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Analysis of Factors Influencing Earthquake Awareness and Preparation Levels Among Residents in the Portland Metropolitan Area, USA

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Researchers at Oregon State University have estimated a 37% chance of a magnitude 8+ earthquake occurring along the Pacific Northwest's Cascadia Subduction Zone in the next 50 years. Despite the high probability of a large earthquake and tsunami severely affecting major west coast cities such as Seattle, Portland, and Vancouver, previous studies have concluded that residents in the area are insufficiently prepared. To that end, it is imperative that local residents increase their level of disaster preparedness. This research aims to determine the level of earthquake awareness and preparation among Portland Metropolitan Area residents, as well as analyze the factors that may have a significant influence on said levels. Over the course of 30 days, a 15-question questionnaire was distributed randomly to Portland Metropolitan Area residents through hard copies and digital copies. Follow-up email interviews were carried out for respondents and state government offices. Statistical cross-sectional analysis was conducted for each factor category compared to earthquake preparation. Among 101 respondents, the ratio of those who have made preparations versus those who have not was approximately half and half. Data analysis revealed minute differences between the majority of the factor categories with respect to the proportions of have and 'have not' made preparations, suggesting an insignificant influence on earthquake awareness and preparation. Alternatively, a 'sense of urgency' and the 'reasons for no preparation' may have a stronger influence over whether or not residents choose to prepare. Among the reasons why respondents have not prepared, the 'lack of concern' for the issue was most prevalent. Research results imply that information on disaster mitigation may not be circulating or reaching residents in the most effective manner. The results from this study may be considered to tailor future efforts to increase earthquake awareness and preparation among PMA residents.

Keywords: Cascadia Subduction Zone, Portland Metropolitan Area, earthquake awareness, earthquake preparation, disaster management

I　Introduction

1．Background

1）Cascadia Subduction Zone

Following the 2011 Great East Japan earthquake and tsunami, concern over the possibility of a similar-sized event occurring on the west coast of the United States heightened among researchers and residents alike (Figure 1). Located approximately 80 km offshore from the Oregon coastline, the Cascadia Subduction Zone is a 1,000 km long four-section convergent plate boundary that stretches from northern Vancouver Island to northern California (Figure 2). The shallowest depth of this seismic fault is 30 km. The fault is capable of generating megathrust earthquakes exceeding magnitude 9.0 (Pacific Northwest Seismic Network, n.d.).

Evidence of ghost forests, seaside arrowgrass, and orphan tsunamis in historical Japanese records have dated the last Cascadia event back to 319 years ago, in January 1700 (Satake, Shimazaki, Tsuji, & Ueda, 1996; Atwater et al., 2005). With a recurrence interval of roughly 243 years, this seismic fault is due for another large rupture. Other subduction zones around the globe typically have recurrence intervals of 100 to 200 years, so the overdue interval of the Cascadia fault may imply an unusually large buildup of tectonic stress.

A 2012 study analyzing carbon dating of seafloor turbidite samples indicated that 41 large earthquakes have occurred along the Cascadia

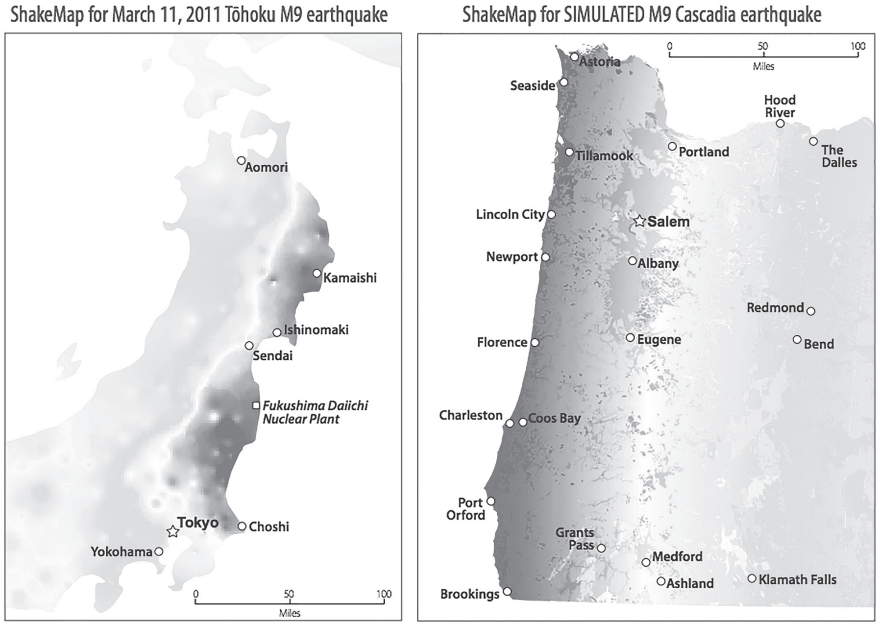

Figure 1 'ShakeMap' computer simulations of the 2011 Great East Japan earthquake (left) and predictions for a similar Cascadia earthquake in Oregon, U.S.A. (right)

Dark gray indicates stronger earthquake intensity and light gray denotes weaker intensity.
100 miles = 160 kilometers.

(Source: Oregon Department of Geology and Mineral Industries, 2012)

fault in the last 10,000 years. Of those 41 events, 19 resulted in a "full margin rupture" wherein the entire length of the fault fractured. The researchers estimated a 37% chance of a magnitude 8+ earthquake occurring along the Cascadia Subduction Zone in the next 50 years (Goldfinger et al., 2012).

2) Expected damages and current situation

The Federal Emergency Management Agency (FEMA) estimates that a Cascadia earthquake of magnitude 8+ could potentially lead to approximately 13,000 fatalities, 27,000 injuries, 1 million displaced residents, and 2.5 million people without food, water, and electricity. The number of heavily damaged or completely destroyed buildings are predicted to reach 39,000 and 130 fires resulting from broken gas lines may inflict further destruction. Economic losses may total $30 billion in just Oregon alone.

Large-scale earthquakes categorized as 'strong', 'major', and 'great' earthquakes (between Richter magnitudes 6.0-9.0+) often result in environmental effects such as ground rupture, landslides, soil liquefaction, subsidence, and a tsunami generating immense waves of up to 30 meters, which poses a serious threat to the safety of coastal residents.

Despite the high probability of a large earthquake and tsunami severely affecting major west coast cities such as Seattle, Portland, and Vancouver, previous studies have concluded that residents in the area are insufficiently prepared (Johnston et al., 2005; Houghton et al., 2009; Lindell & Prater, 2010; Dunn, Ahn, Bostrom, & Vidale, 2016). For this reason, it is imperative that local residents are provided with appropriate information on emergency supplies, evacuation facilities, securing housing structures, and early warning systems to increase preparation measures.

In recent years, news coverage by local media outlets is raising awareness on the dangers of large earthquakes occurring in the Pacific Northwest region. As such, it is evident that residents living in the area are becoming increasingly exposed to

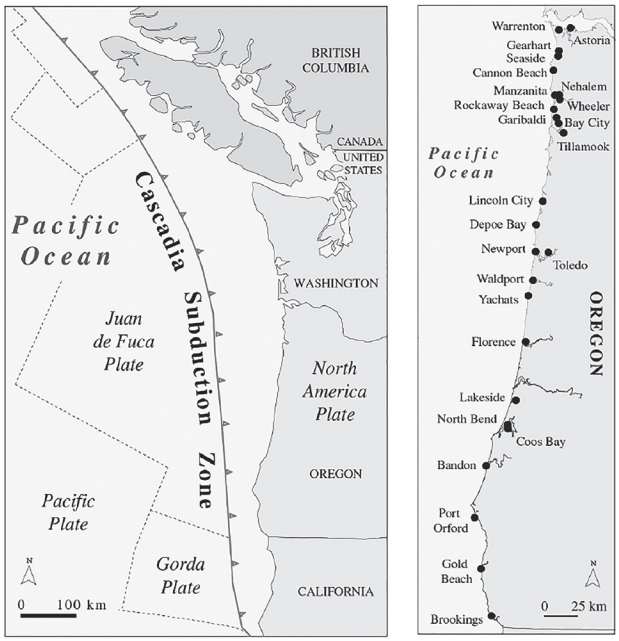

Figure 2 Map of the Cascadia Subduction Zone and its corresponding tectonic plates along the upper west coast of the United States (left) and major coastal cities in Oregon (right)

(Source: United States Geological Survey, 2007; Wood, 2009)

information on hazardous natural disasters, which may potentially encourage better preparation in the coming years.

2. Study Area

The Portland Metropolitan Area (henceforth PMA) covers an area in the Pacific Northwest states of Oregon and Washington, with the city of Portland at its center (Figure 3). It comprises of seven administrative counties; five located in Oregon and two in Washington. The PMA is used as a statistical area by the United States Census Bureau. The largest city in the area is Portland, followed by Vancouver, Hillsboro, Gresham, and Beaverton. The estimated population in 2017 was approximately 2.7 million, with around half of Oregon's population living within the PMA (Metro, n.d.). Though the area is not located within a tsunami inundation zone, there remains a high risk of severe damage to infrastructure including highways, bridges, dams, railways, electrical grids, and housing in the event of a large earthquake occurring off the Oregon coast.

Seismic building codes in both Oregon and Washington were not officially implemented until 1974, therefore most infrastructures built before this are not fit to resist strong ground motion unless they have been recently retrofitted (Figure 4) (Oregon Construction Contractors Board, n.d., American Society of Civil Engineers, 2019). The downtown area of Portland, Oregon is uniquely characteristic in that it is separated by the Willamette River, with twelve major bridges connecting the western and eastern side (Figure 5). However, of these twelve bridges, only two (Tilikum Crossing and Sellwood Bridge) have been built or retrofitted to withstand earthquakes. The remaining ten bridges, which were built between 1908 and 1973, are expected to either collapse completely or remain standing but with extensive damage (Oregon Department of Transportation, 2016). Moreover, two main interstate highways

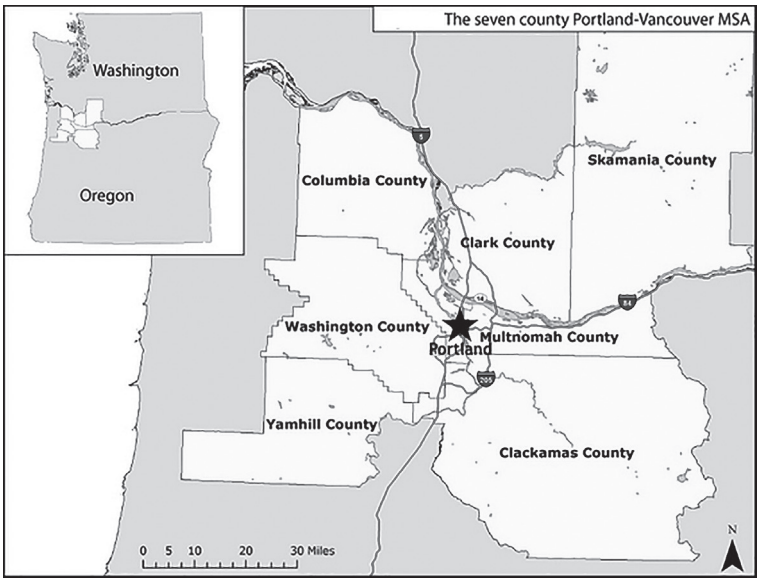

Figure 3 Map of the 7 counties of the Portland Metropolitan Area, including major highways (shield symbols) and the city of Portland (star)

30 miles = 48 kilometers

(Source: modified from Sprague and Picha, 2010)

(Interstate 5 and Interstate 84) connect Oregon and Washington to several neighboring states to the north, south, and east.

3. Purpose

This research aims to determine the level of earthquake awareness and preparation among Portland Metropolitan Area residents, as well as analyze the factors that may have a significant influence on said levels. Research questions to consider include but are not limited to:

- What factors may be influencing the level of earthquake awareness or preparation in residents?
- What proportion of PMA residents have experienced an earthquake whilst living in the area?
- Are residents aware of the potential risk of a large earthquake occurring on the U.S. west coast?
- To what extent do PMA residents understand about the damages that may be inflicted due to the Cascadia Subduction Zone Earthquake (henceforth CSZE)?
- What proportion of residents are prepared in terms of emergency supplies, housing reinforcement, and knowledge of evacuation facilities? How have they prepared?
- What are the motivations behind residents who have and have not made preparations for

Figure 4 Old apartment buildings made of brick and concrete in central downtown Portland

(Taken by Goto, September 2018)

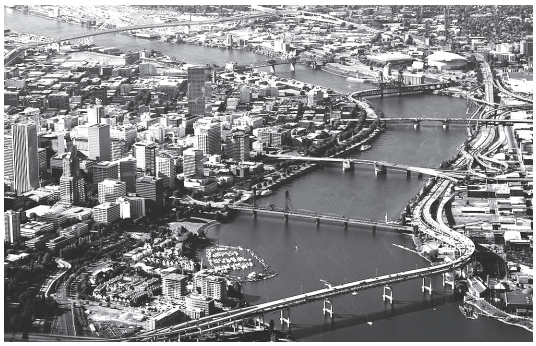

Figure 5 Aerial photo showing the main downtown Portland bridges built along the Willamette River

(Retrieved from: http://www.southportlandba.com/wp-content/uploads/2015/09/portland_oregon_river_bridges.jpg)

a large earthquake?

- Did the occurrence of the 2011 Great East Japan Earthquake (henceforth GEJE) have any effect on the PMA residents' perceptions of a similar disaster occurring in the Pacific Northwest region?
- What efforts have local communities and federal governments made in response to possible natural hazards (particularly earthquakes)?
- What are the implications for government intervention (i.e. mitigation measures, communication of proper information, etc.) and demographic influences on disaster preparation?
- Are there any differences between less-prepared PMA residents and highly-prepared Japanese residents with respect to preparation level and mindsets towards natural hazards?

Ⅱ Methodology

Over the course of 30 days in August 2018, a 15-question questionnaire was distributed randomly to Portland Metropolitan Area residents through hard copies and digital copies via Google Forms. Contents of the questionnaire included sex (#1), age group (#2), occupation (#3), family size (#4), whether or not respondent is/has been a resident of the PMA (#5), length of residency in the PMA (#6), earthquake experience in the PMA (#7), awareness of the CSZE (#8), expected damages from the CSZE (#9), whether or not the household has made emergency preparations (#10), type(s) of emergency preparations made (#11), reason for not making emergency preparations (#12), description of any effects felt from the GEJE (#13), email address (optional) (#14), and comments (optional, #15). Follow-up interviews were carried out for both versions in-person and through email, respectively. Respondents were asked to complete one questionnaire per household. Additionally, interviews with the Oregon and Washington state governments were conducted through email. Microsoft Excel was used in grouping and categorizing similar responses, followed by statistical cross-sectional analysis of each factor category (all questionnaire questions excluding #5, #6, #9, #11, #12, #14, and #15) compared to earthquake preparation. In this case, earthquake preparation was used as the dependent variable instead of awareness, seeing that preparation is a reflection of an individual's awareness of the issue at hand.

Ⅲ Results

1. Demographics and earthquake-related characteristics of respondents

The following are the summarized results of the questionnaire, which totaled 101 respondents.

The most common demographics among the 101 PMA resident respondents include: 'FEMALE' (65%), 'AGES 45-59' (37%), 'EMPLOYED' (50%), 'FAMILY SIZE OF 4' (37%), and 'RESIDENCY LENGTH UP TO 20 YEARS' (26%).

Among the 101 residents, the average length of residency in the Portland Metropolitan Area is 23 years. The shortest length is 1 year and the longest is 68 years.

More than half of the 101 respondents (57%) 'HAVE' experienced an earthquake while living in the PMA, 31% 'HAVE NOT' and 12% are 'UNSURE'. It is likely that the event the respondents experienced was the 1993 Scotts Mills earthquake, which had a moment magnitude of 5.6 Mw (Thomas, Crosson, Carver, & Yelin, 1996).

68% of 101 respondents 'ARE AWARE' of the Cascadia Subduction Zone Earthquake (CSZE). 24% 'ARE NOT AWARE' of it and 8% are 'UNSURE'.

Most residents who 'ARE AWARE' of the CSZE (69 respondents) understand the critical types of damage that can be expected from its rupture (the most common answer being 'infrastructure damage' at 52%), though there are some extremely exaggerated cases (i.e. continental splitting).'

Proportions of residents who 'HAVE' made disaster preparations and those who 'HAVE NOT' are roughly half and half among 101 respondents (48% and 50%, respectively). 2% of respondents are 'UNSURE' if they have made preparations.

The top three most common at-home earthquake preparations among 48 respondents are making emergency supply kits (79%), securing water heaters/large appliances (46%), and stabilizing tall furniture (31%).

The 'LACK OF CONCERN' for future earthquakes is the primary reason for residents to not take any mitigative measures (61% out of 52 respondents).

About half of 74 respondents (51%) answered that the 2011 Great East Japan Earthquake (GEJE) 'HAD AN EFFECT' on their perception of earthquakes, 34% answered that it 'HAD NO EFFECT' on them, and 15% replied it had 'SOMEWHAT' of an effect.

When asked what sort of effects the GEJE had on their perception of disasters, 46% of 74 respondents explained that it made them more aware of earthquakes, 12% took action to prepare at home, 9% had a personal connection to the event, and 1% participated in volunteer activities. 27% of respondents felt indifferent because the event occurred far away from home and 12% felt no effect because they were already aware of natural disasters.

2. Factor categories compared with earthquake preparation

The following are the highest proportions of respondents in each factor category with respect to those who have and have not made earthquake preparations. Full details can be referred to in Figures 6-15.

Sex (101 respondents): 32.7% are 'FEMALE' and 'HAVE' made preparations, 30.7% are 'FEMALE' and 'HAVE NOT' made preparations (Figure 6).

Age Group (101 respondents): 19.8% are between the 'AGES 45-59' and 'HAVE' made preparations, 16.8% are between the 'AGES 45-59' and 'HAVE NOT' made preparations (Figure 7).

Occupation (101 respondents): 22.8% are 'EMPLOYED' and 'HAVE' made preparations, 26.7% are 'EMPLOYED' and 'HAVE NOT' made preparations (Figure 8).

Family size (101 respondents): 20.8% have a

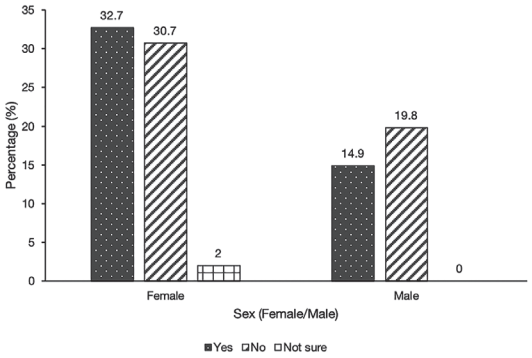

Figure 6 Proportions of female and male respondents who have (dotted), have not (striped), or are unsure (grid) if they have made earthquake preparations (n=101)

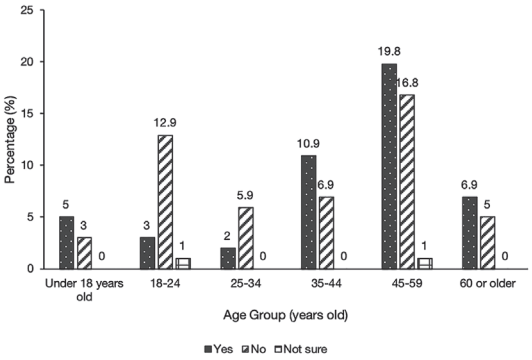

Figure 7 Proportions of respondents in their respective age groups who have (dotted), have not (striped), or are unsure (grid) if they have made earthquake preparations (n=101)

'FAMILY SIZE OF 4' and 'HAVE' made preparations, 15.8% have a 'FAMILY SIZE OF 4' and 'HAVE NOT' made preparations (Figure 9).

Earthquake experience in the PMA (101 respondents): 30.7% 'HAVE HAD' earthquake experience and 'HAVE' made preparations, 25.7% 'HAVE HAD' earthquake experience and 'HAVE NOT' made preparations (Figure 10).

CSZE awareness (101 respondents): 38.6% 'ARE AWARE' of the CSZE and 'HAVE' made preparations, 29.7% 'ARE AWARE' and 'HAVE NOT' made preparations (Figure 11).

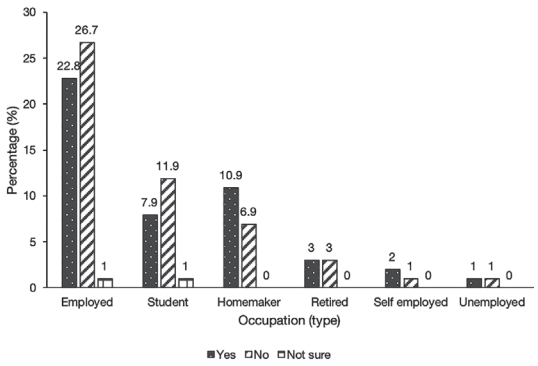

Figure 8 Proportions of respondents in their respective occupations who have (dotted), have not (striped), or are unsure (grid) if they have made earthquake preparations (n=101)

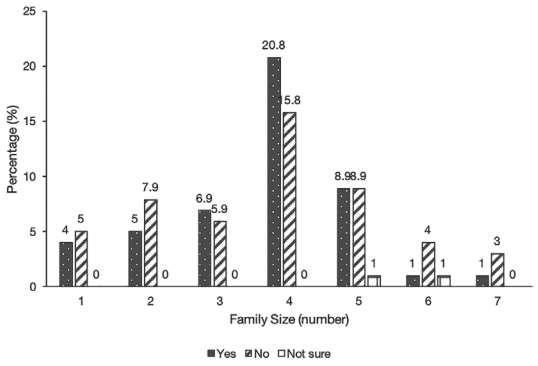

Figure 9 Proportions of respondents with their respective family sizes who have (dotted), have not (striped), or are unsure (grid) if they have made earthquake preparations (n=101)

GEJE effect (74 respondents): 28.4% 'DID FEEL' an effect from the GEJE and 'HAVE' made preparations, 23% 'DID FEEL' an effect from the GEJE and 'HAVE NOT' made preparations (Figure 12).

Damage type (69 respondents): 39.1% predicts 'INFRASTRUCTURE DAMAGE' and 'HAVE' made preparations, 36.2% predicts 'INFRASTRUCTURE DAMAGE' and 'HAVE NOT' made preparations (Figure 13).

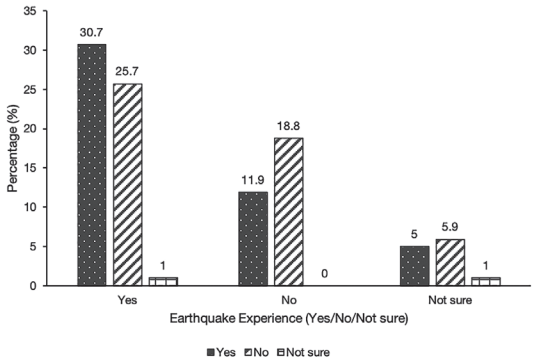

Figure 10 Proportions of respondents who have, have not, or are unsure if they have experienced an earthquake in the PMA with respect to whether they have (dotted), have not (striped), or are unsure (grid) if they have made earthquake preparations (n=101)

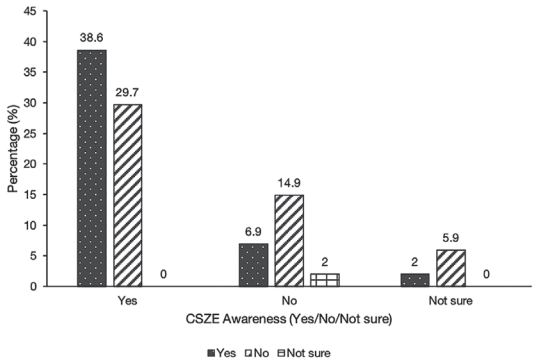

Figure 11 Proportions of respondents who are, are not, or are unsure of their CSZE awareness with respect to whether they have (dotted), have not (striped), or are unsure (grid) if they have made earthquake preparations (n=101)

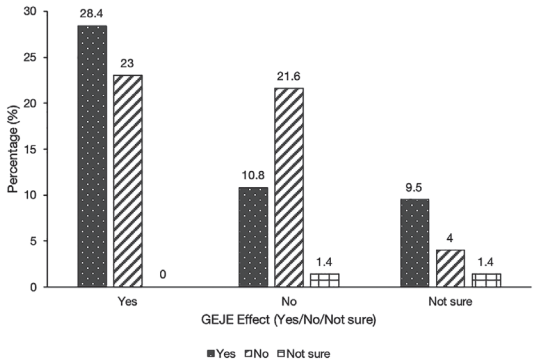

Figure 12 Proportions of respondents who felt, did not feel, or are unsure of an effect from the GEJE with respect to whether they have (dotted), have not (striped), or are unsure (grid) if they have made earthquake preparations (n=74)

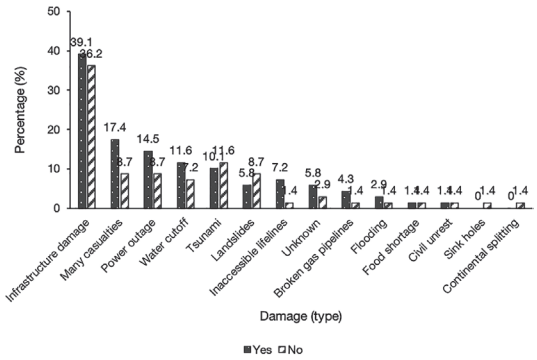

Figure 13 Proportions of answers to earthquake damage types with respect to whether the respondents have (dotted) or have not (striped) made earthquake preparations (n=69)

Preparation type (48 respondents; only those who HAVE made preparations): 79.1% of those who 'HAVE' made preparations have 'EMERGENCY SUPPLY KITS' ready in their home (Figure 14).

Reason for no preparation (52 respondents; only those who HAVE NOT made preparations): 61.5% of those who 'HAVE NOT' made preparations answered it is because they 'LACK CONCERN' for the issue (Figure 15).

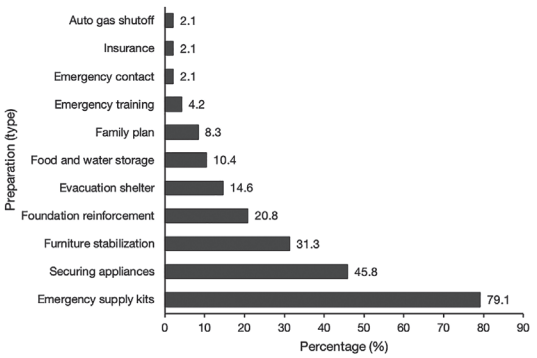

Figure 14 Proportions of emergency preparation types among respondents who have made earthquake preparations (n=48)

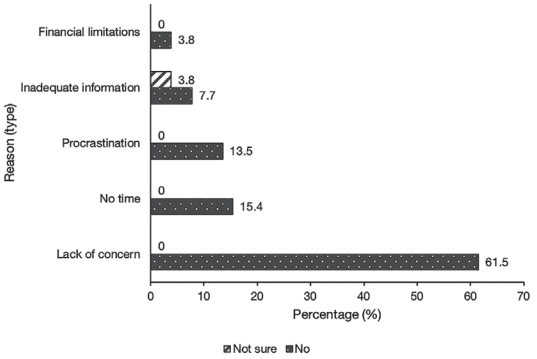

Figure 15 Proportions of the types of reason(s) for not making emergency preparations among respondents who have not (dotted) or are unsure (striped) if they have made earthquake preparations (n=52)

Ⅳ Discussion

1. Analysis of each factor and its level of influence on earthquake preparation

When examining the respondents' sex compared to whether or not they have made preparations, the highest proportions of both 'HAVE' made preparations and 'HAVE NOT' made preparations are both in the 'FEMALE' group. However, the proportional difference between female respondents who 'HAVE' and 'HAVE NOT' made preparations is very small (2%). Therefore, the sex of the respondents

may have a weak influence on earthquake preparation.

The highest proportions of 'HAVE' and 'HAVE NOT' made preparations in the age group category are both in the 'AGES 45-59' range. In this factor category as well, the proportional difference is very small (3%), suggesting that age group may not have a significant influence on whether or not respondents have or have not made preparations.

The occupation factor category shows similar trends. The most common occupation type is 'EMPLOYED', and the highest proportions of 'HAVE' and 'HAVE NOT' made preparations are both in this group. The proportional difference here is also minimal, at 3.9%. Likewise, the occupation factor category may not hold much influence on earthquake preparation among respondents.

Regarding family size, most respondents have a 'FAMILY SIZE OF 4', and the highest proportions of 'HAVE' and 'HAVE NOT' made preparations are both in this group as well. Similar to the previous factor categories, the proportional difference between the two is minor at 5%. Hence, family size may not have an exceptionally strong influence on earthquake preparation.

When looking at earthquake experience of the respondents, the highest proportions of 'HAVE' made preparations and 'HAVE NOT' made preparations are both in the 'HAVE HAD' earthquake experience group. Proportional differences in this factor category are also slight, at 5%. According to this result, earthquake experience does not seem to greatly influence whether or not respondents have or have not made preparations.

Comparison of awareness of the CSZE with respect to earthquake preparation resulted in the highest proportions of 'HAVE' made preparations and 'HAVE NOT' made preparations both being in the 'ARE AWARE' group. The proportional difference in this factor category is slightly larger than previous categories (8.9%), though it is still a relatively small difference. Thus, CSZE awareness may not be the core influencer of earthquake preparation among PMA residents.

Highest proportions of those who 'HAVE' and 'HAVE NOT' made preparations are both in the group wherein respondents 'DID FEEL' an effect from the GEJE. The difference between the two proportions is again fairly little (5.4%), which may suggest a marginal level of influence on earthquake preparation.

For the types of damages respondents expect from the CSZE, the highest proportions of 'HAVE' and 'HAVE NOT' made preparations are both in the 'INFRASTRUCTURE DAMAGE' group. Proportional difference in this factor category is 2.9%, denoting a very small influence on earthquake preparation.

Results of the types of emergency preparations made by respondents indicate that the most common type is emergency supply kits (79.1% out of 48 respondents). This could be on the grounds that putting together supply kits may be the easiest and most cost-effective method of disaster preparation.

The most prevalent reason for not making emergency preparations is the 'LACK OF CONCERN' for the Cascadia Subduction Zone Earthquake (61.5% out of 52 respondents). A considerable number of respondents gave multiple reasons for their lack of preparation, with many of them interconnecting to each other (i.e. 'NO TIME' and 'PROCRASTINATION'). Residents seem to view disaster preparation as a low priority, especially due to the fact that their daily lives are already too occupied with other matters such as work, school, and family.

Other less common but significant reasons for not making preparations include 'INADEQUATE INFORMATION' and 'FINANCIAL LIMITATIONS'. Several respondents answered that they would like to make preparations but cannot due to financial limitations. Measures such as foundation reinforcement and purchasing disaster insurance are undoubtedly more expensive than putting together emergency supply kits and stabilizing household furniture or electric appliances. However, the reality that some families are financially unable to purchase materials for an emergency supply kit raises questions as to whether governments should subsidize basic necessities for disaster preparation.

2. Difference between the 'most' and 'least' prepared respondents

By compiling a list of the highest percentages of 'HAVE made preparations' and 'HAVE NOT made preparations' in each factor category, characteristics for the 'most' and 'least' prepared respondents can be determined. The demographic characteristics for both sides include: 'FEMALE', 'AGES 45-59', 'EMPLOYED', 'FAMILY SIZE OF 4', 'HAS EARTHQUAKE EXPERIENCE IN PMA', 'AWARE OF THE CSZE', 'FELT AN EFFECT FROM THE GEJE', and 'PREDICTS INFRASTRUCTURE DAMAGE'. Compilation of the lists reveals that the characteristics of the two opposing sides of the preparedness spectrum are identical. In other words, there is no clear difference in demographics between the 'most' and 'least' prepared respondents.

However, out of 101 total respondents, the number of individuals who fit into the most and least prepared categories (as previously stated) is 2 and 0, respectively. As such, these two categories are not representative of the majority of respondents. The implication is that most of the respondents fall into other points of the preparedness spectrum.

V Conclusion

1. Earthquake awareness and preparation levels among PMA residents

As stated in the results, the ratio of respondents who have made preparations versus those who have not (among 101 people) is 48% and 50%, respectively. Considering the fact that a large portion of respondents answered that they have experienced an earthquake while living in the PMA (57%) and an even larger number of them are aware of the CSZE (68%), the number of unprepared respondents is surprisingly high. In addition, respondents have demonstrated that most of them are well aware of the expected types of damages from the CSZE. This further highlights a problematic situation wherein respondents have not prepared regardless of their knowledge on the issue (Wachinger, Renn, Begg, & Kuhlicke, 2012).

2. Determining the factor(s) influencing earthquake preparation

Based on the post-statistical data analysis, the most common incentives for respondents to prepare for earthquakes are high awareness of the CSZE and predictions for severe damages resulting in a large earthquake in the PMA. In this regard, a sense of urgency may be a strong driving force for residents to take action towards disaster mitigation.

The results of the data analysis exhibit a small difference between the majority of the factor categories with respect to the proportions of 'HAVE' and 'HAVE NOT' made preparations. This may suggest that the demographic factors shown in Figures 6-14 may not hold a significant role in determining earthquake awareness and preparation level. Instead, among the factors examined in this study, the 'reason for no preparation' may have a stronger influence over whether or not respondents choose to prepare for an earthquake in the PMA. Among the different reasons why respondents have not prepared for earthquakes, lack of concern for the issue holds the highest proportion at 61.5%.

3. Implications for disaster management and recent local efforts

In both Oregon and Washington, various state government efforts have been planned and implemented. Launched in 2003, the federal government has also established an emergency readiness campaign called the 'Ready Campaign' (U.S. Department of Homeland Security, n.d.). However, based on this study as well as previous studies, many residents in the area seem to believe that there is a lack of information and support provided by the government (Donahue, Eckel, & Wilson, 2013). Given this, it is evident that information on disaster mitigation may not be circulating or reaching the residents in the most effective manner.

In order to increase earthquake awareness and preparation levels among PMA residents, both the private and public sectors (i.e. local and federal governments, private organizations, home associations, educational institutions, etc.) will need to

enhance how information on disaster preparation is communicated to residents (Tanaka, 2005). It can be said that making mitigation procedures more accessible and attainable for all residents is key for increasing earthquake awareness and preparation. By doing so, residents may begin to consider disaster preparation as a greater concern.

Some suggestions given by follow-up interview respondents for increasing preparation include holding information sessions at workplaces/schools/neighborhood events, distributing pamphlets on emergency kits, promoting disaster training programs and drills (Portland Bureau of Emergency Management, n.d.), creating a consolidated web page with information on disaster mitigation, and maximizing media coverage on the issue.

In September 2018, the Multnomah County announced plans to retrofit the 92-year-old Burnside Bridge, a vital route for lifelines spanning across the PMA (Multnomah County OEM, 2018). Although crucial for securing the safety of residents, this retrofit plan will require residents' strong consensus and willingness to pay additional taxes to cover construction costs. Based on follow-up interview results, there seems to be a positive reception towards these plans. If retrofitting plans are approved, construction is estimated to begin in 2023 and end in 2028.

'ShakeAlert' is an earthquake early warning system for the West Coast currently under development by USGS along with a group of State and university partners. The main purpose is to provide an early earthquake alert to citizens (via mobile phones, TV, and radios) to give them enough time to take cover before a large earthquake occurs. In September 2018, the system entered its testing phase before making it fully operational to the public (Multnomah County OEM, n.d.; USGS, n.d.).

Also in 2018, researchers at the MIT Urban Risk Lab announced their collaboration with the city of Portland, Portland State University, and the Portland General Electric company to develop an innovative gathering place for community members to go to after a natural disaster. The structure, named the 'PREPhub', is designed to have solar panels, LED lights, monitors, charging ports, speakers, and generators. Installation in the PSU campus is expected to be complete in the Summer of 2019 (MIT Urban Risk Lab, 2018).

On a more local scale, follow-up interview responses provided anecdotal evidence of mitigation efforts made by home associations and school districts. Several neighborhoods and schools have begun holding disaster preparation workshops and information sessions for residents to participate in. Evidently, both the City of Portland and private organizations are already beginning to take greater steps to advance disaster mitigation in the area.

4. Earthquake preparation in the PMA vs. Japan

When comparing preparation levels between residents living in the PMA and those in Japan, there is a stark contrast between the two. In Japan for example, local and federal governments, neighborhood associations called "jishu bōsai soshiki" (Bajek, Matsuda, & Okada, 2008), and schools continuously promote efforts to prepare for natural disasters. Since 1960, September 1st has been dedicated as Disaster Prevention Day ("bōsai no hi") to raise awareness and hold wide-scale emergency drills for all residents to participate in (Ministry of Foreign Affairs of Japan, n.d.). In the Tokyo Metropolis, the local government has developed a disaster preparation manual in several languages for all residents to reference (Tokyo Metropolitan Government, n.d.). The country's Earthquake Early Warning system operates at high accuracies (Japan Meteorological Agency, n.d.). As a country that experiences frequent natural disasters, such high levels of preparation can be expected (Onuma, Shin, & Managi, 2017).

On the other hand, the long absence of large earthquakes occurring in the PMA may have led residents to see preparation as a low priority in their daily lives. A fair number of questionnaire respondents in this study commented that they feel making preparations for an earthquake of such large magnitude would be futile. This kind of mindset is not typically seen among Japanese residents, where many feel that it is "better to be safe than

sorry". The notion that a Cascadia earthquake may or may not occur during their lifetime also impacts residents' perception of the importance of disaster preparation. These kinds of viewpoints can be reasoned by the protection motivation theory proposed by Professor Ronald W. Rogers in 1975 (Rogers, 1975).

Furthermore, there seems to be a difference between PMA and Japanese residents in regard to mindsets towards how much the government should intervene in disaster preparation (Palm, 1998; Eiser et al., 2012; Johnson & Nakayachi, 2017). According to the responses from follow-up interviews, PMA residents seem to expect the government to provide small-scale support for the people (e.g. emergency supply pamphlets/kits) in addition to the large-scale emergency mitigation measures (e.g. infrastructure retrofitting, first responders, early earthquake warning system). In contrast, Japanese residents tend to make small-scale preparations on their own and rely on the government for mainly large-scale mitigation efforts (Nakayachi, 2018).

5. Future direction

The results from this study may be considered to tailor future efforts to increase earthquake awareness and preparation among PMA residents. By understanding the factors associated with earthquake mitigation at the individual level, governments and private organizations could modify their efforts to reach more residents and boost their motivation to prepare. Doing so may effectively minimize damage inflicted upon the economic, environmental, and social aspects of the Portland Metropolitan Area.

Some limitations that can be said of this study include the skewed data of the respondents' demographics (i.e. sex, age group, and occupation), the subjective nature of residency length, the lack of details on the magnitude of the earthquake(s) respondents experienced while living in the PMA (Question #7), and the need to clarify whether the amount of earthquake preparation(s) respondents have made actually meet recommended standards (Question #10 and #11).

Further research on this issue may look into more detail on the specifics of how and why PMA residents have or have not prepared for a large Cascadia Subduction Zone earthquake. Future surveys should collect a larger number of respondents in order to make more accurate conclusions that are representative of the population majority. Similarly, a more in-depth statistical analysis by correlation and regression may be necessary to make clearer distinctions between prepared and unprepared residents.

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