research concludes that females are more likely to take protective actions than males. Performing these actions may indicate that females are not as vulnerable as previously reported in earthquakes, and in fact are aware of the actions to take and able to perform them. By contrast, and in common with research in other fields, males were more likely to display riskier behaviour such as going outside, although this difference was not statistically significant in this study.

This gender difference fails to explain why females are more likely to be injured or killed in an earthquake than males, and while there are many possible reasons for this connected to factors such as women's roles in society, more research is needed to check that the outcomes of taking advised actions are not contributing to this effect.

The exploration of other demographic factors such as household size, religion and ethnicity, was limited in this research as sample sizes for these groups were small, and it was not possible to comment with any degree of certainty on the influences of these variables.

In exploring the relationship between official advice and actions taken, high levels of awareness of advice were found in both of the field studies. However, awareness did not appear to translate into action, as low levels of compliance with the advice were found. Some of this may be due to differences in descriptions given in the guidance and the everyday language people use to describe their actions. For example, many people describe seeking shelter, rather than using the term 'drop-cover-hold'. It may be that using a catch-phrase, such as drop-cover-hold, is ineffective in so far as, while memorable, it actually fails to create the impetus for action that more directive language could. The three words 'drop', 'cover' and 'hold' are all verbs with no object attached. Drop what? cover what? and hold what? are not explained. In this respect it has been argued that instructions along the lines of 'drop to the ground, seek shelter and hold on to something' might be more effective.

One area where a significant relationship between guidance and action was found, was in the use of exercises and drills. In Sendai, a strong relationship was found with people who had previously taken part in earthquake exercises being more likely to drop-cover-hold than those who had not. However, this relationship was not found in Christchurch and one explanation for this might be in the duration of the two earthquakes, with those in Sendai having more time to decide to perform drop-cover-hold before shaking ceased.

People's actions and behaviours form part of a complex relationship with their experience of earthquakes. From the previous discussion and conclusions above, as well as considering the available literature, it can be evidenced that a variety of influences exist that impact on both the actions taken during earthquake shaking and survivability. These influences come from a variety of directions including individual and social factors, the nature of the physical environment and the characteristics of the earthquake event itself.

Figure 8.1, below, attempts to illustrate these factors diagrammatically. The diagram shows how the interaction of these factors produce yet further influences on actions and outcomes, or survivability. For example, it may be argued that people from wealthier countries may be better prepared as individuals (i.e. a human factor) to survive an earthquake, because their society has the physical resources available to provide the necessary information and training to achieve this (an environmental factor). Figure 8.1, therefore, is a way of showing that many variables affect how individuals may act during shaking as well as how these can affect outcomes such as level of injury.

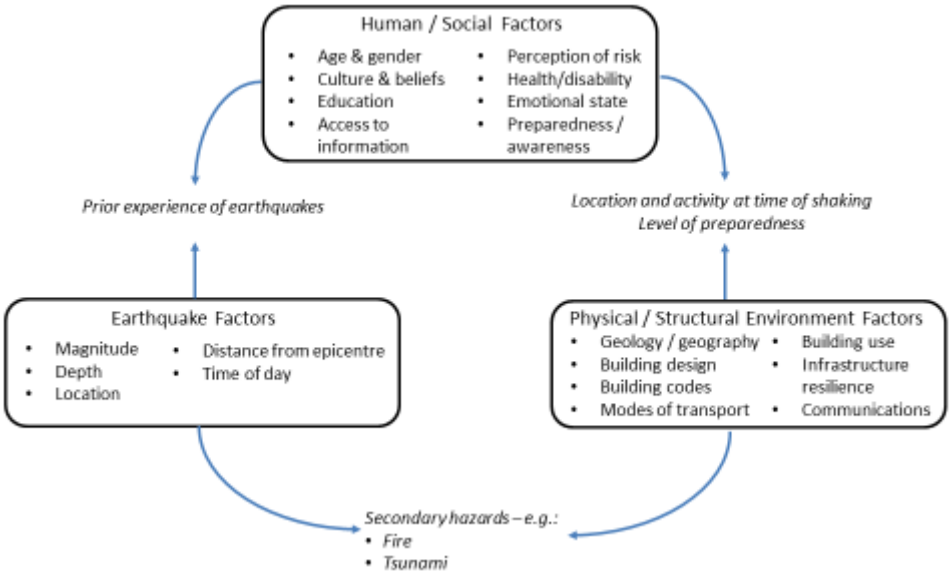


Figure 8.1. Factors influencing protective actions during earthquakes

While the value of such a model is yet to be proven, it is worth noting the similarity it has to the epidemiological triangle relating to disease transmission that comprises a) the host, b) the environment and c) an agent (e.g. pathogen), and which has been adapted to reflect the disaster environment (Parrish *et al.*, 2014; Ramirez & Peek-Asa, 2005). In the context of earthquakes the three major factors, described in Figure 8.1, might serve to remind disaster management agencies that saving lives and reducing injuries requires a range of inputs and responses, of which providing preparedness advice is only one (other variables may also be added to those described under each of the three main factors). This idea is developed further below.

8.3. What are the consequences of the actions taken?

Another aspect of this research was to explore how the actions that people take are related to the outcomes in terms of survival. Fortunately, for the respondents in Christchurch and Sendai, the overwhelming majority were uninjured during their respective earthquakes, but this meant that few inferences could be made about how individual actions affected outcomes.

However, information was gathered about what people attributed their survival to. For example, was one particular action seen as more effective than another, or was 'fate' the only determinant? The surveys showed that most people attributed their survival to building strength and few mentioned the actions they took as the main cause. This does not mean that people do not see any value in taking action, but that, perhaps not unreasonably, while seeking shelter can reduce injuries, it is unlikely to be seen as the deciding factor in whether or not one survives a collapsing building.

This study also explored the little researched area of entrapment during earthquakes, including the actions taken and the advice given. In both cases, levels of knowledge amongst respondents and the prevalence of

relevant official advice were found to be limited, with little evidence to suggest that this situation had been considered in any great detail. While entrapment situations are generally rare, it is nevertheless an important area of earthquake advice and response that has received little attention and further practical research in this field would be beneficial.

Another question raised by this research but which is not directly addressed by it, is the question of how effective the prescribed actions are in preventing injury and death. While advice and training are sometimes effective in influencing people's behaviour, there is a lack of evidence to show that this has a significant impact on the outcomes for the individuals who act according to the advice. This may be due to the challenges of researching real-life actions during earthquakes, or perhaps simply because there has been insufficient research into the efficacy of the accepted advice.

8.4. What actions are recommended in earthquake preparedness advice?

The review of preparedness advice across 67 countries and territories found both similarities and differences between the guidance given by nations.

Common themes were uncovered that ran through advice from most counties, and from this it is possible to provide a characterisation of the main advice given. The advice would be structured according to actions to take before, during, and after an earthquake, and analysis of national earthquake advice found that the most frequently advised actions to take during shaking are:

- Avoid glass or loose and falling objects
- Shelter under furniture
- If outside, keep clear of buildings and powerlines
- If driving, pull over and stop the car

This advice tends to be general in nature, with driving being the only specific activity referred to. Analysis of the national plans revealed gaps in the advice provided for specific groups in society, such as the elderly, those with disabilities or mental impairment, and children outside of the school setting.

Similarly, advice tended to be generic for all situations, with little distinction made for public spaces such as shopping malls, or high-risk areas such as coastal zones.

8.5. Scope and constraints on the research

As with any social research, a number of limitations apply to this study and have been highlighted throughout this work. Some were inevitable due to constraints on resources such as funding for travel and time spent in the field. Other issues arose due to factors such as sample size and composition. Some limitations of this research relating to methodology have been discussed previously in Chapter 4. Acknowledging these

boundaries allows suggestions to be made for future research that might build on from this work, and incorporate design elements that go some way to reducing these limitations.

This research focused on two cities in countries with high standards of living and earthquake preparedness, therefore the findings may be less applicable to earthquake situations in other areas and less developed countries. To better understand actions taken in a wider context, comparative studies in less developed countries with high earthquake risk should also be carried out, for example, Turkey, the Philippines and Pakistan. Countries such as these also have differing ethnic diversity and religious traditions, factors that may also influence actions.

This research was primarily exploratory and conducted against a backdrop of little prior research, and questions in the survey were not as detailed or probing as they might have been had further information been available. Future research might build on this study by developing a more nuanced understanding of the various actions that people take and the factors that influence them.

This research has shown that a number of variables can influence actions. This presents a problem in terms of having a sufficient sample size to detect effects that might otherwise be missed. While increasing sample size is one potential solution, it may also be possible, once again, to conduct more tightly targeted research into the impact of just one or two of the many variables included in this study.

One example of where sample size was a problem is in the number of people who sustained injuries during the earthquakes versus those who were uninjured. This has meant that drawing conclusions from the injuries sustained as a result of taking protective actions is limited. Similarly, only a small portion of the sample had disability or mobility issues during the earthquake, thereby prohibiting any firm conclusions to be drawn over the possible effects of these factors on taking protective actions.

Finally, the opportunities for comparing this study with other research was constrained by the fact that there is little consistency between studies on the definitions and categories used to describe data, meaning that not all variables were comparable, such as age groups, types of protective actions, and levels of fear. Where possible, consistency amongst researchers on using common ranges for variables such as age groups, and clear definitions and terminology to ensure that findings can be compared more freely, will help to ensure that benefits from research can be felt amongst the communities within which the research is conducted.

8.6. Implications for wider disaster risk reduction activities

Governments have a responsibility, to ensure they protect their citizens as far as possible from the effects and impact of disasters. (UNISDR, 2015). One way of achieving this is by ensuring disaster preparedness guidance and information is distributed to the public. The findings from this research indicate that some

current advice, such as the drop-cover-hold message, may need to be reviewed, and that further research is undertaken to ensure the most appropriate and relevant advice is distributed.

Individual human behaviours and actions during an earthquake are influenced by a complex interaction of factors, as shown above in Figure 8.1. One thing that is clear from this research is that predicting people's behaviour at the time of an earthquake is complex, and that to assume otherwise would be ill-advised. This means that earthquake advice needs to accommodate that complexity and be careful not to over-generalise or over-simplify instructions.

It is also important for those involved in disaster risk reduction not to assume that what people say they will do, either prior to or after receiving advice, will match what they actually do. Research that claims to make predictions about people's behaviour from such reported intentions needs to be treated with caution.

Another important factor for disaster preparedness policy is to recognise that even with training, people will still undertake actions that are not recommended, and this may need to be accommodated in any planning and development programme. For example, this research suggests that people continue to seek shelter in doorways during earthquakes, despite it not being a recommended action, and this may support the need for strengthened exit points along escape routes within a building.

On the other hand, findings indicate that exercises and drills may be an effective way in which to enable people to both understand and practice an action prior to implementing it in a real emergency. Therefore, it might be prudent to promote earthquake exercises in the workplace to assist people with learning the correct protective actions to take for their location.

Suggestions from this research that are supported throughout this work, and that might assist disaster managers to further enhance the preparedness advice provided to citizens, includes:

- Acknowledging that people will take actions other than those contained in the guidance, and that this needs to be accommodated in the planning process.
- Using positive language to frame actions that direct people towards the desired behaviour (e.g. stay inside) and avoid advice that described what not do to (e.g. don't go outside).
- Researching and addressing the needs of specific groups in society, such as those with mobility limitations, the elderly and those with learning difficulties, and provide advice on actions that are relevant to their situation.
- Care should be taken when using overly simplified catch-phrases to describe recommended actions, as these may be reduced to little more than easy to remember catch-phrases which are devoid of much useful guidance.

- Provide advice on what to do when trapped during an earthquake. This advice should be included in the 'during' shaking category, rather than alongside advice on clearing up damage after the event.
- Ensuring that exercises and drills are conducted frequently and that protective actions are practiced in both workplaces and homes.

Further research into the safety and efficacy of undertaking protective actions, may identify further changes that need to be made to advice. Disaster managers need to be flexible and open to new evidence. The Sendai Framework also acknowledges that authorities are recommended to take into account relevant research and best practice to inform disaster actions (UNISDR, 2015). This research can be used as part of that process.

8.7. Opportunities for future research

As a result of analysing and interpreting the data acquired for this study, a number of suggestions for further research can be made in addition to those already mentioned previously. At a general level, the case has been made for more consistency in research around the definitions of terms and variables, and in the categories used to group data (e.g. age ranges). Given the already mentioned challenge of comparing studies of different earthquakes, owing to the large number of variables involved, the current individualised approach to research is making the challenge even greater.

At this point, it is appropriate to look forward and consider what issues exist for the future study of actions taken during earthquakes. Various lines of enquiry are suggested by this current research. Specifically:

- What are the effects of fear on peoples' actions and how best can preparedness advice be provided to account for of this effect?
- How are actions influenced by position in the building at the time of shaking?
- How effective are actions such as standing in a doorway, drop-cover-hold, and going outside at providing protection during an earthquake?
- Does leaving a building during an earthquake actually lead to higher levels of injury?
- Does attempting to take recommended protective actions, such as drop-cover-hold, result in an increase in injury?
- Do 'unnecessary actions', such as retrieving personal belongings, lead to more injuries?
- What are appropriate and achievable actions to take if trapped during an earthquake to maximise chances of survival?
- What is the best advice to give for people who are in bed at the time of an earthquake?
- What are the most effective ways to influence behaviour, and are there lessons available from other areas such as education?

- How effective is educating people in protective actions as opposed to improving building standards in low-income countries?

8.8. Concluding remarks

This research developed as a result of personal experiences during earthquake response and the search and rescue for survivors in collapsed buildings. The aim of this research was to investigate the protective actions people take during earthquakes, and the effect of preparedness advice along with other demographic variables on those actions. Questions relating to this aim have been explored and this has also pointed the way to possible future opportunities for research.

This work has shown that protective actions taken during earthquakes are varied and do not always reflect the advice laid out in preparedness guidance. The drop-cover-hold message, whilst widely known is not as widely performed. People continue to stand in doorways and go outside during earthquakes despite these not being recommended actions. However, more positively, exercises were shown, at times, to be beneficial for encouraging people to seek shelter and drop-cover-hold.

The wide variety of advice contained in national earthquake preparedness advice across a range of countries suggests that perhaps some consensus might be reached over the most applicable and relevant advice that is also culturally appropriate and takes into account building strength and design.

Ultimately, this research suggests that in order to increase the uptake of protective actions during earthquakes, the use of the drop-cover-hold action should be reviewed, and the use of preparedness exercises and drills be increased alongside relevant and updated messaging.

Much earthquake research, including this study, is conducted in developed and accessible countries such as New Zealand, Japan and the United States, however other countries at risk from devastating earthquakes, such as Pakistan, Iran, Indonesia, and Haiti, could also benefit from further research to help better understand the impact of earthquake protective advice on the population. In countries with limited resources, high levels of poverty and vulnerable people, education may be a more effective tool for saving lives than trying to implement costly building codes.

It is hoped that this research may benefit people as they prepare for and respond to earthquakes. In particular, this work may be of use to building engineers, disaster managers, and citizens. For building engineers, knowing that people continue to leave buildings during earthquakes, even when advised to remain indoors, means that building design may need to address this behaviour as part of improvements to building safety and strength. Knowing more about how people respond and behave during earthquakes may assist disaster managers in developing effective and relevant messages and to consider the variety of groups in society who must be offered appropriate guidance. In this way, it is hoped that this research will lead to

more people knowing what to do during an earthquake, and be able to perform effective protective actions at a time of uncertainty and potential danger.

Appendices: Contents

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Appendix 1: Earthquake Preparedness Advice – New Zealand

The following are selected recommendations for actions to take during an earthquake sourced from the 2010 version of 'Working from the Same Page' issued by the New Zealand Ministry of Civil Defence and Emergency Management (MCDEM, 2010):

Preparedness activities prior to an earthquake to protect people include:

3. *Pick safe places in each room of your home and your office or school….*
4. *Practice drop, cover, and hold in each safe place. Drop to the floor, take cover under a sturdy piece of furniture, and hold on to a leg of the furniture. If suitable furniture is not nearby, sit on the floor next to an interior wall and cover your head and neck with your arms. Responding quickly in an earthquake may help protect you from injury.*
5. *Practice drop, cover, and hold on at least twice a year.*

If you are inside when the shaking starts, you should:

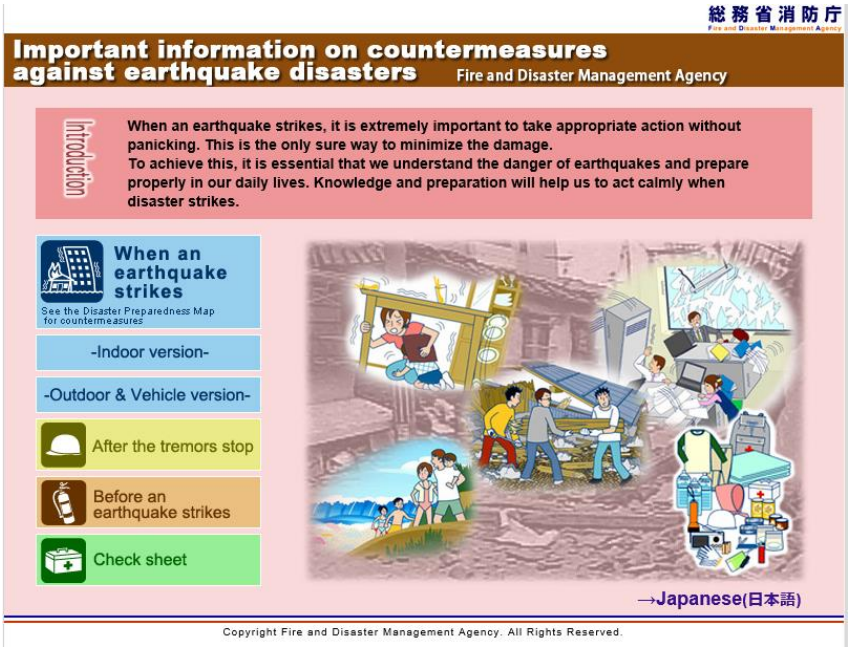
20. *Drop, cover, and hold on. Move only a few steps to a nearby safe place. Most people injured in earthquakes move more than three metres during the shaking.*
21. *If you are elderly or have limited mobility, remain where you are, bracing yourself in place."*
22. *If you are in bed, stay there, hold on, and protect your head with a pillow. You are less likely to be injured if you stay in bed. Broken glass on the floor can injure you.*
23. *Stay away from windows. Windows can shatter with such force that you can be injured by flying glass even if you are several metres away.*
24. *Stay indoors until the shaking stops and you are sure it is safe to exit. In most buildings in New Zealand, you are safer if you stay where you are until the shaking stops. If you go outside after shaking stops, move quickly away from buildings to prevent injury from falling debris.*
25. *If you are in a coastal area, drop, cover and hold during an earthquake and then move immediately to higher ground when the shaking stops or, if the area is flat move as far inland as possible. Earthquakes off the coast can generate tsunami.*

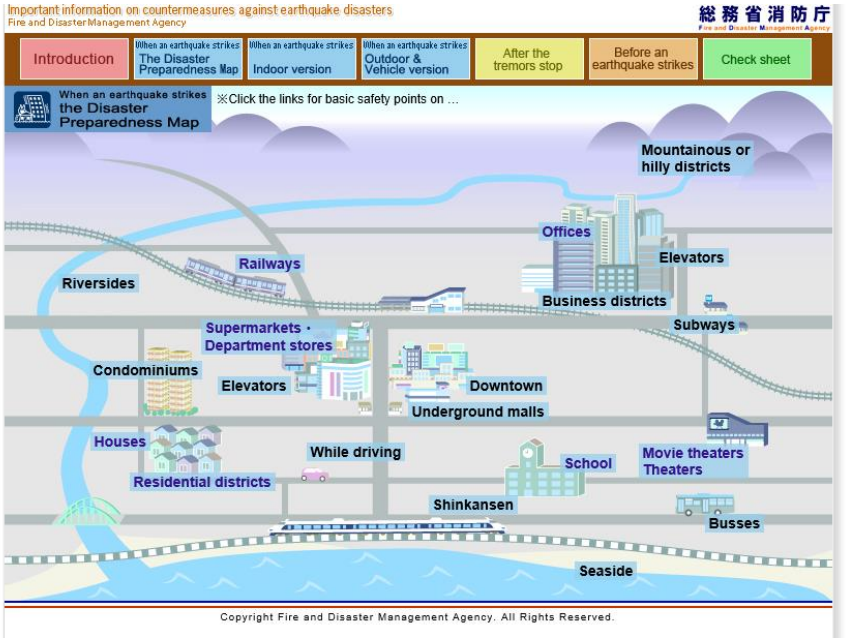
If you are outdoors when the shaking starts, you should:

26. Find a clear spot away from buildings, trees, streetlights and power lines.
27. *Drop to the ground and stay there until the shaking stops. Injuries can occur from falling trees, streetlights, powerlines, and buildings debris.*
28. *If you are in a vehicle, pull over to a clear location, stop and stay there with your seatbelt fastened until the shaking stops. Trees, power lines, poles, street signs, overpasses and other overhead items may fall during earthquakes. Stopping in a clear location will reduce your risk, and a hard-topped vehicle will prevent you from flying or falling objects. Once the shaking has stopped, proceed with caution. Avoid bridges or ramps that might have been damaged by the quake.*
29. *If you are in a mountainous areas or near unstable slopes or cliffs, be alert for falling rocks and other debris that could be loosened by the earthquake. Earthquakes often trigger landslides.*

Appendix 2: Earthquake Preparedness Advice – Japan

The screenshots below are retrieved from the Japanese FDMA website (via web.archive.org) showing the most recent advice for Japanese citizens – issued 30 April 2009 - prior to the March 2011 Great Eastern Japan Earthquake.





Indoor version

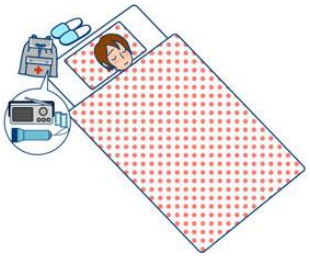
1 .General housing ▪ Basic points at home

Get under a stable desk or table and hold onto its legs tightly. Protect your head with a cushion or the like and stay put until the tremors stop.

- If a big tremor strikes suddenly, remember to secure your own safety first.
- Open doors and secure exit and entry routes.
- Shelves and items placed on shelves (TV sets, etc.) may fall. Stay clear of shelves until the tremors stop.
- Try not to flee from the building in a wild panic.

1 .General housing ▪ When sleeping in a bedroom

If a tremor wakes you, secure your safety by getting under your bedding or bed, if possible.



- Beware of broken glass from windows or light bulbs in the dark.
- To prepare for a sudden evacuation, keep a pair of thick socks, slippers, flashlight, and mobile radio next to your bed or futon.
- Never put anything that can easily fall or topple over in your bedroom. Make sure that nothing can fall on you while you asleep.

1 .General housing ▪ When in a bathroom

If you feel a tremor, open the door immediately to secure your exit route, then wait until the tremors stop.

- Tiles or mirrors may fall in a bathroom, or a water tank may topple from the toilet.
- Beware of injuries from broken mirrors or glass, if the tremors strike while you're bathing.
- If in the bathtub, protect your head by covering yourself with the bathtub lid, or whatever else is available.
- Put on only essential clothing, (deletion) wait until the tremors stop, and evacuate.

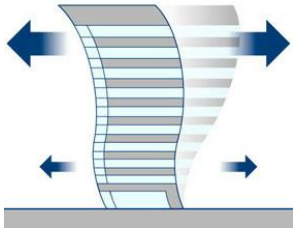
1 .General housing ▪ When in the kitchen

Get under a table or the like and wait until the tremors stop.

- If you rush to turn off a gas flame, falling pots and pans may scald you. Wait until the tremors stop before turning off the flame.
- Watch out for cupboards or refrigerators. These can fall on you, or contents can fly out from them.
- If near cooker, move away in case pots or pans slip and fall. Wait until the tremors stop and then carefully turn off the flame.
- Most households are equipped with gas leakage breakers (gas micron meters) that sense tremors and stop the gas supply automatically. Be sure to understand these devices and use them properly.

2.Condominiums

Note that tremors are more intense on the upper floors than on the ground level.



- The risk of collapse is low. (delete) Get under a stable desk or the like and wait until the tremors stop.
- There may be a small delay before you feel the tremors on the upper floors. Once they start, however, they tend to last longer at a wider amplitude.
- Check the locations of the emergency exits on a regular basis.

3.Offices

Move away from cabinets, shelves, lockers, and copying machines in the office. Cover your head and get under a desk or the like to protect yourself.

- Move away from the windows. Window glass may break during the tremor.
- Watch out for falling office equipment.
- Try to improve your working environment on a daily basis by organizing, tidying up, and so on.
- When evacuating the building, watch out for falling objects and never try to use an elevator.

4.Supermarkets・Department stores

Protect your head with a bag or shopping basket and move away from showcases or high shelves stocked with items that may fall.

- Find shelter in an elevator hall, or anywhere else uncluttered with merchandize and near a supporting pillar column.
- Watch out for falling glassware, ceramic ware, and other items on display shelves.
- Do not just rush to the exit. Follow the instructions of the staff.
- Do not attempt to evacuate on an elevator, even if it seems to be working.

5.Movie theaters・Theaters

Protect your head using a bag or the like and find shelter between the seats. Stay put until the tremors stop.

- Evacuate to a safe place, watching out for window glass and objects falling from above.
- Even if the power supply is cut off, evacuation lights or emergency lights will turn on. Follow the instructions of the theater staff without panicking..
- Never rush to the exits or staircases.
- Check the locations of the emergency exits beforehand.

6.Underground mall

Protect your head with a bag or the like and try not to panic. Stay put until the tremors stop.

- If the power supply cuts off, wait until the emergency lights turn on. Do not move without good reason.
- Emergency exits are located at 60m intervals in underground malls. Be calm and proceed through the exit up to the ground level. Never rush to an emergency exit congested with people.
- When evacuating, walk alongside the walls.
- You will be safe as long as there is no fire. Act calmly, without panicking.

7.Schools

Get under a desk to protect yourself from falling objects in the classroom. Follow the instructions of the teacher without taking sudden actions (such as fleeing the building in a panic).

- In corridors, playgrounds, or gymnasiums, get together and squat in the middle of the area.
- In any kind of laboratory, pay attention to chemicals or fire while evacuating.
- The route back home may be dangerous in some cases. Do not return home without asking.

8.Elevators

The basic rule is to press the buttons for all floors and get off at the first floor where the elevator stops. Be sure, however, never to rush onto a floor with fire or other serious danger.

- Emergency services assume that there will be many people trapped in elevators when an earthquake strikes. You may not be rescued immediately.
- If you are trapped in an elevator, try to remain calm without panicking. Try to make contact with someone using the Emergency Call Button, etc.

Outdoor and vehicle version

1. Residential district

If a strong quake strikes, the streets of residential districts will probably be blocked off with collapsed objects.

- Block or stone walls along residential streets may fall during strong quakes. If you feel an earthquake, move away from these walls.
- Electric poles and vending machines may also fall over, so move away from them, too.
- Roofing tiles, external air conditioners, and planters on verandas and upper floors may fall. Look out for objects falling from above.
- If a strong quake strikes, houses with low earthquake resistance may collapse, filling the road with rubble or window glass. Be vigilant of surrounding conditions if you feel a strong tremor

2.Business districts・Downtown

Window glass, outer walls, and signboards may fall from high- and middle-rise buildings downtown or in business districts.

- If window glass in an office building breaks and falls, it will disperse fast (at a speed of 40 ~ 60 km). Tiles on the outer walls of buildings or signboards attached to outer walls may also fall. Protect your head with your shoes or the like and move as far away from the buildings as possible.
- The danger of falling signboards and neon signs is greater in downtown areas than in business districts. Be especially alert if there are strong tremors.

3.Seaside

The biggest earthquake danger facing you at the seaside is a tidal wave (tsunami). Move to higher ground or an evacuation site immediately, without waiting for instructions or evacuation advice.

- If there is no higher ground nearby, go into a building with at least four floors and take the stairs up to the 4th floor or above.
- Tidal waves attack in series. In some cases, the second and third wave is higher than the first. Never go back to the seaside, even if the waves recede.
- If there are signs pointing out evacuation routes, use them as a guide for evacuation.
- If an earthquake strikes while you're bathing in the sea, there may be lifeguards or lifesavers nearby. If so, they will tell you where and how to evacuate the area.

4.Riverside

Tidal waves travel up water-filled rivers.

- If you evacuate upstream along the river, the tidal wave may chase you. You need to evacuate quickly at a right angle to the flow of the river.

5.Mountainous・Hilly districts

Move away from dangerous areas such as steep sloping land, watching out for falling rocks as you proceed.

- If you are struck by a strong tremor while hiking or climbing a mountain, protect yourself from falling rocks first.
- The ground may loosen and become highly unstable during an earthquake. Be sure to stay away from areas with fallen rocks or steep sloping land.

1.While driving a car

Unforeseen accidents may result if you try to make a sudden stop.

- If you feel a tremor,
- Never make a sudden stop. Keep firm hold of the steering wheel and gradually slow down, paying attention to the cars in front of you and behind. Pull over to the left side of the road when it is safe to do so.
- Turn off the engine and stay in your car until the tremors stop. Get information from the car radio.
- If you need to evacuate the area, take important items, including your car registration. Leave the key in the car and a note with your contact address. Leave the doors unlocked.
- Vacate the area on foot.
- Do not vacate by car. This will block the passage of emergency vehicles.
- If driving on the highway, observe the following points in addition to the points mentioned for regular roads above.
- When driving at high speed, turn on your hazard lamps to ensure that the cars ahead of you and behind you can see you.
- Emergency exits are located at about 1 km intervals on highways. You can escape to the ground on foot via one of those exits.

2.Railways

Be prepared for an emergency stop. Stay low and keep hold of handrails or straps to avoid injury.

- If a strong tremor is detected, the train will make an emergency stop.
- If sitting, keep low and protect your head with a bag or the like. If standing, keep hold of a handrail or strap to avoid falling over.
- Once the train comes to a halt, follow the instructions of the crew.

3.Shinkansen (Bullet Train)

The Urgent Earthquake Detection and Alarm System (UrEDAS) stops the train in the event of an emergency.

- The Shinkansen runs at a very high speed. If you are sitting on a seat, get down between the seats to prevent yourself being flung forward. If you are standing, keep hold of the handrail to avoid falling.
- Once the train comes to a halt, follow the instructions of the crew.

4.Subway

Subway trains will come to an emergency stop when a quake of intensity 5 lower is detected. If the train is between stations, it checks and proceeds to the nearest station at low speed.

- The subway travels at a speed of about 40~50 km per hour.
- If sitting, keep low and protect your head with a bag or the like. If standing, keep hold of a handrail or strap to avoid falling over.
- Even if the power supply is cut off, emergency lights will remain on for about 1 hour. This gives you ample time to evacuate calmly. Be sure never to panic.
- Some subway lines have high-voltage electric wires laid at the sides of the rails. This makes it extremely dangerous to jump onto the tracks. Never attempt to do so without asking.
- Once the train comes to a halt, follow the instructions of the crew.

5.Bus

The bus driver may brake suddenly. Stay low and hold of a handrail or strap to avoid injury.

- If the driver feels a strong quake, he will try to slow down gradually without making a sudden stop. If necessary to avoid danger, however, the driver may be forced to brake suddenly.
- If sitting, keep low and protect your head with a bag or the like. If standing, keep hold of a handrail or strap to avoid falling over.
- Once the bus comes to a halt, follow the instructions of the driver.

Appendix 3: The Modified Mercalli Scale

Intensity	Shaking	Description/Damage
I	**Not felt**	Not felt except by a very few under especially favourable conditions.
II	**Weak**	Felt only by a few persons at rest, especially on upper floors of buildings.
III	**Weak**	Felt quite noticeably by persons indoors, especially on upper floors of buildings. Many people do not recognize it as an earthquake. Standing motor cars may rock slightly. Vibrations similar to the passing of a truck. Duration estimated.
IV	**Light**	Felt indoors by many, outdoors by few during the day. At night, some awakened. Dishes, windows, doors disturbed; walls make cracking sound. Sensation like heavy truck striking building. Standing motor cars rocked noticeably.
V	**Moderate**	Felt by nearly everyone; many awakened. Some dishes, windows broken. Unstable objects overturned. Pendulum clocks may stop.
VI	**Strong**	Felt by all, many frightened. Some heavy furniture moved; a few instances of fallen plaster. Damage slight.
VII	**Very strong**	Damage negligible in buildings of good design and construction; slight to moderate in well-built ordinary structures; considerable damage in poorly built or badly designed structures; some chimneys broken.
VIII	**Severe**	Damage slight in specially designed structures; considerable damage in ordinary substantial buildings with partial collapse. Damage great in poorly built structures. Fall of chimneys, factory stacks, columns, monuments, walls. Heavy furniture overturned.
IX	**Violent**	Damage considerable in specially designed structures; well-designed frame structures thrown out of plumb. Damage great in substantial buildings, with partial collapse. Buildings shifted off foundations.
X	**Extreme**	Some well-built wooden structures destroyed; most masonry and frame structures destroyed with foundations. Rails bent.

Appendix 4: Questionnaire used in Christchurch, New Zealand

Reference: NZ _____

Self-Protective Behaviour During Earthquake Shaking:

A comparative study of the effect of earthquake preparedness advice on human behaviour and the subsequent impact on survivability

Qualifying information

You must answer 'Yes' to the following three questions to participate:

- Are you aged 20 years or older?
  Yes ○
  No ○

- Were you in Christchurch at the time of the earthquake on 22 February 2011?
  Yes ○
  No ○

- Have you read, and understood the enclosed information that outlines the purpose of this study?
  Yes ○
  No ○

By completing and submitting this questionnaire you consent to participating in this study

1.0 Location

This section asks you about your location when the earthquake occurred.

a) What was your location when the earthquake struck? (address or near what landmark?)

_____

b) Were you inside or outside a building at the time of the earthquake?

Inside ○ Go to Question 1.1 (inside a building)
Outside ○ Go to Question 1.14 (outside a building)

Inside a building

1.1 What was the main use of the building you were in? *(select one only)*

Residential ○
Office ○
School or education ○
Retail ○
Café or restaurant ○
Light industry ○
Other ○ *please specify*_____

1.2 How many floors were in the building, including any basements?

1 ○
2 ○
3 ○
4 ○
5 ○
6 ○
7 or more ○
Don't know ○

1.3 What floor of the building were you on?

Basement ○
Ground ○
1st ○
2nd ○
3rd ○
4th ○
5th or higher ○

1.4 Which room of this building were you in? *(select one only)*

Hall or lobby ○
Bathroom ○
Dining room ○
Kitchen ○
Bedroom ○
Living room ○
Stairs ○
Work office ○
Classroom ○
Shop ○
Other ○ *please specify*_____

1.5 What was your position in the room when the earthquake struck? *(select one only)*

- Near the centre of room ○
- Near an outside wall ○
- Near an internal wall ○
- In a doorway ○
- Other ○ *please specify*_____

1.6 How many doors were in the room from which you could exit?

- 1 ○
- 2 ○
- 3 ○
- 4 or more ○
- Don't know ○

1.7 How many doors did you have to pass through to exit the building?

- 1 ○
- 2 ○
- 3 ○
- 4 or more ○
- Don't know ○

1.8 When the earthquake struck which of the following objects were in the room with you? *(select all that apply)*

- Table or desk ○
- Chairs or sofas ○
- Bed ○
- Television ○
- Bookcase ○
- Shelving units ○
- Food or drink ○
- Tall furniture ○
- Don't know ○
- Other ○ *please specify*_____
- Computer and equipment ○
- Wall mirror or pictures ○
- Ornaments ○
- Storage cabinets ○
- Chest of drawers ○
- Animals or pets ○
- Machinery ○

1.9 Who else was with you in the room at time of the earthquake? *(select all that apply)*

- Family ○
- Friends ○
- Colleagues ○
- Children (age 0-17yrs) ○
- Stranger or member of public ○
- No one ○
- Other ○ *please specify*_____

1.10 Which statement <u>best</u> describes the <u>general</u> damage caused to objects in the room? (select one only)

- No damage ○
- Items wobbled or shook ○
- Small items fell over ○
- Large or heavy items fell over ○
- Significant damage to room ○
- Complete destruction ○

1.11 Which statement best describes the general damage caused to the building you were in? (select one only)

- No damage ○
- Minor cracks or negligible damage ○
- Moderate damage ○
- Substantial damage ○
- Severe damage ○
- Complete destruction ○

1.12 How would you describe the construction of the building you were in? *(select one only)*

- Reinforced concrete ○
- Wood frame ○
- Steel frame ○
- Mud and brick ○
- Stone ○
- Brick ○
- Don't know ○
- Other ○ *please specify*_____

1.13 Approximately what age was the building you were in? *(select one only)*

- Built between 2000 and 2011 ○
- Built between 1980 and 1999 ○
- Built between 1950 and 1979 ○
- Built between 1900 and 1949 ○
- Built on or before 1899 ○
- Don't know ○

Please go to Section 2.0

Outside a building

1.14 What was your location outside relative to the nearest building when the earthquake struck? (select one only)

- Next to a building ○
- On a footpath ○
- On a road ○
- In a home garden ○
- In an open space or park ○
- Other ○ please specify_____

1.15 Which statement best describes the general damage caused to the building nearest to you? (select one only)

- No damage ○
- Minor cracks or negligible damage ○
- Moderate damage ○
- Substantial damage ○
- Severe damage ○
- Complete destruction ○

1.16 What other objects or structures were around you? *(select all that apply)*

- Awnings or overhangs ○
- Traffic lights ○
- Street lamps ○
- Power poles ○
- Advertising billboards ○
- Large glass windows ○
- Vehicles ○
- Other ○ *please specify*_____

1.17 What visible environmental changes occurred at your location as a result of the earthquake? (select all that apply)

- Liquefaction ○
- Ground or road damage ○
- Trees moving or breaking ○
- Change in animal behaviour ○
- Landslide ○
- No visible changes ○
- Other ○ please specify_____

1.18 What other visible damage occurred at your location as a result of the earthquake? (select all that apply)

- Building damage (including falling masonry, dust) ○
- Building collapse (partial or total) ○
- Damage to street furniture (lights, power poles, signs) ○
- Damage to bridges or tunnels ○
- Damage to vehicles ○
- Burst water mains ○
- No visible damage at location ○
- Other ○ please specify_____

Please go to Section 2.0

2.0 Your actions during the earthquake

This set of questions asks about actions you took during the earthquake shaking.

2.1 What activity were you doing when the earthquake started? *(select one only)*

- Working ○
- Shopping ○
- Eating ○
- Sleeping ○
- Driving ○
- Exercising ○
- Other ○ *please specify*_____

2.2 Were you – (*select one only*)

- Standing ○
- Walking ○
- Sitting ○
- Lying down ○
- Other ○ *please specify*_____

2.3 Did you take any of the following actions <u>during</u> the earthquake shaking?

	Yes	No
Sheltered under a desk or table	○	○
Avoided falling objects	○	○
Moved to or stood in a doorway	○	○
"Drop, Cover, Hold" action	○	○
Protected others	○	○
Moved outside a building	○	○
Moved away from a building	○	○
Stayed where I was	○	○
Sat or lay down	○	○
Reached for personal belongings	○	○
Stopped the car	○	○
No actions taken (took no action)	○	○
Other	○	○ *please specify*_____

2.4 Why did you take the actions you indicated in question 2.3? *(select one only)*

- Learned from previous experience ○
- Taught in exercises and drills ○
- It seemed sensible ○
- I was told to ○
- An instinctive response ○
- Don't know ○
- Other ○ *please specify*_____

2.5 Were you struck by objects during the earthquake that were shaking, moving or falling?

- Yes ○
- No ○

2.6 Would it have been <u>possible</u> to "Drop, Cover, Hold" during the earthquake?

- Yes ○
- No ○
- Don't know ○

2.7 Would it have been safe to "Drop, Cover, Hold" during the earthquake?

- Yes ○
- No ○
- Don't know ○

2.8 Which of the following factors do you believe contributed to your survival?
(select all that apply)

- The strength of the building ○
- The "Drop, cover, hold" action ○
- It was not a severe earthquake ○
- God's will ○
- I was helped by others ○
- I stayed inside ○
- I moved outside ○
- I took shelter ○
- I was not in or near a building ○
- Don't know ○
- Other ○ *please specify*_____

2.9 Did you save, or attempt to save, any of the following items during the shaking?

	Yes	No
Animals or pets	○	○
Ornaments	○	○
Computer equipment	○	○
Personal documents	○	○
Wallet or handbag	○	○
Mobile phone	○	○
Other	○	○

*please specify*_____

2.10 Did you leave or attempt to leave a building during the shaking?

- Yes ○
- No ○
- Not in a building ○

2.11 Did you provide assistance to other people during shaking?

- Yes ○
- No ○

If Yes, who? _____

2.12 Did you receive assistance from other people during shaking?

- Yes ○
- No ○

If Yes, who? _____

2.13 During the earthquake shaking did you have responsibility for, or care for, people in the following situations?

	Yes	No
At school	○	○
At home	○	○
At a care home	○	○
At a hospital	○	○
At a hotel	○	○
At university or college	○	○
Any other situation	○	○

*please specify*_____

2.14 What were your <u>initial</u> actions once the shaking stopped?
(select all that apply)

- Left a building and went outside ○
- Checked a building for safety ○
- Phoned family or friends ○
- Went inside a building ○
- Rescued or assisted people nearby ○
- Sought treatment for your injuries ○
- Called emergency services ○
- Took photos or film ○
- Posted on social media ○
- Other ○ please specify_____

Please go to Section 3.0

3.0 Your feelings

This set of questions asks about your feelings and emotions during the earthquake.

3.1 Select one of the following that best describes your feelings during the earthquake shaking?

(select one only)

Surprised	○	Disgusted	○
Angry	○	Anxious	○
Sad	○	Fearful	○
Happy	○	Panicked	○
Courageous	○	Hysterical	○
Calm	○	Annoyed	○
Worried	○	Other	○ please specify_____

Respond to the following six statements by circling the number that best describes your feelings.

3.2 I felt anxious during the earthquake.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3.3 I felt fearful during the earthquake.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3.4 I felt helpless during the earthquake.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3.5 I felt confident during the earthquake.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3.6 I felt calm during the earthquake.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3.7 I felt in control during the earthquake.

1	2	3	4	5
Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree

3.8 What are your greatest fears during earthquake shaking? *(select all that apply)*

- Being injured ○
- Being trapped ○
- Being killed ○
- Death of a family member ○
- Loss or damage to personal property ○
- Being unable to exit a building ○
- Unsure how severe the earthquake will be ○
- Possible collapse of a building ○
- Safety of a building ○
- I have no fear of earthquakes ○
- Other ○ *please specify*_____

Please go to Section 4.0

4.0 Injury

This section asks about any injuries you sustained during the earthquake.

a) Were you injured as a result of the earthquake?

Yes ○

No ○ Go to Section 5.0

4.1 When were your injuries caused? *(select one only)*

During the main shaking ○

After the main shaking ○

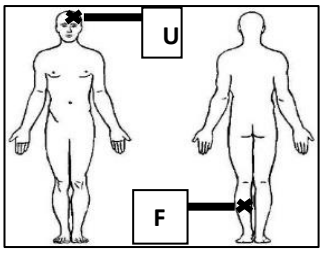
During an aftershock ○

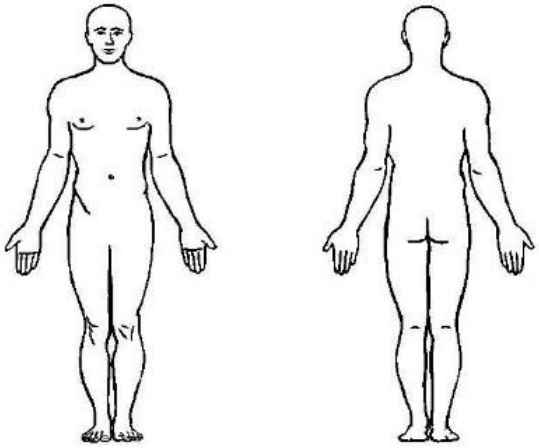
Other ○ *please specify*_____

4.2 What were your injuries? *(select all that apply)*

Amputation	○	A
Burn or scald	○	B
Crush injury	○	C
Dust inhalation	○	D
Fracture (broken) bone	○	F
Severe bleeding	○	H
Internal injuries	○	I
Kidney damage or failure	○	K
Minor lacerations or abrasions	○	L
Spinal or nervous damage	○	N
Impaled object or foreign body	○	O
Bruising	○	R
Sprain or strain	○	S
Unconscious or head injury	○	U
Other	○	*99 please specify*_____

4.3 Please indicate on the diagram the location of your injuries outlined in Q4.2
(Be as accurate as possible using the corresponding letter above and mark with an X on the diagram as shown on the right)





4.4 Select one statement below that best describes the initial severity of your injury.

Able to walk ○

Unable to walk and not life-threatening ○

Unable to walk and life-threatening ○

4.5 Where were you when your injury occurred? *(select one only)*

- Inside a building in a room ○
- Inside a building on stairs ○
- Outside in the street or open place ○
- In a vehicle ○
- Other ○ *please specify*_____

4.6 What were you doing when your injury happened? *(select one only)*

- Evacuating a building ○
- "Drop-Cover-Hold" action ○
- Protecting myself ○
- Protecting others ○
- Protecting property ○
- Other ○ *please specify*_____

4.7 Which of the following best describe the cause of your injury? *(select all that apply)*

- Masonry falling outside ○
- Objects falling inside ○
- Collapse of structural beams ○
- General debris and glass ○
- Exposed reinforcing steel bar ○
- Airborne dust ○
- A fall from height ○
- Slipped or tripped ○
- A fire or chemicals ○
- Damage to a vehicle ○
- Other ○ *please specify*_____

4.8 Were you trapped under debris or rubble as a result of the earthquake?

- Yes ○ Go to question 4.8a
- No ○ Go to question 4.9

4.8a Who rescued you? (select all that apply)

- Search and Rescue or emergency team ○
- Bystanders ○
- I self-rescued ○
- Other ○ please specify_____

4.8b How long were you trapped for?

- Less than 1 hour ○
- 1-2 hours ○
- 3-5 hours ○
- 6-12 hours ○
- 13+ hours ○

4.9 From whom did you first seek medical assistance after the earthquake? *(select one only)*

- Hospital ○
- GP or family doctor ○
- Ambulance ○
- First aid post ○
- Family or relatives ○
- Self-treated ○
- No assistance sought ○
- Other ○ *please specify*_____

4.10 How were other people around you affected? *(select all that apply)*

- Not injured ○
- Injured ○
- Trapped ○
- Died ○
- No one else near me ○
- Don't know ○
- Other ○ *please specify*_____

Please go to Section 5.0

5.0 Your earthquake experience and preparedness

This section is about your previous experience of earthquakes and general preparedness activities.

5.1 Was the 22 February 2011 earthquake the first you have ever felt?

Yes ○
No ○

5.2 Was the 22 February 2011 earthquake the strongest you have ever felt?

Yes ○
No ○

5.3 Had you participated in any earthquake drills or exercises prior to 22 February 2011?

Yes ○
No ○

If yes, which exercises and when were they held?

_____

5.4 Are you aware of official guidance issued about earthquake preparedness actions to take before, during and after an earthquake?

Yes ○
No ○

5.5 Have you heard of "Drop, Cover, Hold" in relation to earthquakes?

Yes ○
No ○

5.6 Which of the following earthquake preparedness activities have you or your household undertaken in your home? *(select all that apply)*

Secured heavy items to a wall ○
Prepared a survival kit ○
Completed a first aid course ○
Practised earthquake drills ○
Have a torch and spare batteries ○
Have a radio and spare batteries ○
No activities undertaken ○
Other ○ *please specify*_____

5.7 Which of the following earthquake preparedness activities have you or work colleagues undertaken in your workplace? *(select all that apply)*

Secured heavy items to a wall ○
Prepared a survival kit ○
Completed a first aid course ○
Practised earthquake drills ○
Erect signs for actions or evacuation ○
No activities undertaken ○
Don't attend a workplace ○
Other ○ *please specify*_____

5.8 To what do you <u>most</u> attribute the <u>cause</u> of earthquakes in general? *(select one only)*

A natural phenomenon ○
An act of God ○
The wrath of God ○
Don't know ○
Other ○ *please specify*_____

5.9 To which of the following do you most attribute survival from earthquakes? *(select one only)*

Preparedness actions taken before an earthquake ○
Actions taken during an earthquake ○
The will of God ○
Fate, chance or luck ○
Don't know ○
Other ○ *please specify*_____

5.10 In your opinion what do you think is the best action to take during an earthquake if you are inside a building?

_____
_____
_____

5.11 In your opinion what do you think is the worst action to take during an earthquake if you are inside a building?

_____
_____
_____

5.12 Following an earthquake, if you became trapped under debris or rubble and could not immediately escape, what actions do you think you would take?

_____
_____
_____

5.13 Has your experience of the 2011 earthquake changed the actions you would now take during an earthquake?

Yes ○
No ○

Please go to Section 6.0

6.0 Personal information

This last set of questions asks some details about you.

6.1 How old are you?

_____

6.2 Are you?

- Male ○
- Female ○

6.3 What is your highest level of education? *(select one only)*

- Primary school ○
- High school ○
- Technical / vocational college ○
- University ○
- Other ○ *please specify*_____

6.4 In what occupational field do you currently work? *(select one only)*

- Civil servant / government ○
- Education ○
- Finance ○
- Health ○
- Home-based ○
- Information Technology ○
- Manufacturing ○
- Retail ○
- Retired ○
- Transport ○
- No occupation ○
- Other ○ *please specify*_____

6.5 What is your religion? *(select one only)*

- Christian ○
- Muslim ○
- Hindu ○
- Jewish ○
- No religion ○
- Other ○ *please specify*_____

6.6 Which ethnic group do you belong to? *(select one only)*

- New Zealand European ○
- New Zealand Maori ○
- Samoan ○
- Indian ○
- Chinese ○
- Other ○ *please specify*_____

6.7 Did any of the following apply to you at the time of the earthquake in February 2011?

	Yes	No
A wheelchair user	○	○
Required assistance to move from one location to another	○	○
Used crutches or a walking frame to walk	○	○
Confined to bed	○	○
Unable to bend down	○	○
Registered blind or visually impaired	○	○

6.8 How many people live in your household, including yourself?

1 ○
2 ○
3 ○
4 ○
5 ○
6 ○
7 or more ○

6.9 Does your household have a television?

Yes ○
No ○

6.10 Do you have a mobile phone registered to you?

Yes ○
No ○

6.11 Does your household have internet access?

Yes ○
No ○

Thank you for taking part in this research.

Please place this completed questionnaire in the envelope provided.

Appendix 5: Questionnaire - Introduction Letter

INSTITUTE FOR RISK AND DISASTER REDUCTION

UCL

10 November 2014

Dear Participant,

A few weeks ago I contacted you by telephone asking whether you would be willing to participate in my research connected with the Christchurch earthquake of 22 February 2011.

Thank you for agreeing to complete this questionnaire as part of my PhD research. The questionnaire forms a vital component of the research to determine whether self-protective behaviour and actions taken during earthquake shaking are effective in improving survivability.

This pack contains the following documents:

- This letter
- The questionnaire
- Questionnaire instructions
- A research information brochure explaining the research
- A return envelope
-

The questionnaire should take no longer than 30 minutes to complete. I will visit between 1 and 13 December to collect your completed questionnaire.

Before you complete the questionnaire, I can confirm that –

- Ethical approval has been given for this research by UCL – reference 5659/001
- Your personal information will be treated as confidential and handled in accordance with the UK Data Protection Act 1988
- Your anonymity is maintained, and it will not be possible to identify you in publications.
-

Participation is voluntary. By completing and submitting the questionnaire, you consent to participate in the research.

If you have any queries about the research, please contact me at [redacted]

Again, thank you for taking the time to assist with my research.

Yours sincerely,

Gillian Dacey

[redacted]

Appendix 6: Questionnaire - Instruction Sheet – Christchurch

INSTITUTE FOR RISK AND DISASTER REDUCTION

UCL

Self-Protective Behaviour During Earthquake Shaking:

A comparative study of the effect of earthquake preparedness advice on human behaviour and the subsequent impact on survivability.

Instructions for completing the questionnaire

Thank you for agreeing to take part in this research.

Please follow these instructions to complete the questionnaire.

There are 6 sections in this questionnaire –

1.0 – Your location during the earthquake
2.0 – Your actions during the earthquake
3.0 – Your feelings during the earthquake
4.0 – Your injuries
5.0 – Your earthquake experience and preparedness
6.0 – Personal information

Complete all questions unless otherwise directed, and provide information for yourself only. You may not be required to answer all sections. Answer the questions from your experience and as they relate to you, only referring to other people if specifically requested.

Mark your answers with a tick in the O. If you make a mistake, cross it out and clearly tick the appropriate option.

Research Focus:
The Christchurch earthquake struck at 12:51 on Tuesday 22 February 2011 with a magnitude of 6.3. This earthquake followed the Darfield event in September 2010. For this questionnaire, please focus on events that relate to the earthquake on 22 February 2011.

By completing and submitting this questionnaire you consent to participating in this study.

You will not be identifiable from final information.

All information provided is kept secure and handled in accordance with the UK Data Protection Act 1998.

A member of the research team will call to collect the completed questionnaire between 1st and 13th December 2014.

Appendix 7: Countries and territories included in the national document analysis

The following list records the country or territory included in the research, along with the hyperlink to the earthquake advice and the date accessed.

Afghanistan Accessed 23 Nov 2016
http://www.andma.gov.af/en/content/view/earthquake

Albania Accessed 28 Oct 2016
http://www.mbrojtjacivile.al/index.php/si-te-mbijetojme-ne-raste-emergjencash/2016-02-22-15-24-34/2016-03-11-09-33-47

Antigua and Barbuda Accessed 30 Oct 2016
http://nods.gov.ag/hazzards/earthquake/

Argentina Accessed 16 Nov 2016
http://www.mendoza-conicet.gob.ar/portal/upload/terremotossegemar1.pdf

Armenia Accessed 19 Dec 2016
http://www.nssp-gov.am/for_kids.htm

Australia Accessed 28 Oct 2016
https://www.ag.gov.au/EmergencyManagement/Community/Community-Safety-Action-Guides/Pages/Community-safety-action-guide-earthquake.aspx

Azores Accessed 29 Nov 2016
http://www.prociv.azores.gov.pt/sensibilizacao/riscos/ver.php?id=5

Bangladesh Accessed 22 Dec 2016
http://www.modmr.gov.bd/site/files/2ba5e11c-723d-45cd-9cc3-4e5e0460cd8f/To-do-during-the-earthquake

Barbados Accessed 12 Nov 2016
http://dem.gov.bb/public/downloads/Earthquakes.pdf
http://dem.gov.bb/public/downloads/EarthquakeBrochure.pdf

Belgium Accessed 23 Nov 2016
http://diplomatie.belgium.be/fr/Services/voyager_a_letranger/problemes_de_securite/catastrophes_naturelles/tremblement_de_terre

Belize Accessed 22 Nov 2016
http://site.nemo.org.bz/?s=earthquake

Bhutan Accessed 30 Oct 2016
https://www.ddm.gov.bt/awareness-information/

Canada Accessed 30 Oct 2016
https://www.getprepared.gc.ca/cnt/rsrcs/pblctns/rthqks-wtd/index-en.aspx#s5

Cayman Islands Accessed 11 Nov 2016
http://www.caymanprepared.ky/portal/page/portal/hmchome/hazards/earthquake

Chile Accessed 30 Oct 2016
https://www.onemi.gov.cl/terremoto/

Colombia Accessed 28 Nov 2016
http://portal.gestiondelriesgo.gov.co/Documents/preparativos_frente_sismo_UNGRD.pdf#search=INFORMACI%C3%93N%20DE%20PREPARATIVOS%20ANTE%20SISMO

Costa Rica **Accessed** 31 Oct 2016
https://www.cne.go.cr/index.php/gestireventiva-la-instituci40/36-educacion-y-asesoria/80-terremotos

Croatia Accessed 11 Nov 2016
http://www.duzs.hr/news.aspx?newsID=14637&pageID=134

Cuba Accessed 16 Nov 2016
http://www.cenais.cu/index.php/que-hacer-antes-y-despues-de-un-terremoto

Cyprus Accessed 31 Oct 2016
http://www.moi.gov.cy/moi/cd/cd.nsf/7DC479F67C33A88FC2257A36001E3F13/$file/Μέτρα%20αυτοπροστασίας%20και%20ασφάλειας%20από%20το%20σεισμό.pdf

Dominican Republic Accessed 22 Dec 2016
http://www.desastre.org/index.php?option=com_content&view=article&id=69:recomendaciones-en-caso-de-terremoto&catid=38:huracanes-y-terremotos

Ecuador Accessed 31 Oct 2016
http://www.gestionderiesgos.gob.ec/sismos/

El Salvador Accessed 31 Oct 2016
http://proteccioncivil.gob.sv/guias-y-manuales/

Fiji Accessed 29 Dec 2016
http://www.ndmo.gov.fj/images/Hazards/Pull-up-banner_Earthquake.pdf
http://www.ndmo.gov.fj/images/Hazards/Earthquakes.pdf

France Accessed 31 Oct 2016
http://www.gouvernement.fr/risques/seisme

Greece Accessed 22 Dec 2016
http://www.oasp.gr/sites/default/files/English_digital.pdf

Guatemala Accessed 16 Nov 2016
http://www.conred.gob.gt/www/index.php?option=com_content&view=article&id=4760&Itemid=1090

Iceland Accessed 29 Dec 2016
http://www.almannavarnir.is/english/preventive-measures/earthquakes-duck-cover-hold/

India Accessed 12 Nov 2016
http://www.ndma.gov.in/en/do-s-don-ts

Indonesia Accessed 24 Nov 2016
http://www.bnpb.go.id/pengetahuan-bencana/siaga-bencana#

Israel Accessed 31 Oct 2016
http://mapi.gov.il/Earthquake/downloads/eq_guide_english_2016.pdf

Italy Accessed 31 Oct 2016
http://www.protezionecivile.gov.it/jcms/en/cosa_fare_sismico.wp;jsessionid=4939CD09764FB422BD017B8B402489AF.worker2?pagtab=3#pag-content

Jamaica Accessed 11 Nov 2016
http://odpem.org.jm/DisastersDoHappen/TypesofHazardsDisasters/Earthquakes/ProtectYourselfFromanEarthquake/tabid/258/Default.aspx

Japan Accessed 24 Nov 2016
http://www.jma.go.jp/jma/en/Activities/EEWLeaflet.pdf
http://www.fdma.go.jp/bousai_manual/e/index.html

Kazakhstan Accessed 16 Nov 2016
http://www.inform.kz/kz/zher-silkinisi-kezindegi-kauipsizdik-sharalary_a2376391

Kyrgyzstan Accessed 11 Nov 2016
http://www.mes.kg/en/emergency/full/58.html

Lebanon Accessed 19 Dec 2016
http://www.unisdr.org/files/27111_bookletlebanon.pdf

Lithuania Accessed 24 Nov 2016
http://www.civilinesauga.lt/go.php/eng/What-to-do-during-an-earthquake/650

Macedonia Accessed 16 Nov 2016
http://www.brif.mk/kako-da-postapite-vo-sluchaj-na-zemjotr-2/

Madeira Accessed 16 Nov 2016
http://www.procivmadeira.pt/images/stories/Sismos-1.pdf

Mexico Accessed 16 Nov 2016
http://www.nl.gob.mx/servicios/que-hacer-en-caso-de-un-sismo

Mongolia Accessed 11 Nov 2016
http://nema.gov.mn/?page_id=46

Nepal Accessed 12 Nov 2016
http://www.seismonepal.gov.np/index.php?linkId=130

New Caledonia Accessed 23 Nov 2016
http://www.seisme.nc/index.php?option=com_content&view=article&id=66&Itemid=210&lang=en

New Zealand Accessed 28 Nov 2016
http://www.civildefence.govt.nz/assets/Uploads/publications/CM-01.1-earthquakes-June-2015-v2.pdf

Nicaragua Accessed 16 Nov 2016
http://www.ejercito.mil.ni/contenido/sociedad-civil/defensa-civil/defensa-civil-normas.html

Oman Accessed 19 Dec 2016
http://pacdaoman.gov.om/content.aspx?page_key=earthquakes1&lang=ar

Pakistan Accessed 12 Nov 2016
http://www.ndma.gov.pk/PSM.php

Palestine Accessed 11 Nov 2016
https://www.dm.pcd.ps/ar/node/64

Panama Accessed 16 Nov 2016
http://www.sinaproc.gob.pa/nota-numero-1128.html

Papua New Guinea Accessed 28 Nov 2016
http://pngndc.gov.pg/?page_id=53

Peru Accessed 16 Nov 2016
http://www.ins.gob.pe/repositorioaps/0/0/jer/sismos/Cartilla%20de%20Sismos.pdf

Philippines Accessed 11 Nov 2016
https://drive.google.com/file/d/0B8_KPQhbpktXcGhXcTh0VlRTV3M/view?usp=sharing

Portugal Accessed 16 Nov 2016
https://www.ipma.pt/pt/enciclopedia/geofisica/caso.sismo/index.html?page=durante.xml

Puerto Rico Accessed 11 Nov 2016
http://www2.pr.gov/agencias/aemead/PortalEducativo/Pages/Terremotos-y-Tsunamis.aspx

Slovenia Accessed 11 Nov 2016
https://translate.google.com/translate?hl=sl&sl=sl&tl=en&u=http%3A%2F%2Fwww.sos112.si%2Fslo%2F
http://www.sos112.si/slo/page.php?src=np41.htm

Solomon Islands Accessed 22 Nov 2016
http://www.ndmo.gov.sb/index.php/prepare-earthquake

Spain Accessed 11 Nov 2016
http://www.proteccioncivil.org/webinfantil/fsismos.html

Switzerland Accessed 11 Nov 2016
http://www.naturgefahren.ch/home/umgang-mit-naturgefahren/erdbeben/waehrend-erdbeben.html

Taiwan Accessed 11 Nov 2016
http://www.cwb.gov.tw/V7e/earthquake/quake_preparedness.htm

Trinidad and Tobago Accessed 11 Nov 2016
http://www.odpm.gov.tt/sites/default/files/Earthquakes.pdf

Turkey Accessed 16 Nov 2016
http://www.icisleriafad.gov.tr/deprem-sirasinda-yapilmasi-gerekenler

United Arab Emirates Accessed 11 Nov 2016
http://www.ncema.gov.ae/en/general-awareness.aspx

United States of America Accessed 11 Nov 2016
https://www.ready.gov/earthquakes

Uzbekistan Accessed 30 Nov 2016
http://www.uz.undp.org/content/uzbekistan/en/home/library/environment_energy/basic-_do_s-and-donts-before--during-and-after-an-earthquake.html

Venezuela Accessed 16 Nov 2016
http://www.pac.com.ve/contenido/seguridad-y-proteccion/ique-hacer-antes-durante-y-despues-de-un-terremoto/4789/76

Vietnam Accessed 19 Dec 2016
http://www.dmc.gov.vn/kien-thuc-co-ban/dong-dat-pt32.html?lang=vi-VN

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