Analysis of Felt Detailed 'Final Comments' for the 2016 Kaikōura earthquake.

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ABSTRACT

The GeoNet "Felt Detailed" survey collects information about people's experiences after earthquakes - from behavioural responses through to damage to buildings and infrastructure. One of the questions asked at the end of the survey is whether people have any 'Final Comments'. This is an open-ended question, where people can add any information that they wish. Our research was focused on the analysis of these 'Final Comments' to understand the kind of information that is provided by the public. We used manual coding of 977 comments in particular relating to experiences of the 2016 Kaikōura Earthquake. We arranged these into three categories: (1) psychological response to earthquake: fear and quest for reassurance (21.1% of comments), (2) call for accountability and renewed hope in earthquake response (30.4% of comments), and (3) navigating experiences, responses, and preparedness (48.6% of comments). These themes were further identified into sub-themes. The analysis shows that respondents have a strong interest in earthquake science, particularly in advancements in early warning and enhanced tsunami warning systems following the Kaikōura earthquake. Most respondents are knowledgeable about protective actions, emergency preparedness, and structural reinforcements. The experience of earthquakes has further led to a focus on personal and structural preparedness, with comments indicating a strong commitment to household preparedness. This analysis opens up possibilities for further investigation into how people experience and behave during seismic events, and how they interact with both structural and non-structural factors.

1 INTRODUCTION

Earthquakes are the most the frequently occurring natural hazard in New Zealand with about 20,000 earthquakes per year(GNS Science, n.d.-a). They are also one of the most potentially damaging and disruptive natural hazards in New Zealand (National Hazardscape Report, 2007). Several large earthquakes have occurred in the recent past which have affected communities, including those related to the Canterbury

Earthquake Sequence in 2010 and 2011(Vinnell et al., 2023a) and the Kaikōura earthquake in 2016 (Stevenson et al., 2017).

The Kaikōura earthquake was a powerful 7.8 magnitude earthquake that struck the South Island of New Zealand, centred near the town of Waiau. The quake ruptured several active faults (Hamling et al., 2017), affecting coastal and inland areas in the north-east of the island. The effects were severe, causing extensive damage to buildings and infrastructure (Kaiser et al., 2017). A new version of the GeoNet "Felt Detailed" online survey, which collects information about people's experiences after earthquakes, was released after the Kaikōura earthquake (Goded et al., 2017). Despite only being released shortly after the earthquake, 3506 Felt Detailed reports were submitted.

The "Felt Detailed" Report in New Zealand is a type of online macro-seismic survey, similar to surveys used in several countries (Goded et al., 2018; Sbarra et al., 2012; Wald et al., 1999). These reports are an important source of information in which members of the public describe their experiences in the event of an earthquake. Information from these reports is used to calculate the intensity of the shaking experience, providing a geographical distribution of shaking that can be used by emergency responders to understand post-earthquake damage and prioritise interventions (Goded et al., 2021). While these reports are mostly used to collect data to calculate macro seismic intensity, the questionnaire also gathers answers on how people respond, and their behaviour during and after the earthquake(Goltz et al., 2020). Understanding how people behaved and their reaction during and after a disaster is crucial to analysing the human response to an event. Felt reports offer citizens a valuable opportunity to share their experiences, facilitating the rapid dissemination of information to the public. Like GeoNet, authorities in several other countries have adopted similar approaches to understanding and collecting information on human behaviour in the aftermath of an earthquake. The table 1 below shows the behavioural questions for the "Felt Detailed" survey in New Zealand and similar surveys in other countries as listed. All the surveys listed have similar questions about an individual's immediate response, but the response options for answers are different. The NZ Felt Detailed has very specific and varied options for answers to the behavioural questions compared to the other macro-seismic surveys.

In addition to the multiple choice and close ended questions, almost all of above questionnaires include a comments section for respondents to share their experiences of the earthquake. Including an option to provide comments during the survey allows participants to express their experiences and convey the messages. These comments help the researchers to understand the attitudes, behaviours and emotional responses of the respondents in an unrestricted format(Rowney et al., 2014). The Felt Detailed questionnaire also includes comments section where people can share additional information beyond their responses to the survey questions. In the post-Kaikōura earthquake survey, nearly one-third of respondents had provided comments. A detailed analysis of these comments was conducted to understand people's impressions after the earthquake. This type of analysis can provide a broader understanding of people's experiences and behaviours, identify complaints and/or feedback from the public that can be used to improve survey questions or provide direction on practical issues such as preparedness, and ultimately build resilience to these hazards. Furthermore, the analysis of feedback and remarks from such surveys contributes to the refinement of macroseismic intensities, which in turn enhances ShakeMap's utility for engineering applications. In this study, we explored those comments to understand the additional information people provided.

Table 1 : Behavioural questions for the Felt Detailed survey (NZ) and similar surveys in other countries.

Survey Name	**NZ Felt Detailed (New Zealand)(GNS Science, n.d.-b)**	**USGS- Did you Feel it? (US based but can be filled for any earthquake)(United States Geological Survey, n.d.)**	**NRCAN- Did you Feel it ? (Canada)(Government of Canada, n.d.)**	**BGS Earthquake Questionnaire (UK)(British Geological Survey, n.d.)**
Question	What was your first response while the earthquake was shaking?	How did you respond?	How did you respond?	Where you were; did anybody run outdoors in fright?
Response options for the question	Continued what I was doing before. Stopped what I was doing but stayed where I was. Dropped, covered, and held. Moved to a doorway. Tried to protect other people nearby. Tried to protect property nearby (e.g., prevent things from falling) Immediately left the building I was in. Continued driving. Stopped driving and pulled over to the side of the road. Not applicable Other (please explain)	Not specified Took no action. Moved to doorway. Dropped and covered. Ran outside. Other	Not specified Took no action. Moved to doorway. Ducked and covered. Ran outside. Other	No Yes, a few. Yes, many. Yes, most/all. Don't know

2 METHODS

We conducted an analysis of the 'Final Comments' section of the Felt Detailed survey collected from the 2016 Kaikōura earthquake. Out of a total of 3506 responses to the Felt Detailed Survey, 977 respondents provided 'Final Comments' from which we conducted the analysis.

We conducted manual coding of the 977 comments from the survey. We conducted the thematic analysis to the comments. Thematic analysis is a qualitative analytical method used to identify, analyze and report

patterns or themes within the dataset (Braun & Clarke, 2006). This method includes organizing and describing data as well as interpreting various aspects of the data. The data was filtered and sorted using Microsoft Excel and exported to NVivo for reading, organizing, and coding. Coding is the process of identifying and categorizing meaningful units of the qualitative data. It involves systematically assigning codes or labels to the text or part of the text to organize and analyze the information (Braun & Clarke, 2019). For the analysis of the comments from the survey, one researcher initially coded and categorized the comments into three broad themes. A second researcher further used the comments to create sub-categories underneath the broad themes.

3 RESULTS

From the analysis, we identified three main categories of comments which were termed as themes (1) psychological response to earthquake: fear and quest for reassurance, (2) call for accountability and renewed hope in earthquake response, and (3) navigating experiences, responses, and preparedness. Almost half of these comments were about the navigating experiences, responses, and preparedness (48.4%), call for accountability and renewed hope in earthquake response accounted for 30.4% and psychological response to earthquake: fear and quest for reassurance constituted for 21.1% of the responses. Two themes; psychological response to earthquake: fear and quest for reassurance and call for accountability and renewed hope in earthquake response, had comments with positive, negative, and neutral expressions. The categorisation of comments is illustrated in Figure 1 below.

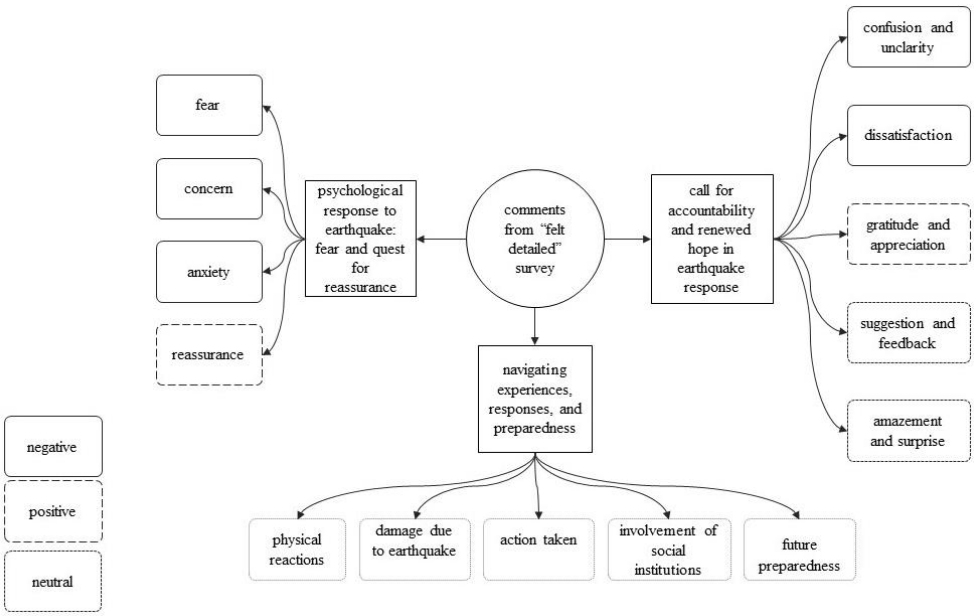

Figure 1: Categorisation of the comments into three themes, with their associated sub-themes.

3.1 Psychological response to earthquake: fear and quest for reassurance

Fear was the most common feeling people expressed in their comments. People reported that they were frightened due to the movement-action, duration, and intensity of the quake. Some individuals reported feeling disoriented and frightened, particularly those who were alone or responsible for vulnerable family members, such as children or disabled partners. There was strong dislike and fear of recurring earthquake events and even desire for the earthquakes to stop happening. There was concern of safety and well-being of family and friends in other cities and parents were worried about children's frightening experiences. These feelings of fear compounded with the need to assess tsunami risks, and the absence of clear and timely

evacuation information – all of which contributed to overall anxiety amongst the public. People were relieved to get information on the details of the earthquake which contributed to managing anxiety and stress, provided comfort, and helped to calm and reassure others.

3.2 Call for accountability and renewed hope in earthquake response.

There were two identifiable areas where people expressed negative thoughts in terms of response. First, there was confusion and lack of clarity on the tsunami evacuation and its related messaging, including a perceived unclear assessment by Civil Defence regarding tsunami. In an absence of consistent and clear message, the respondents found it hard to decide whether to evacuate or stay. Second, failure of vital services like communication, power and internet services, and backup generators for tsunami sirens added to the unclarity about whether to evacuate. This state of confusion, lack of clarity, and failure of vital services, coupled with the inconsistent and delayed response, led to some comments regarding dissatisfaction with the authorities. There were also frustrations with the overall emergency preparedness of the authorities.

People provided large number of suggestions and feedback for improving tsunami warning systems and refining communications between authorities (most prominently GNS Science and Civil Defence), including a desire for more information on precise and unambiguous guidance on evacuation zones, potential risks especially in coastal areas, and providing clear evacuation procedures. Some of the responses were from visitors from other countries, who expressed a desire for earthquake advice on arrival in New Zealand, highlighting the need for easily accessible and comprehensive information.

Despite the dissatisfaction and disappointment from the citizens, there was a huge amount of response applauding the efforts of GeoNet, local Civil Defence, and news channels in providing updates and vital information during difficult times. People expressed their gratitude and appreciation for Civil Defence's management of the situation in certain regions. Regardless of the challenges faced during the seismic events, people expressed hope for stability, safety, and well-being of the citizens.

There was also a desire to understand the reasons for differential effects in neighbourhood. People were also interested in earthquake early warning systems and seeking consistent guidance on the best actions to take in the event of an earthquake.

3.3 Navigating experiences, responses, and preparedness

The responses show that some of the respondents' experience with the 2011 Christchurch earthquake and their ability to identify visual and auditory cues, such as creaking floors and swinging blinds, allowed them to promptly recognize the onset of the Kaikōura earthquake. One of the respondents stated that once they knew it was an earthquake they were assessing where to drop, cover and hold.

In the aftermath of the earthquake, people clearly reported different effects, impacts and sensations in their environment. Some described it as the worst earthquake they had ever felt, reporting physical responses such as difficulty walking, feeling unsteady on their feet and dizziness. Individuals reported that the type of house they were in showed significant differences due to shaking. Timber-framed houses were reported to have significant swaying and movement by their residents, whereas those on concrete slabs experienced less perceptible shaking. Depending on location, the earthquake caused significant damage, including cracked walls, loose windows, driveway slumps, subsidence around pools, and cracks in walls or ceilings. In the survey, people also reported that the items fell off shelves or cabinets, and water splashed out of fish tanks and swimming pools. The earthquake was notable for its prolonged duration and unique rolling motion. The earthquake was characterized by a prolonged swaying, rotating, or rolling movement, unlike the usual sudden jolts.

In addition to the shaking and impact of the earthquake, a large majority of the respondents shared the preventative measures they had taken beforehand, or protective actions they took in response to the earthquake. Some had confidently embraced preventive measures in their homes to keep their furniture and valuables safe. The preventive measures extended beyond these basic actions to technological interventions such as installing a quake alarm system, structural improvements like demolishing brick chimneys and compliance to earthquake specifications during construction.

Several accounts of evacuation decision-making were also highlighted by individuals during the survey. Factors such as proximity to the sea, assessment of potential road and bridge damage, and directives from Civil Defence officers were considered for evacuation decision making. Reports on the involvement of social institutions such as the church were provided which reassured residents that they were being looked after. The survey also provided valuable insights on the preparedness actions people planned for in future, after they experienced the Kaikōura earthquake. People shared about how they had been preparing emergency kits, and planning for conducting inspections to identify necessary precautions to be taken to strengthen their houses. Respondents emphasized the importance of having necessary items readily available due to the uncertainty of when they might be needed.

4 DISCUSSION

The analysis of comments from Felt Detailed Reports of the Kaikōura earthquake revealed three themes: 1) psychological response to earthquake: fear and quest for reassurance, (2) call for accountability and renewed hope in earthquake response, and (3) navigating experiences, responses, and preparedness.

People's reactions to the earthquake were expressed in a range of negative and positive emotions. Fear and emotional distress emerged as negative feelings, while reassurance was seen as more positive. In between was concern for friends and family. Fear after the event was prominent, as is common in emergency situations(Prati et al., 2012). The intensity, movement, action and duration of the earthquake all contributed to the feeling of fear. In particular, the movement and action of the earthquake shaking created a sense of helplessness and induced a fear of death, which can be associated with psychological distress(Rowney et al., 2014). Similarly, emotional distress, a persistent fear of aftershocks and a strong dislike of seismic events were similar to those reported by people during the Christchurch earthquake (Rowney et al., 2014).

Another significant reaction we found in people's comments was concern for friends and family after the earthquake. There were several accounts of concern for family members and for those living close to the epicentre or in the cities. Concern and seeking information about family members has been found to be a notable behavioural response after an earthquake(Jon et al., 2016). Seismological information, such as the epicentre and intensity of the earthquake, provided a sense of reassurance and helped people cope with post-earthquake stress.

After the earthquake, thoughts arising from confusion and lack of clarity about the situation and how to respond, and related dissatisfaction, emerged from the respondents, which were negative, whereas gratitude and appreciation tended to be positive. Suggestions and feedback, as well as amazement and surprise, were categorised as neutral comments. A large proportion of comments related to the accountability of authorities and gaps in services such as communication, risk management and evacuation decision making. The confusion and lack of clarity in the tsunami evacuation messages after the earthquake left many dissatisfied, leading to frustration and subsequent dissatisfaction with the authorities. The post-event report on the Kaikōura earthquake (MCEDM, 2017) also highlighted this as an issue to be improved. During the same event in Christchurch, the lack of clear instructions on tsunami evacuation led to chaos and traffic congestion as some residents evacuated unnecessarily(Kardos, 2017) .This issue is further illustrated by research conducted on communicating evacuation information during Kaikoura earthquake(Becker et al., 2023) which has highlighted the need for increased awareness and sharing of information about tsunami evacuation zones

prior to an event as well as preparation (NEMA, n.d.). In times of crisis, clear and unambiguous instructions are needed to avoid confusing people about whether to evacuate. This is now being improved and 24/7 monitoring of geohazards in New Zealand, including earthquakes, tsunamis, volcanoes and landslides, is provided by the National Geohazard Monitoring Centre (EQC, 2018; GNS Science, n.d.-c)Comments indicate that there is still a strong need to improve communication procedures, to ensure that people understand the risk and hazard areas, and to provide a clear evacuation process(Dhellemmes et al., 2021).

In terms of physical experience, the ability to utilise the knowledge and information to take protective action is a notable characteristic seen among the respondents. Accounts of enhancing preparedness measures, ranging from basic modifications to technological interventions, demonstrate residents' earthquake preparedness. The physical effects of the earthquake and the accounts shared provide a diversity in the emotional and physical responses which shows the variety of behaviour that needs to be understood to improve preparedness measures and design awareness programs.

The Felt Detailed survey validated the importance of collecting impact information, as evidenced by the responses people provided. It also provided a platform for individuals to share preparedness information and consider their future response actions. This survey has proven to be beneficial in understanding not only people's behaviour and responses, but it has also provided a variety of opinions on accountability, gaps in service delivery and public expectations of emergency preparedness and response. Additionally, the survey has inspired individuals to prioritize future preparedness like strengthening their homes. The proactive approach of individuals to implement risk reduction is demonstrated by their determination to prepare for the future, considering the unpredictable nature of earthquakes. These experiences can provide valuable insights for future preparedness and strengthening actions that lead to building resilience at the individual and community level.

4.1 Limitations

We only analysed the "Final comments" section of the responses. Other questions from the survey are not included in this analysis. In addition, we used a manual coding method, which is feasible for small amounts of data. This analysis only includes responses from the Kaikōura earthquake. Analysing responses from other large earthquakes may result in more variability in the categories.

4.2 Future Research

This analysis provided a snapshot of possible categories that can be determined from the comments of the Felt Detailed survey. Themes such as fear and anxiety, concern for others appeared to be drivers of human behaviour during an earthquake. This needs to be further examined. Analysis of the Felt Detailed reports from other earthquakes can provide detailed information about the decision-making process of people during earthquake shaking (Vinnell et al., 2023b). These analyses will further help explain the differences in behaviour and relationship with other variables such as immediate action taken, duration of shaking, damage level, age and gender (Goded et al., 2021).This understanding will help with developing more effective earthquake preparedness and response advice. There is also a need to research what factors influence or prevent people to take protective action. In future, when analysing text data with a large number of responses, we could use a machine driven framework and tools for powerful and efficient analysis (González Canché, 2023).

5 CONCLUSION

This analysis highlighted the accounts of the people affected /impacted by the 2016 Kaikōura Earthquake who participated in Felt Detailed survey after the earthquake. The analysis identified the themes: 1) psychological response to earthquake: fear and quest for reassurance, (2) call for accountability and renewed

hope in earthquake response, and (3) navigating experiences, responses, and preparedness from the comments people provide during the survey. Following the significant seismic event, intensity, duration, and movement action of the earthquake induced fear, anxiety, and stress. We also found that, unclear and inconsistent messaging regarding response to the earthquake and a potential tsunami threat exacerbated confusion. The analysis highlighted a perceived delayed and inconsistent response to the crisis which led to dissatisfaction among the public. In addition, the study highlighted the demand for accountability from public authorities to ensure that critical services won't fail during such disasters. The analysis shows that there is a desire for detailed information on earthquake science and advancements in early warning systems, and a desire to improve the tsunami warning system (some improvements of which have taken place after the Kaikōura earthquake). It is worth noting from the analysis that most respondents are aware of protective actions such as bracing furniture, restocking emergency supplies, tsunami evacuations and employing structural improvements. The earthquake's physical impact has prompted individuals to consider personal and structural preparedness. Comments related to household level preparedness shows the commitment of the residents to undertake preparedness, thus strengthening resilience.

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