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ABSTRACT

Washington State, United States, has variable seismic risk as a result of a major plate boundary off the western coastline known as the Cascadia Subduction Zone. Seismic risk generally decreases from west to east with distance from the subduction zone. Much recent attention has been focussed on the seismic risk in western parts of the State because of the potential impact on large, concentrated populations in the Seattle-Tacoma area. While the risk to communities in eastern Washington is less than western parts of the state, future damaging earthquakes remain a distinct possibility, and could result from earthquakes associated with either the offshore subduction zone or from local faults.

This report describes the results of a study investigating resident perceptions of natural hazard risk in eastern Washington. Data was collected using a structured survey at five County and State fairs in September 2010, and through follow-up focus groups in October 2011. The results highlight that few eastern Washington residents had experienced damaging earthquakes in the past, but many believed they would experience one during their lifetime. While awareness and understanding of the likelihood of future earthquakes was found to be relatively high, this did not translate into residents taking steps to get more prepared, with only a small proportion adopting mitigation measures other than owning a flashlight, fire extinguisher or first aid kit.

KEYWORDS

Washington, seismic risk, earthquakes, natural hazard, resident perceptions, Cascadia Subduction Zone, preparedness, awareness, mitigation

1.0 INTRODUCTION

Seismic hazard in Washington State poses a significant threat to lives and livelihoods as a result of a major plate boundary along the western seaboard of the state. The Juan de Fuca plate is involved in complex subduction with the North American Plate across the Cascadia Subduction Zone, which extends off the coast of Washington and south to Oregon and northern California (Figure 1). United States Geological Survey (USGS) have developed a range of scenarios for possible future earthquakes in the state, including a number of eastern Washington events (available on the USGS website).

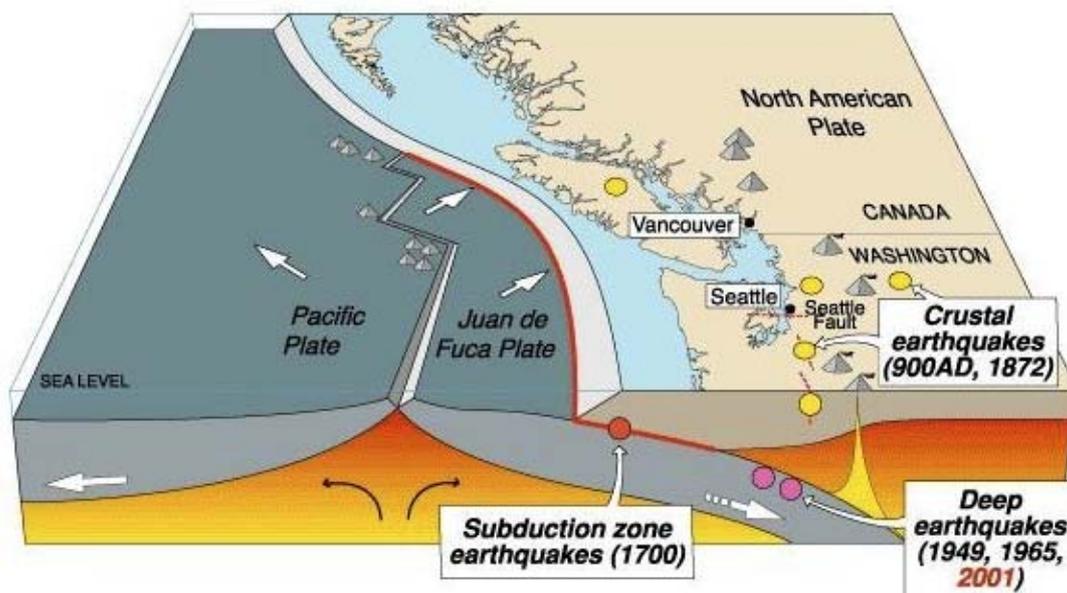


Figure 1 Tectonic setting of Washington, illustrating the Cascadia Subduction Zone (Source: USGS).

Overall, the seismic hazard in Washington comes from three potential sources:

1. Subduction earthquakes on the Cascadia subduction zone (approx. M¹8-9)
 These earthquakes pose the most serious risk to western Washington. The largest known earthquake event (M¹9) in the region took place in 1700 on the Cascadia Fault (Wang et al. 2003; Satake et al. 1996). An earthquake of this size that takes place under the sea has the potential to generate a powerful tsunami, much like the Japan tsunami and earthquake of March 2011. Future earthquakes on the Cascadia Subduction Zone are likely to be M¹8-9 events, with a recurrence interval of ~ 500 years (Wang et al. 2003).
2. Intraplate earthquakes (approx. magnitude M¹6-7+)
 These earthquakes take place between 35 and 60 km on the subduction zone beneath the Puget Sound region. Because of their depth they are less damaging on the surface of the earth than crustal earthquakes. The recurrence interval in Puget Sound for this type of earthquake is 30-50 years. An example of this type of earthquake is the Nisqually earthquake in 2001 (M¹6.8), centred 17 km northeast of Olympia. This event resulted in approximately \$2 billion damage to buildings and property, and power

¹ M refers to magnitude, or the amount of seismic energy released by an earthquake.

outages in Seattle. It was felt widely across the state (including in Spokane), however no damage was reported outside the epicentral region. Other examples of intraplate earthquakes include the 1949 Olympia earthquake (**M6.8**) and the Seattle earthquake (**M6.5**) in 1965.

3. Crustal faults in eastern Washington (M5-7+)

While eastern Washington communities may experience some damage from distant earthquakes in the western part of the state, the biggest threat comes from local shallow crustal faults. In fact, eastern Washington experienced the two largest crustal earthquakes felt by European populations. In 1872, an earthquake of an estimated **M6.8** struck the Chelan area and generated a landslide that blocked the Columbia River. The entire state felt the event. The 1936 Milton-Freewater earthquake, estimated at **M6.3**, caused damage in Walla Walla.

Many crustal faults in eastern Washington are long features, striking across the landscape for tens of kilometres. The length of the faults suggests the possibility of earthquakes as large as **M7** or greater, but lack of field data limits assessments. Based on limited field studies, the USGS assessed the Saddle Mountain fault, about 30km north of Richland, as capable of a **M7.3** earthquake. The repeat time for these events is poorly known.

Figure 2 illustrates the current seismic hazard map for Washington. USGS is currently working on an updated version of the National Seismic Hazard Map, including Washington, and expects to publish the revised map in 2013. The revised map will incorporate new fault studies underway in eastern Washington that are using aeromagnetic surveys and lidar mapping to identify sites for geologic investigations of selected crustal faults in the region.

2.0 METHODOLOGY

Data was gathered through a questionnaire completed by 527 respondents at five County/State fairs in eastern Washington between September 2-11th 2010 (Kittitas County Fair, Ellensburg – September 2nd; Ferry County Fair, Republic – September 3rd; Walla Walla Fair and Frontier Days – September 5th; Spokane Interstate Fair, Spokane – September 10th; Columbia County Fair, Dayton – September 11th (Figure 4). The two-page questionnaire consisted of twelve questions investigating resident understanding of the hazards affecting their communities (past and future), as well as the likelihood of occurrence, and preparedness for future events. The questions were designed to find out about resident understanding of seismic risk, but the survey was positioned within an all-hazards context to investigate relative levels of concern about hazards in their region. Attendees at the fairs were invited to participate, and those who agreed to take part completed the survey and returned it immediately. A copy of the survey is included in Appendix 1.

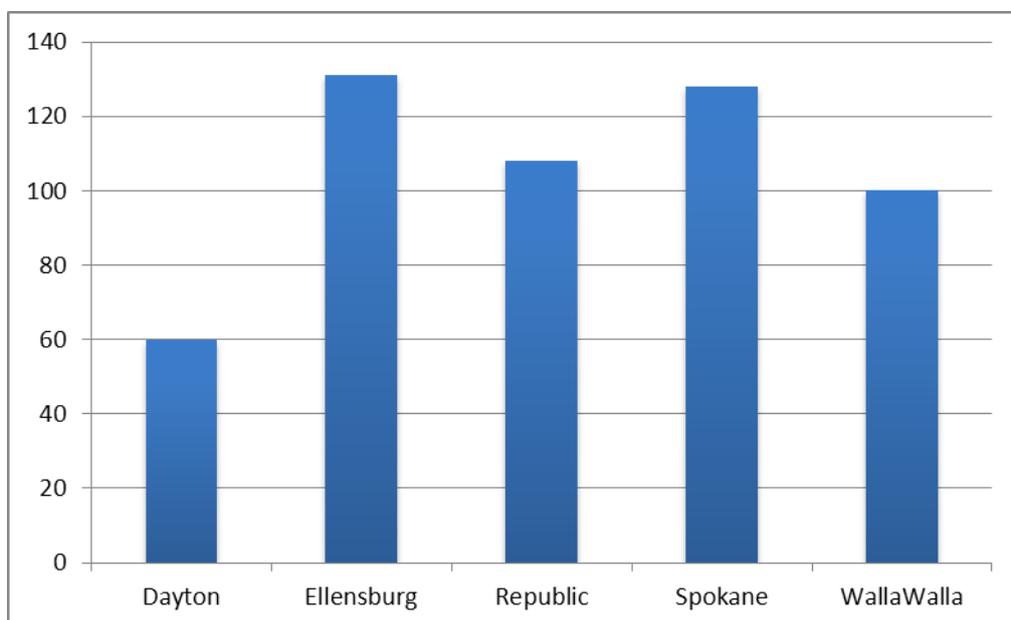


Figure 4 Distribution of surveys in eastern Washington study (N=527).

3.0 RESULTS

The data was processed using SPSS Statistics software (Version 19). Results are presented in the same order as the survey, followed by demographic results and cross tabulations.

3.1 Question 1

Have you ever been affected by any of the following events?

(Respondents were given a list of hazards (Table 1) and asked to tick all the boxes that applied to them).

Respondents were asked if they had been affected by natural hazards in the past. They reported a low level of personal experience of earthquakes, with only 20% of the total sample stating that an earthquake had affected them in the past. This is compared to a high of 39% who reported being affected by storms. Ellensburg and Spokane residents had the

highest levels of past experience of earthquakes, with Dayton having the lowest (Table 1). Volcanic ash fall, floods, fires and storms were the most commonly experienced hazards across all of the communities.

Table 1 Residents affected by natural hazards in the past (shown as frequency per cent).

Natural Hazard	Dayton	Ellensburg	Republic	Spokane	Walla Walla
Flood	52	22	32	18	22
Fire	30	13	16	9	13
Earthquake	13	24	18	25	15
Volcanic ash	45	37	26	34	29
Landslide	7	4	7	3	4
Chemical Spill	7	1	7	2	10
Storm/high winds	28	28	34	41	55
Pandemic	2	2	2	2	2
n	60	131	108	128	100

3.2 Question 2

When do you think the next hazard events are likely to affect your community?

Four timeframes were offered: < 1 year, within 10 years, within your lifetime and not within your lifetime.

A large proportion of respondents reported the possibility that an earthquake would affect their community within their lifetime (43%), however almost a quarter suggested that earthquakes would not happen within their lifetime (23%, Table 2a-2f). Floods, fires and storms were the most common hazards, with many suggesting they would occur within the next 1-10 years. Volcanic ash fall had the highest proportion of respondents who placed the likelihood into the distant future (53%).

In Dayton, 45% of respondents thought an earthquake would not affect their community during their lifetime, compared to 39% in Republic, 25% in Walla Walla, 24% in Spokane and 23% in Ellensburg. In contrast, 38% Ellensburg residents suggested an earthquake could happen within the next 10 years. Republic residents were the least concerned about earthquakes over the same time period (20%).

Table 2a Total resident perceptions of the likelihood of natural hazard events over given timeframes (shown as row frequency per cent).

Location	< 1 year	Within next 10 years	Within your lifetime	Not within your lifetime	n
Flood	11	38	28	23	396
Fire	37	13	28	21	383
Earthquake	4	24	43	29	368
Volcanic ash fall	2	15	53	30	378
Landslide	7	22	26	46	341
Chemical/gas	9	28	37	26	352
Storm/high winds	42	26	22	10	446
Pandemic	9	16	44	32	343

Table 2b Dayton resident perceptions of the likelihood of natural hazard events over given timeframes (shown as row frequency per cent).

Location	< 1 year	Within next 10 years	Within your lifetime	Not within your lifetime	n
Flood	11	46	33	9	54
Fire	33	20	31	16	45
Earthquake	0	26	33	45	40
Volcanic ash fall	2	18	42	39	45
Landslide	5	32	22	46	41
Chemical/gas	2	29	44	24	41
Storm/high winds	34	30	26	10	50
Pandemic	5	14	40	42	43

Table 2c Ellensburg resident perceptions of the likelihood of natural hazard events over given timeframes (shown as row frequency per cent).

Location	< 1 year	Within next 10 years	Within your lifetime	Not within your lifetime	n
Flood	18	42	15	25	98
Fire	41	8	19	32	90
Earthquake	6	32	38	23	94
Volcanic ash fall	2	19	49	31	97
Landslide	11	24	20	46	85
Chemical/gas	13	32	25	30	87
Storm/high winds	45	23	17	16	101
Pandemic	15	19	32	34	85

Table 2d Republic resident perceptions of the likelihood of natural hazard events over given timeframes (shown as row frequency per cent).

Location	< 1 year	Within next 10 years	Within your lifetime	Not within your lifetime	n
Flood	5	46	24	25	79
Fire	44	13	26	18	80
Earthquake	3	17	41	39	70
Volcanic ash fall	1	10	62	26	69
Landslide	6	23	37	35	71
Chemical/gas	5	15	37	43	67
Storm/high winds	36	23	28	13	94
Pandemic	9	9	48	34	67

Table 2e Spokane resident perceptions of the likelihood of natural hazard events over given timeframes (shown as row frequency per cent).

Location	< 1 year	Within next 10 years	Within your lifetime	Not within your lifetime	n
Flood	10	25	32	33	84
Fire	36	10	34	20	89
Earthquake	6	19	51	24	88
Volcanic ash fall	5	13	55	28	88
Landslide	10	17	26	47	72
Chemical/gas	9	35	42	15	81
Storm/high winds	40	24	28	9	106
Pandemic	8	17	54	22	79

Table 2f Walla Walla resident perceptions of the likelihood of natural hazard events over given timeframes (shown as row frequency per cent).

Location	< 1 year	Within next 10 years	Within your lifetime	Not within your lifetime	n
Flood	9	36	37	19	81
Fire	30	19	33	18	79
Earthquake	3	26	46	25	76
Volcanic ash fall	1	14	57	28	79
Landslide	1	19	24	56	72
Chemical/gas	12	28	42	18	76
Storm/high winds	52	31	14	4	95
Pandemic	4	19	45	32	69

3.3 Question 3

Have you heard or received information about preparing for emergencies from any of the following places?

Twenty options were offered, and respondents were asked to tick all that applied to them.

The majority of respondents had heard or received information about preparing for emergencies from at least one source (Figure 5). The most common source of information was the television/radio (64%). Newspapers/magazines (50%), emergency services (33%), Internet (32%), and friends and family (29%) were also frequently utilised sources of information. This result illustrates the wide range of information sources that are typically used by individuals as they make decisions about getting prepared for future disasters. The least common sources are cell phone messages, neighbourhood groups, telephone books, businesses, and information from businesses.

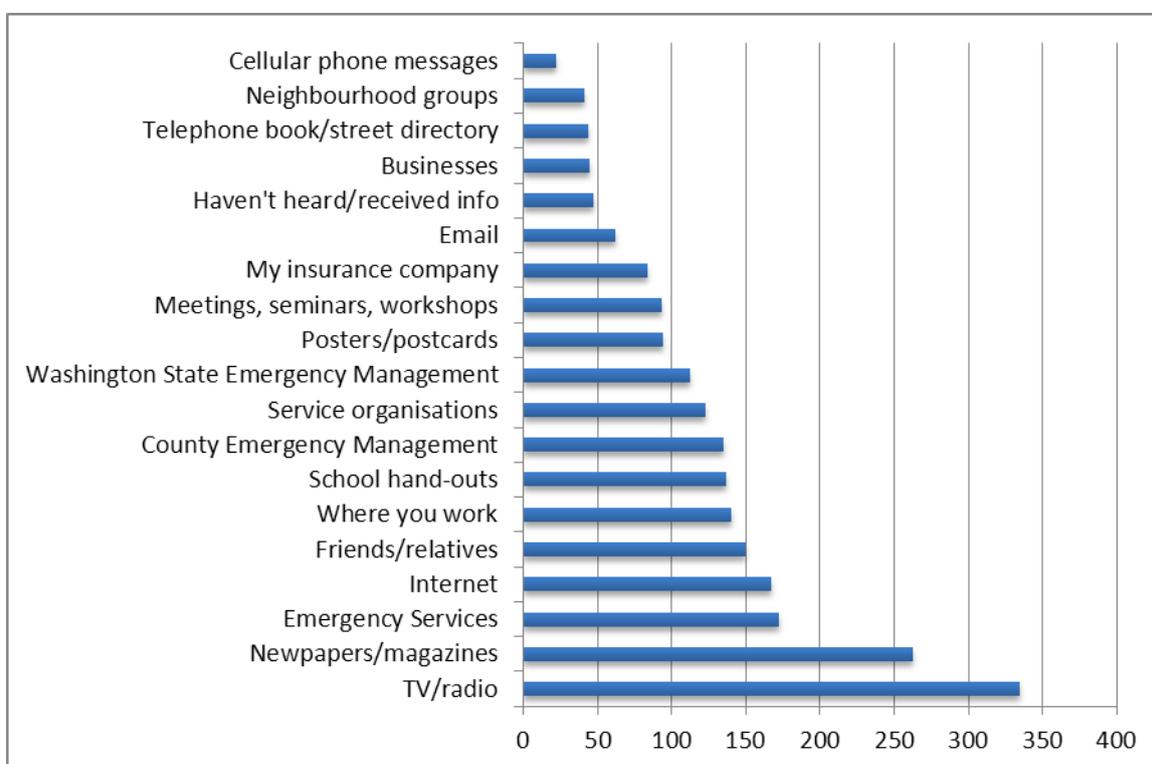


Figure 5 Sources of information about preparing for emergencies (frequency, multiple response).

3.4 Question 4

Have you or your family done any of the following to prepare for a hazard or emergency?

Eighteen options were offered, and respondents were asked to tick all that applied to them.

Figure 6 illustrates the range of preparedness measures adopted by respondents in order from most to least common. Respondents were asked what they or their family had done to prepare for a hazard or emergency. While, 95% reported having a flashlight and 94% reported having a smoke detector, the five earthquake-specific actions were reported by only a minority: 5% had added lips to shelves, 11% had attached strong latches to cabinet doors, 17% had installed flexible tubing to gas appliances, 20% had strapped their water heater, and 25% had bolted their house to the foundation.

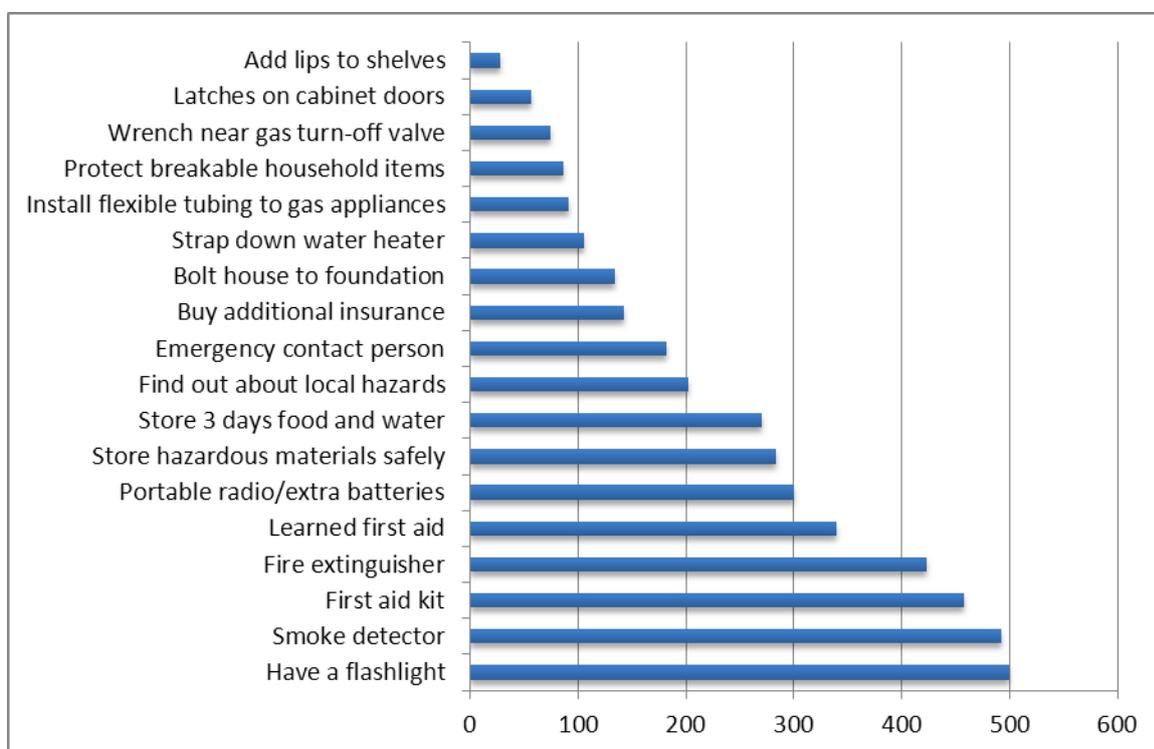


Figure 6 Preparedness actions used by respondents and their families for a hazard or emergency (frequency, multiple response).

3.5 Question 5

In an emergency, do you have plans for how to contact family?

The majority of respondents throughout the six communities stated that they had a plan for how to contact family in the event of an emergency (59%). The details of those plans were not described, but it is likely that the plans will vary significantly from simply relying on cell phone coverage and contact with schools, to a written plan describing where to meet in the event of different emergency scenarios. There was very little variability in the results between different communities in eastern Washington (Table 3).

Table 3 Respondent plans for contacting family in an emergency (shown as column frequency per cent).

	Dayton	Ellensburg	Republic	Spokane	Walla Walla
Yes	64	61	61	68	63
No	11	18	14	19	18
Not sure	25	21	25	13	18
n	55	123	99	123	93

3.6 Question 6

In regard to what happens in your community, please describe the extent to which you agree or disagree with each of the following statements:

1. I think about hazard issues and problems in my community
2. I talk about hazard problems and issues with others in my community

This question was designed to investigate the role of community in hazard awareness with regard to how individuals engage with others, either through thinking or talking about the hazards relevant to their community (Figure 7 and 8). Two thirds of respondents reported thinking about these issues and problems once a month or more frequently, and 72% talked about them that often.

Each of the six communities were similar in terms of both how frequently they think and talk about hazards and issues within their own communities.

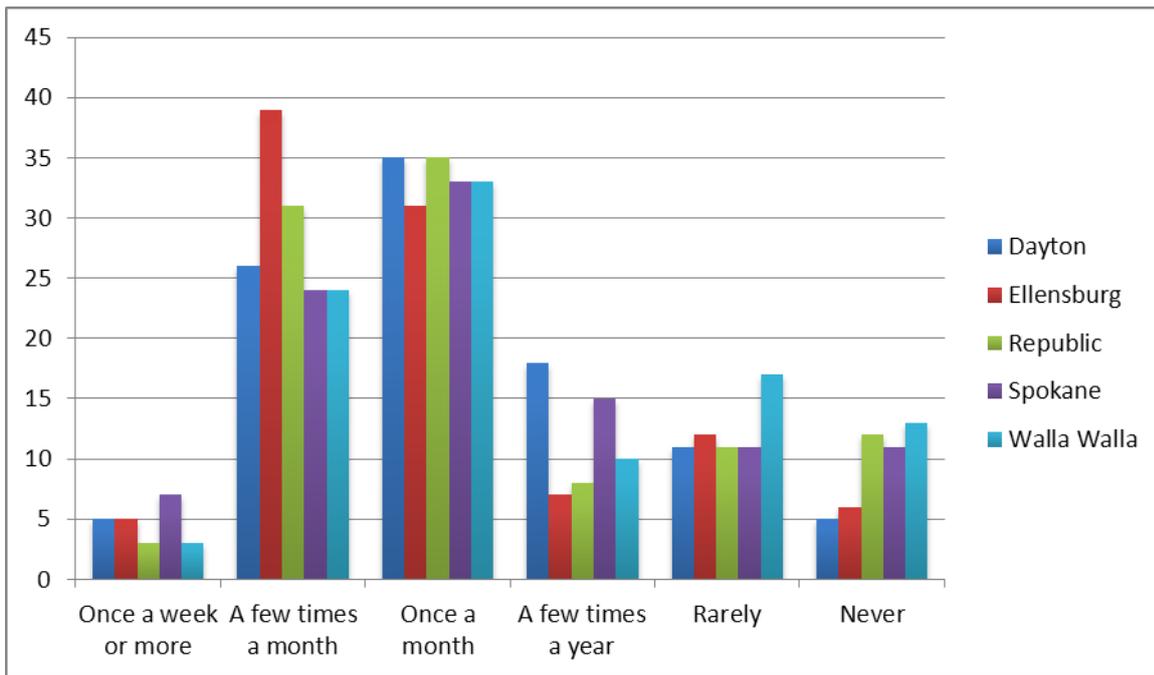


Figure 7 The frequency that respondents think about hazard issues and problems in their community (shown as frequency per cent).

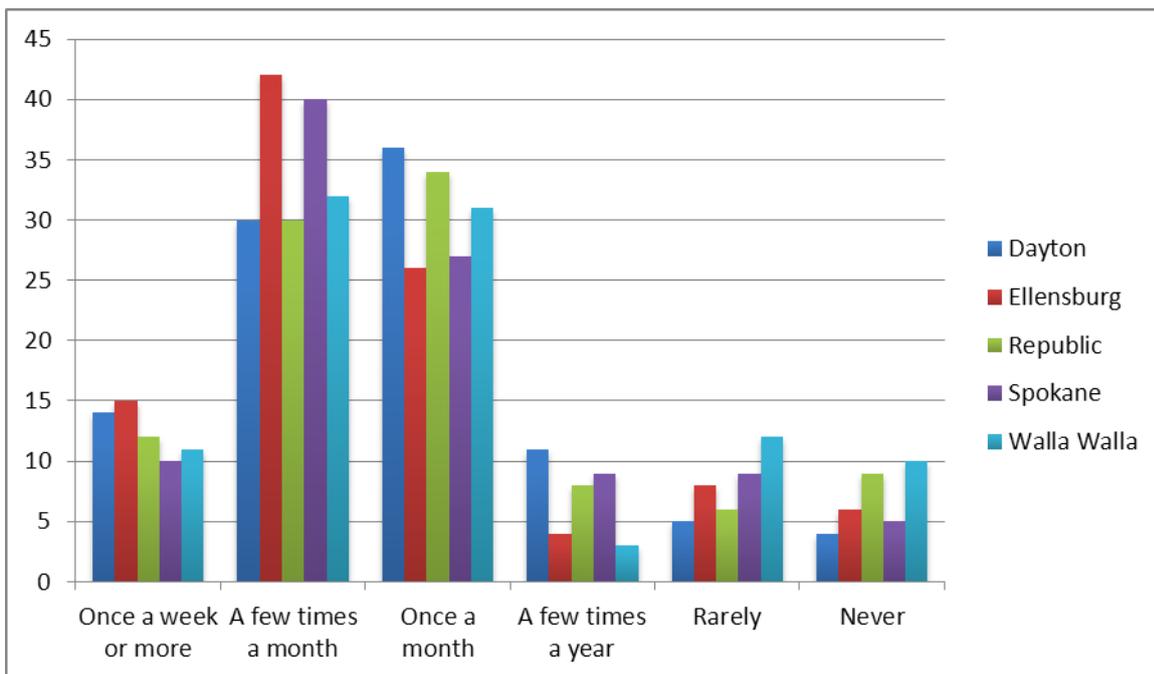


Figure 8 The frequency that respondents talk about hazard issues and problems in their community (shown as frequency per cent).

3.7 Question 7

In regard to participating in community life, please describe how often you undertake each of the following:

1. I participate in local activities or events (e.g. festivals, fetes and fairs);
2. I have attended a public meeting on a community issue;
3. I have been involved in volunteer activities intended to benefit my community (e.g. fundraising, clean-up days, local groups).

This question built on question 6 in terms of investigating the level of community involvement and engagement by respondents (Figure 9). The majority of respondents for all communities selected either the 'rarely' or 'never' categorised to indicate their level of involvement. Residents in Dayton were the least likely to take part in communities activities (64%) compared to Ellensburg residents (41%). Twenty-three per cent of Ellensburg residents stated they 'often' or 'sometimes' participate, compared to 5% from Dayton, 10% from Spokane, 11% from Walla Walla and 15% from Republic.

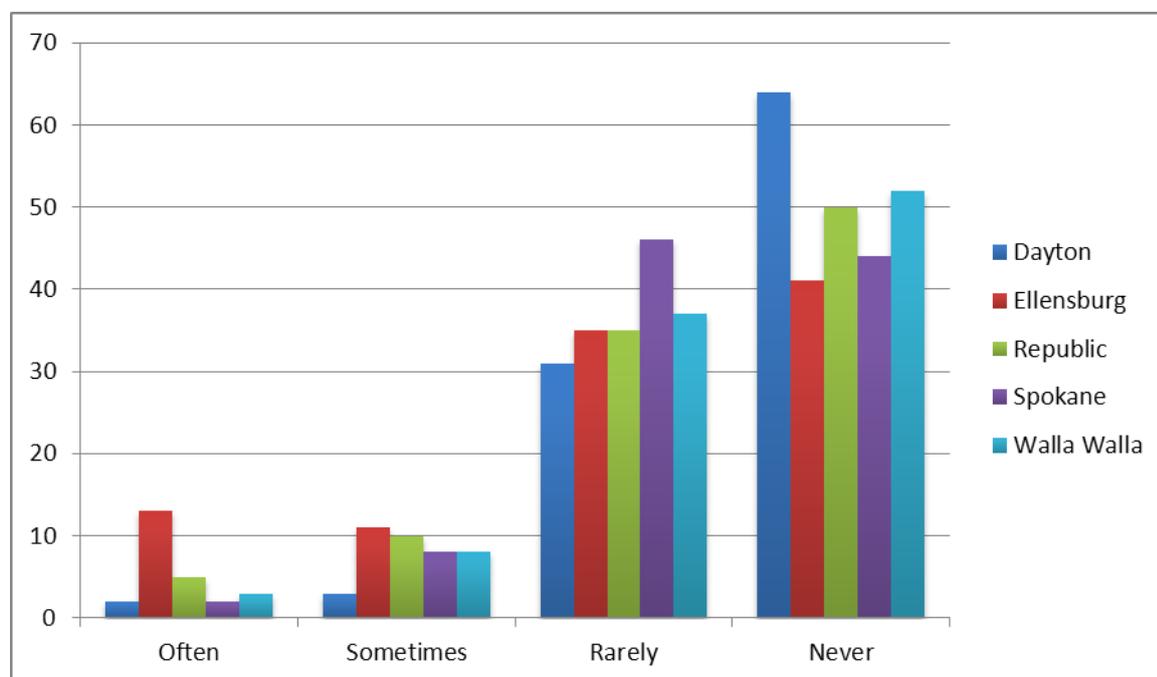


Figure 9 The frequency of participation in local activities or events (shown as frequency per cent).

In terms of attendance at public community meetings, the results varied across each of the communities (Figure 10). In Ellensburg, 30% of respondents 'often' attended meetings, compared to 14% in Walla Walla. More than a quarter of Walla Walla residents reported they 'never' went to meetings. Only 6% of Ellensburg residents 'never' went to meetings.

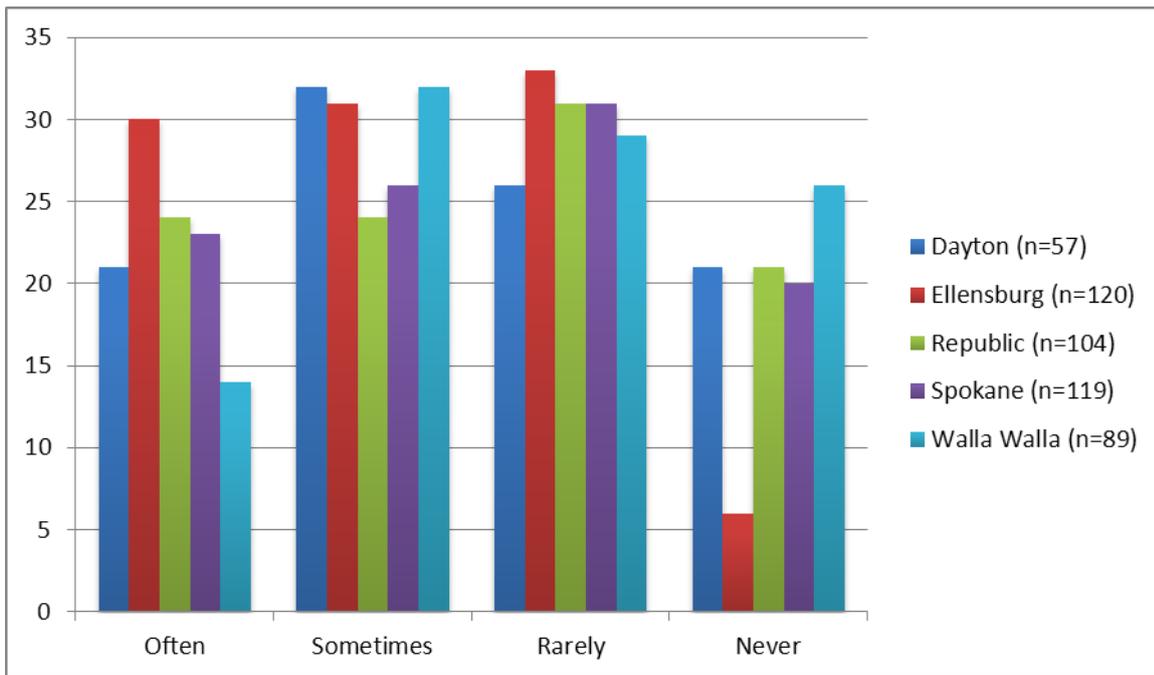


Figure 10 The frequency of attendance at public meetings on a community issue (shown as frequency per cent).

Involvement in volunteer activities that benefit the community was most common in Ellensburg, with 39% reporting that they ‘often’ or ‘sometimes’ take part, compared to 21-31% in the rest of the communities (Figure 11). Dayton and Republic residents were the least likely to get involved, with 79% stating that they ‘rarely’ or ‘never’ take part in volunteer activities.

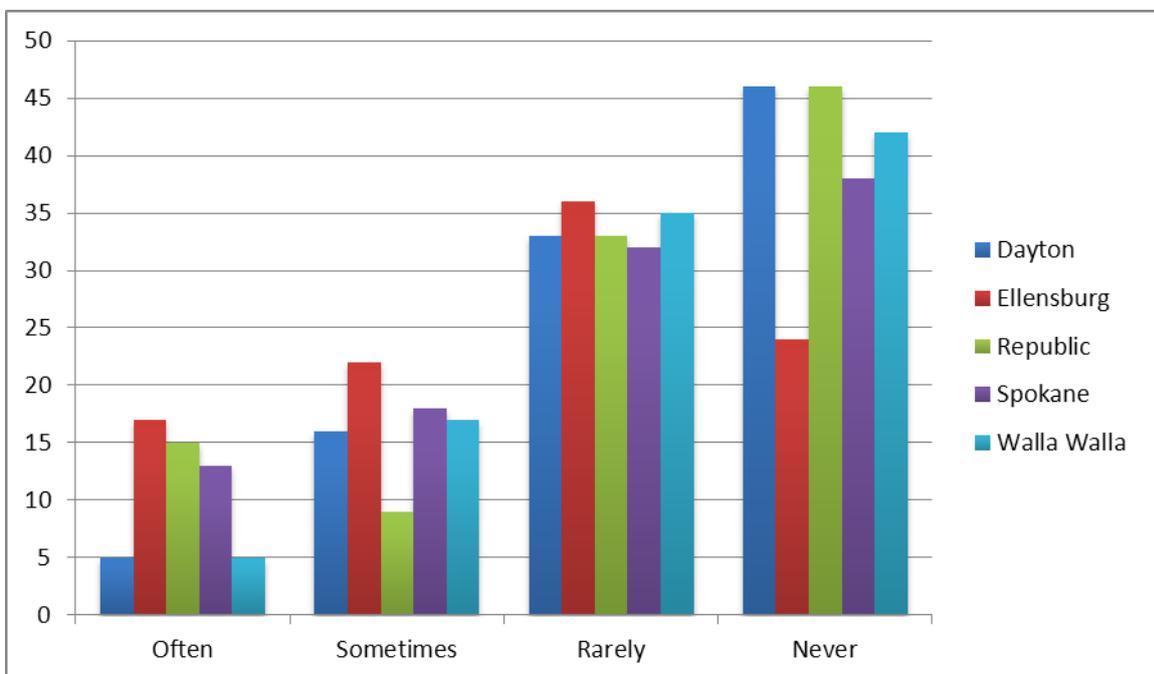


Figure 11 The frequency of involvement in volunteer activities intended to benefit the community (shown as frequency per cent).

3.8 Question 8

Please describe the extent to which you agree or disagree with the following statements (4-point scale from strongly agree to strongly disagree):

- **Eastern Washington has experienced damaging earthquakes in the past;**
- **Eastern Washington will experience damaging earthquakes in the future;**
- **Eastern Washington does not have earthquakes hazards.**

Of the total number of responses to this question (n=466), 52% either disagreed or strongly disagreed that eastern Washington had experienced damaging earthquakes in the past, and 48% agreed or strongly agreed (Table 4). There were some differences in opinion between communities. Sixty per cent of Ellensburg respondents agreed there had been damaging seismic activity in eastern Washington in the past. Dayton residents were the least likely to agree or strongly agree with the statement (33%), compared to 37% in Republic, 51% in Spokane and 52% in Walla Walla.

Table 4 Respondent opinion about whether eastern Washington has experienced damaging earthquakes in the past (shown as column frequency per cent).

	Dayton	Ellensburg	Republic	Spokane	Walla Walla
Strongly disagree	11	8	17	11	10
Disagree	56	32	46	38	39
Agree	29	44	27	42	41
Strongly agree	4	16	10	9	11
n	52	110	98	115	91

There was general agreement that eastern Washington will experience damaging earthquakes in the future, with 70% of the total sample agreeing or strongly agreeing (n=473, Table 5). Ellensburg residents were the most likely to agree (77%), compared to Republic (59%), Dayton (63%), Spokane (71%) and Walla Walla (72%).

Table 5 Respondent opinion about whether eastern Washington will experience damaging earthquakes in the future (shown as column frequency per cent).

	Dayton	Ellensburg	Republic	Spokane	Walla Walla
Strongly disagree	6	3	8	6	4
Disagree	32	20	32	23	24
Agree	56	58	43	61	54
Strongly agree	7	19	16	10	18
n	54	112	99	117	91

The majority of respondents (76%) disagreed with the statement that 'Eastern Washington does not have earthquake hazards' (n=461, Table 6). Dayton residents were the most likely to agree that there is no seismic risk (37%), compared to Walla Walla (18%), Ellensburg (20%), Spokane (25%) and Republic (26%).

Table 6 Respondent opinion about the statement 'Eastern Washington does not have earthquake hazards' (shown as column frequency per cent).

	Dayton	Ellensburg	Republic	Spokane	Walla Walla
Strongly disagree	28	33	27	23	28
Disagree	35	47	47	52	54
Agree	28	16	23	22	14
Strongly agree	9	4	3	3	4
n	54	106	99	112	90

3.9 Question 9

If you heard a warning for your community (e.g. flood warning), what would you do? (Tick all that apply)

Results for this question highlight the importance of radio and television with respect to providing warnings to communities at risk from a natural event (Figure 12a-12f). Checking information on the Internet was frequently the third most likely action that respondents reported taking if they heard a community warning announcement. The fourth most common action was contacting the neighbours, although in Republic this option was the second most popular action after listening to the radio. In all communities, fewer respondents said they would evacuate at once, compared to those who would wait until later to evacuate.

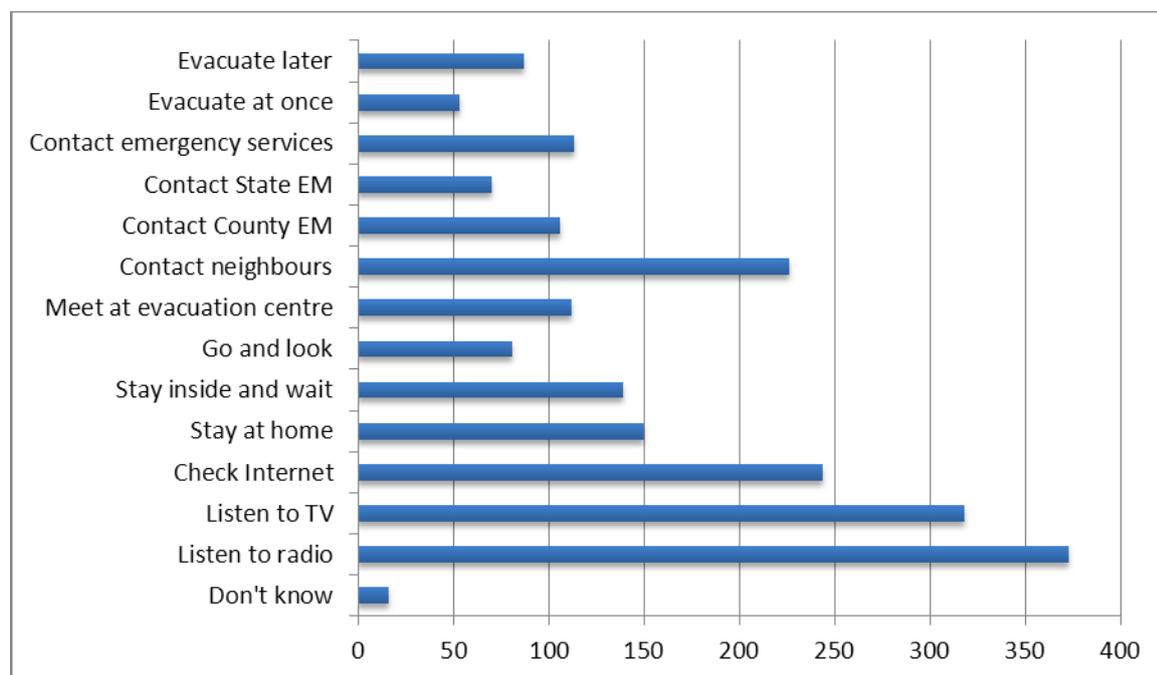


Figure 12a Total respondent opinion on what they would do if they heard a warning for their community (shown as frequency).

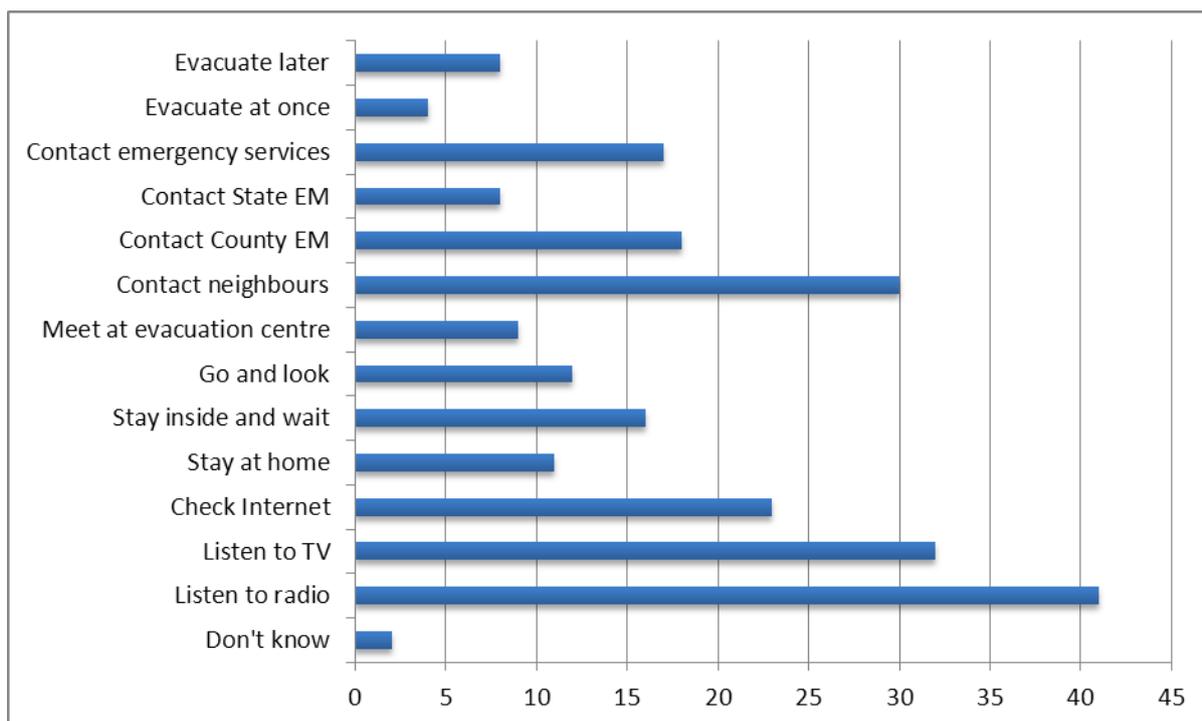


Figure 12b Dayton respondent opinion on what they would do if they heard a warning for their community (shown as frequency).

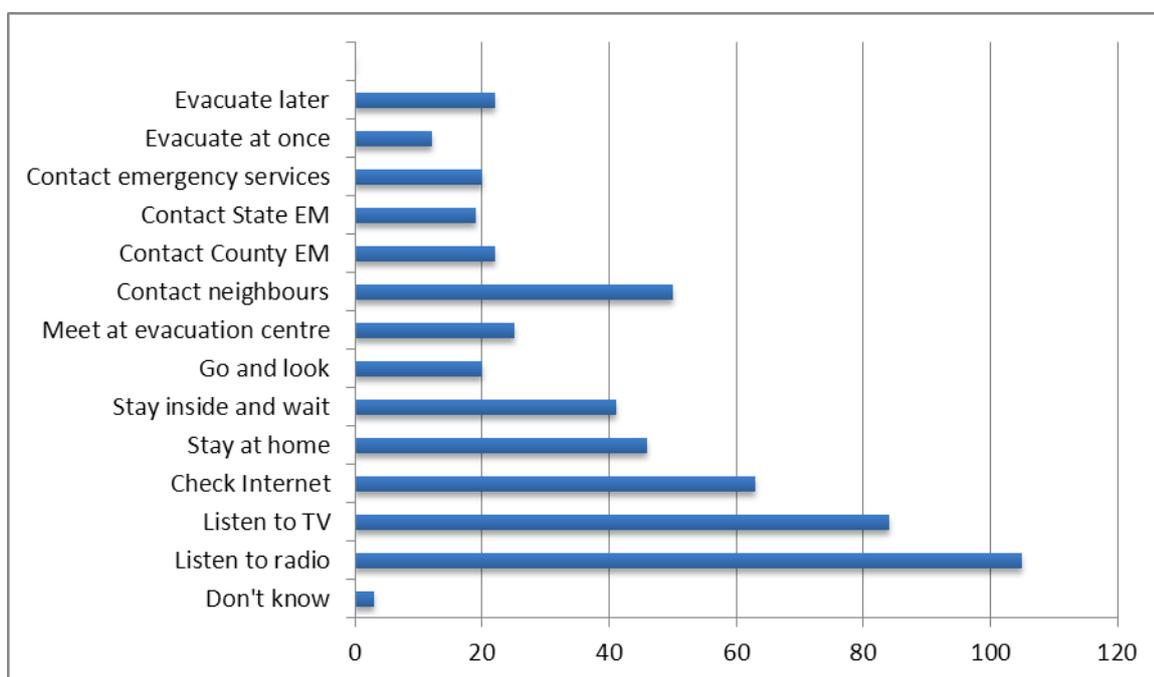


Figure 12c Ellensburg respondent opinion on what they would do if they heard a warning for their community (shown as frequency).

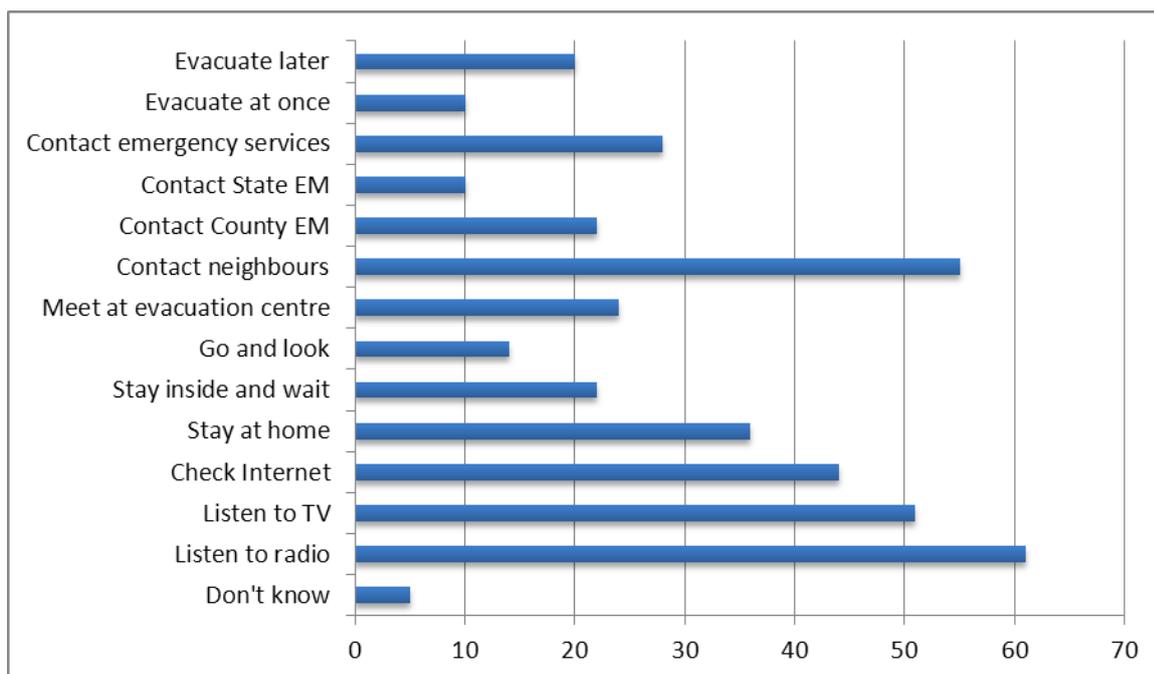


Figure 12d Republic respondent opinion on what they would do if they heard a warning for their community (shown as frequency).

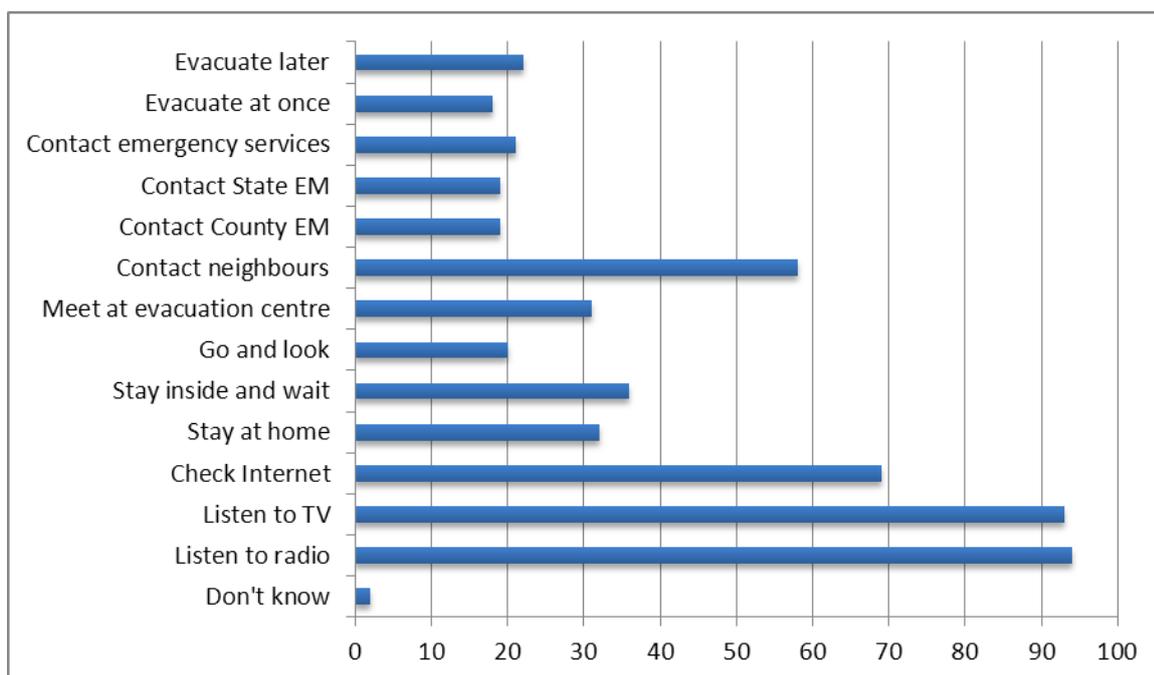


Figure 12e Spokane respondent opinion on what they would do if they heard a warning for their community (shown as frequency).

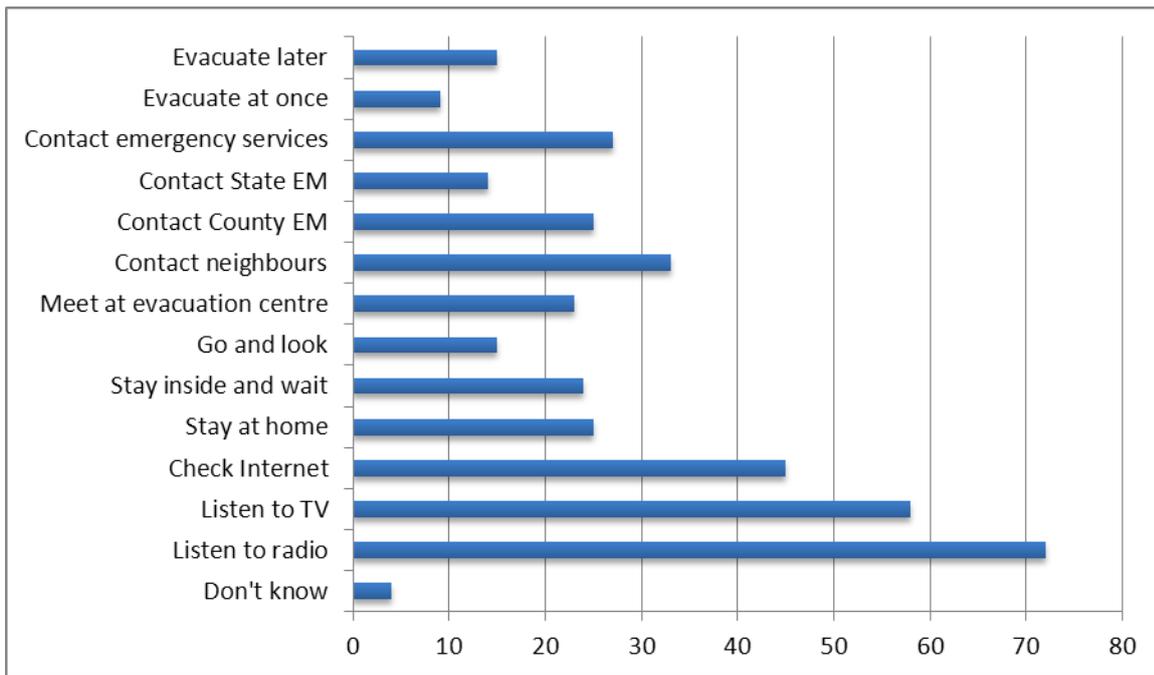


Figure 12f Walla Walla respondent opinion on what they would do if they heard a warning for their community (shown as frequency).

3.10 Question 10 and 11

Male/Female, Age.

The survey was completed by both males (45%) and females (55%). The age range was broad, illustrated in Figure 13, with a mean of 49 years and a mode of 59 years.

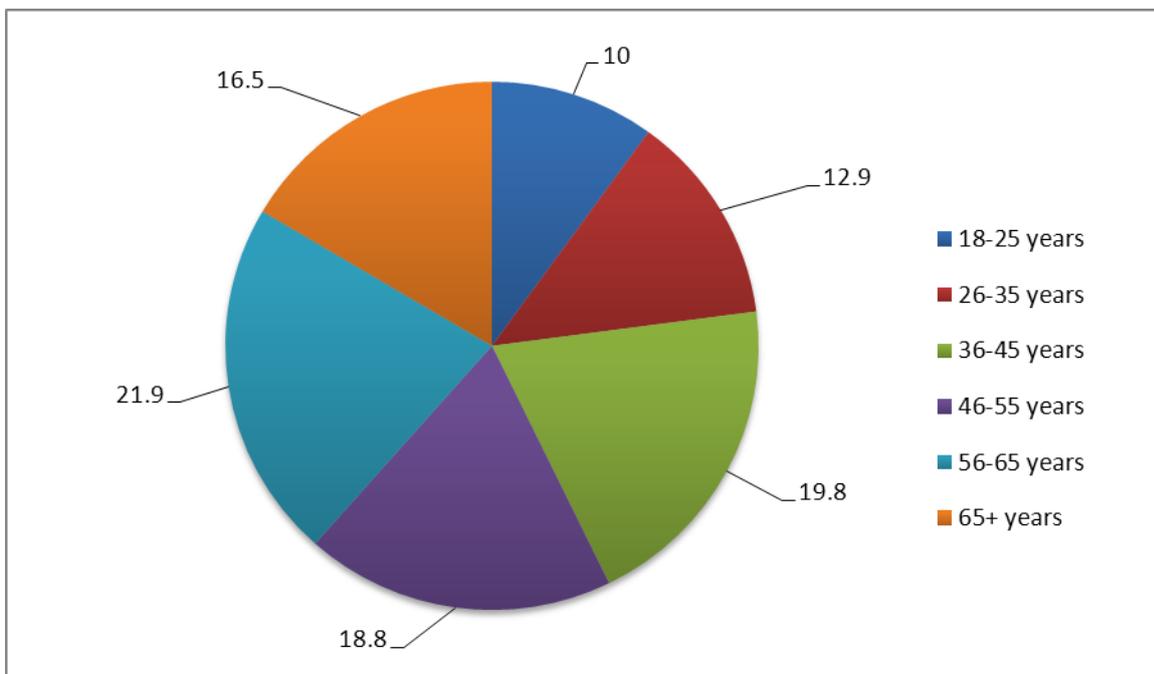


Figure 13 Age.

3.11 Cross tabulations

The results for some key questions were compared to see if there was any relationship between variables such as gender and prior experience of earthquakes. A full suite of analyses was conducted, and there were no correlations between gender and any of the awareness or preparedness questions. Prior experience was found to correlate with respondent understanding of the likelihood of future earthquakes events affecting their community, i.e. those having experienced a damaging earthquake in the past considered that future earthquakes were likely to happen in the near future (as opposed to the distant future). Also respondents were more likely to think and talk about hazards if they had a previous experience of a damaging earthquake.

4.0 FOCUS GROUPS

In October 2011, results of the study were reported back to the eastern Washington communities involved in data collection at State and County Fairs in 2010. The purpose of the visits was twofold: to disseminate results from the study, and to conduct focus group discussions and feedback sessions within the community groups. The meetings were organized with help from the State Emergency Management Department, and facilitated by local emergency services organizations in each community. Local residents were encouraged to attend, together with emergency management officials and volunteers.

Data analysis and discussion was presented to each of the communities via PowerPoint, and afterwards people could ask questions, which led to further discussion and comment within the group. In the following section, each community meeting will be described in terms of participation, with a list of discussion points that arose after the presentation.

Ellensburg – Emergency Management Group monthly committee meeting 19th October 2011

Attendance: 28

Types of officials: Fire, police, public health, local government, Red Cross.

- Is the State going to put together an earthquake program based on our eastern WA work?
- Do we have volcanic hazards in NZ?
- How did the building structures in heritage buildings hold up in Christchurch, in terms of facades?

The audience was asked: What is your understanding of how residents perceive earthquake risks in Ellensburg?

A range of views were offered, including:

- People understand and know about earthquake risk, but they are complacent because of the long return period of earthquakes.
- While personal preparedness may be good, 24 hours after a large event they will be upset if authorities haven't come to their rescue, and 'crying foul' about it.
- School preparedness is an issue – particularly in terms of funding mitigation measures in schools. Morgan Middle was cited as a case in point (see section 6.0).

- There is a process for applying to get hazard mitigation funding from FEMA, and it starts with organizations lodging a full plan to the local County authorities and then to FEMA.
- Funding is a major issue. A doctor in charge of the medical emergency response said that there used to be 50 beds in the Emergency Department, but now there are only 11. There is no capacity to respond to a large disaster.

At the conclusion of the meeting, a Red Cross representative said they had planned to run a winter storm scenario at their next meeting, but will instead do an earthquake scenario as a result of the meeting.

Spokane Fire Training Centre – 22nd October 2011

Attendance: 22

Types of officials: Fire, police, public health, local government, Red Cross, National Guard, concerned citizens.

- The Deputy Director of Emergency Management (Spokane) said that the experts from the West Coast were coming over to talk to them about seismic mitigation planning involving fire, police and health.
- Someone noted there used to be seismometers in Spokane, but that they had been relocated westward. He asked if there were still any seismometers left in the region?
- Answer: There are two regional seismographs operating west of Spokane and three strong motion sensors, designed to capture strong shaking, running in the city. See <http://old.pnsn.org/OPS/stations.gif> for a map of current seismic stations in Washington. Improved seismic monitoring is needed in the Spokane area.
- A member of Red Cross commented that Christchurch wasn't expecting to get hit by a destructive earthquake, so why not use that in a TV campaign - 'expect the unexpected'.
- If the public in Christchurch knew that the earthquake had a 16,000 year return period, would they then say 'We survived that one and so we will be fine, we got through the big one'.
- Business challenges – one resident suggested that after recent local earthquakes (M3.9), business owners think this will be the biggest one they will be affected by, and that complacency then sets in quickly.
- A local government official said there is currently lots of building going on in the outer suburbs of Spokane. He wondered how earthquake risk impacts on building out there? Should the building of new properties be allowed?
- Deputy Director of Emergency Management (Spokane) believed that Emergency Management on the 'West side' (Seattle area) worked in a silo. When they have a big earthquake they will need to use Spokane's resources/personnel (Spokane is the biggest city between Seattle and Montana), so they need to keep them informed in terms of planning.

Republic – Ferry County, October 22nd 2011

We had several informal chats with local people around the township and on Saturday night in a local bar between 5-9pm.

- Several people had experience of past earthquakes in Republic many years ago, but no damage was reported.
- One local citizen described Republic in this way: ‘The area is a stable block’.
- The general impression was that locals don’t see earthquakes as an issue for their community.
- They are aware of earthquakes happening in western parts of the state.
- Some had experienced large earthquakes in other places (California and a recent event in Washington DC), but were not concerned about earthquakes in Republic.

Dayton – Columbia County, October 24th 2011

This meeting was held with the Director of Columbia County Emergency Management.

Floods (1996/7) and wildfires (2005/6) were described as the most frequently occurring local natural hazards over the last 10 years. The last fire event burnt 140,000 acres and was the biggest event in the United States at the time. He was aware of active faults around Walla Walla, and that the town had a very damaging earthquake in the 1930s (approximately M6). He wondered if Dayton would or could be affected by future events?

He also asked if this project was initiated before the Christchurch earthquakes happened? He noted how interesting it was that this project was investigating low risk seismicity in eastern Washington and that Christchurch was also considered to be a relatively low risk seismic zone. His perception of the Christchurch earthquakes from the TV coverage was that the city wasn’t expecting a large earthquake, and that it appeared the community was in shock.

He said that after the big fire in Dayton, mitigation measures were easy to sell to the local population, but that within 2-3 years of the event people had lost interest, and fire hazards were no longer salient to the townsfolk. He wondered if the same loss of motivation was apparent in New Zealand communities.

Walla Walla, October 24th 2011

Attendance: 28

Types of officials: Fire, police, Emergency Management officials, concerned citizens.

- The audience noted having been impacted / having experience of ash fall from Mt St Helens in 1980.
- Would the perceptions of natural hazards risks be different between long-term residents and those that had just come to the district?
- Was the NZ building code found to be adequate in the aftermath of the Christchurch earthquakes?
- Liquefaction was noted as being a concern in Walla Walla.
- One local man who had experienced the 1972 earthquake in California had done a lot of research on the seismic risk in Walla Walla before choosing to move there, but he said there wasn’t a lot of publically available information.
- All the local Emergency Management Department seismic hazard documents are on their website (www.emd.info - look for Hazard ID valuation documents).

5.0 BUILDING LIFE SAFETY: A CASE STUDY OF MORGAN MIDDLE SCHOOL, ELLENSBURG

At the conclusion of the Ellensburg community meeting Paul Farris (Superintendent of Schools in Kittitas County) invited us to visit Morgan Middle School in Ellensburg, together with Michelle Bibich (Principal of Morgan Middle School). There is increasing concern that the school is seismically unsafe, and we were invited to look around the school with our hosts.

Morgan Middle School was built in 1929, and added onto several times up until the 1970s as the role increased from 200 pupils to its current level of 730 (Figure 14). The auditorium was originally built to hold 800 people, doubling as a community center for the town. The building is made of hollow brick with no support structures connecting the roof to the walls, or the walls to the foundations. The oldest part of the school is structurally the most hazardous, and has 2/3 of the pupils in it each day. It is 2-storey, but has no fire escapes from the upper floors.

Paul and Michelle have been lobbying to have the school closed down and rebuilt. They have tried to convince the community but there is resistance because, as Paul put it, they have a 'sweat investment' into the school and local people don't understand the risk it poses in the event of an earthquake. Community decisions of this nature are taken by sending out a ballot form to everyone in the town so they can vote. In order to pass a vote 60% of residents or more need to support it. Last time it went to a community vote the school received 55% support, which wasn't enough.

Paul said that to carry out a basic retrofit of the building would cost \$5 million, with a thorough retrofit costing \$14-15 million. A total rebuild has been estimated at \$40 million. They are proposing that the school is rebuilt alongside the high school nearby, which has some existing green space, and that the current site is left as green space and then redeveloped as a new elementary school (since the existing elementary school needs to be rebuilt as well).



Figure 14 Ellensburg Middle School, with inset of the hollow bricks, and the school in 1929.

6.0 CONCLUSIONS

- There is an apparent disconnect between awareness of the possibility of future earthquakes and of the risk posed by these earthquakes. While the majority agree that Washington has seismic hazards and that there will be damaging earthquakes in the future, very few have made any attempt to take action to prevent damage to their property in future.
- Preparedness measures adopted by respondents were most frequently 'all hazard' tools, such as having a flashlight, smoke detector, first aid kit, portable radio and fire extinguisher. Very few had adopted earthquake-specific mitigation measures such as placing latches on cabinet doors, adding lips to shelves, strapping their water heater, bolting their house to the foundations or installing flexible tubing to gas appliances.
- Prior experience of a damaging earthquake is an indicator of elevated hazard awareness with respect to the likelihood of future events. In addition, thinking or talking about hazards is more likely to occur if an individual has experienced a damaging earthquake in the past.
- Community involvement in activities, as volunteers and attending meeting was variable across the five communities. Levels of community involvement in earthquake preparedness activities are low, with the majority rarely or never participating in community activities or events. This could be a function of a lack of opportunity to engage, or that participants are not motivated to take part. Attendance at public meetings is common, while volunteering for community activities was variable across the five towns.
- The earthquakes in Canterbury (Christchurch), New Zealand from September 2010 to the present (particularly the February 22nd 2010 aftershock) offer an opportunity for Washington emergency managers to learn lessons from a city that has experienced significant challenges over the past 18 months. Preparedness for seismic activity in the city was comparable to areas in eastern Washington (McClure et al. 2011). While there was a known seismic hazard associated with faults in the Christchurch area, other parts of New Zealand were considered more likely to be hit by a large earthquake, which in affect made people in Christchurch complacent about their own level of preparedness. In addition, the recent earthquakes took place on previously unknown fault systems in the region, which is a stark reminder that seismologists and geophysicists cannot provide a complete understanding of regional seismic risk (Orchiston 2011).

7.0 REFERENCES

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- Orchiston, C. (2011). Seismic risk scenario planning and sustainable tourism management: Christchurch and the Alpine Fault zone, South Island, New Zealand. *Journal of Sustainable Tourism*, vol. 20 (1): 59-79.
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- Wang, K., Wells, R., Mazzotti, S., Hyndman, R. and Sagiya, T. (2003). A revised dislocation model of interseismic deformation of the Cascadia subduction zone. *Journal of Geophysical Research*, vol. 108, No. B1, 2026.

Appendix 1 EASTERN WASHINGTON HAZARDS SURVEY

Date:

Location:

1. Have you ever been affected by any of the following events? (Tick all that apply)

- | | |
|---|---|
| <input type="checkbox"/> ₁ Flood | <input type="checkbox"/> ₆ Chemical spill or gas leak |
| <input type="checkbox"/> ₂ Fire (house fire) | <input type="checkbox"/> ₇ Storm with high winds (e.g. tornado, hurricane) |
| <input type="checkbox"/> ₃ Earthquake | <input type="checkbox"/> ₈ Pandemic |
| <input type="checkbox"/> ₄ Volcanic ash fall | <input type="checkbox"/> ₉ Other (Please specify): _____ |
| <input type="checkbox"/> ₅ Landslides | <input type="checkbox"/> ₁₀ No events have affected me |

2. When do you think the next hazard events are likely to affect your community?
(Tick one in each row)

	Within the next year	Within the next 10 years	Within your lifetime	Not within your lifetime
Flood	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄
Fire (house fire)	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄
Earthquake	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄
Volcanic ash fall	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄
Landslides	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄
Chemical spill or gas leak	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄
Storm with high winds	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄
Pandemic	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄
Other, please specify	<input type="checkbox"/> ₁	<input type="checkbox"/> ₂	<input type="checkbox"/> ₃	<input type="checkbox"/> ₄

3. Have you heard or received any information about preparing for emergencies from any of the following places? (Tick all that apply)

- | | |
|--|--|
| <input type="checkbox"/> ₁ I haven't heard or received any information (Go to Question 4) | <input type="checkbox"/> ₁₂ Friends or relatives |
| <input type="checkbox"/> ₂ Newspapers/magazines | <input type="checkbox"/> ₁₃ Neighbourhood groups |
| <input type="checkbox"/> ₃ Television and radio | <input type="checkbox"/> ₁₄ Where you work |
| <input type="checkbox"/> ₄ Posters or postcards | <input type="checkbox"/> ₁₅ Cellular phone text messages |
| <input type="checkbox"/> ₅ Telephone book/street directory | <input type="checkbox"/> ₁₆ Internet |
| <input type="checkbox"/> ₆ Washington State Emergency Management | <input type="checkbox"/> ₁₇ Email |
| <input type="checkbox"/> ₇ County Emergency Management | <input type="checkbox"/> ₁₈ Service organisations (e.g., Red Cross) |
| <input type="checkbox"/> ₈ Emergency services (e.g. Police or Fire) | <input type="checkbox"/> ₁₉ My insurance company / agent |
| <input type="checkbox"/> ₉ School hand-outs (e.g., brochures, homework) | <input type="checkbox"/> ₂₀ Other (Please specify): _____ |
| <input type="checkbox"/> ₁₀ Meetings, seminars or workshops | |
| <input type="checkbox"/> ₁₁ Businesses | |

4. Have you or your family done any of the following to prepare for a hazard or emergency?
(Tick all that apply)

- | | |
|---|--|
| <input type="checkbox"/> ₁ Have a flashlight | <input type="checkbox"/> ₁₂ Have a smoke detector |
| <input type="checkbox"/> ₂ Protect breakable household items | <input type="checkbox"/> ₁₃ Have a first aid kit |
| <input type="checkbox"/> ₃ Put strong latches on cabinet doors | <input type="checkbox"/> ₁₄ Store wrench near gas turn-off valve |
| <input type="checkbox"/> ₄ Store hazardous materials safely | <input type="checkbox"/> ₁₅ Pick an emergency contact person from outside of the area |
| <input type="checkbox"/> ₅ Add lips to shelves to keep things from sliding off | <input type="checkbox"/> ₁₆ Buy additional insurance (e.g. home) |
| <input type="checkbox"/> ₆ Strap down water heater | <input type="checkbox"/> ₁₇ Someone in family has learned to provide first aid |
| <input type="checkbox"/> ₇ Install flexible tubing to gas appliances | <input type="checkbox"/> ₁₈ Find out if you are in an area particularly vulnerable to a natural or other kind of hazard, (e.g. earthquake, flood, chemical spill) |
| <input type="checkbox"/> ₈ Bolt house to foundation | |
| <input type="checkbox"/> ₉ Store water & food supply for 3 days | |
| <input type="checkbox"/> ₁₀ Have a portable radio & extra batteries | |
| <input type="checkbox"/> ₁₁ Have a fire extinguisher | |

5. In an emergency, do you have a plan for how to contact your family?

- ₁ Yes ₂ Not sure ₃ No

6. In regard to what happens in your *community*, please describe the extent to which you agree or disagree with each of the following statements: (Tick one in each row)

	Once a week or more	A few times a month	Once a month	A few times a year	Rarely	Never
I think about hazard issues and problems in my community	<input type="checkbox"/> ₆	<input type="checkbox"/> ₅	<input type="checkbox"/> ₄	<input type="checkbox"/> ₃	<input type="checkbox"/> ₂	<input type="checkbox"/> ₁
I talk about hazard problems and issues with others in my community	<input type="checkbox"/> ₆	<input type="checkbox"/> ₅	<input type="checkbox"/> ₄	<input type="checkbox"/> ₃	<input type="checkbox"/> ₂	<input type="checkbox"/> ₁

7. In regard to participating in life in this *community*, please describe how often you undertake each of the following: (Tick one in each row)

	Often	Sometimes	Rarely	Never
I participate in local activities or events (e.g., festivals, fetes, fairs)	<input type="checkbox"/> ₄	<input type="checkbox"/> ₃	<input type="checkbox"/> ₂	<input type="checkbox"/> ₁
I have attended a public meeting on a community issue	<input type="checkbox"/> ₄	<input type="checkbox"/> ₃	<input type="checkbox"/> ₂	<input type="checkbox"/> ₁
I have been involved in volunteer activities intended to benefit my community (e.g., fundraising, clean-up days, local groups).	<input type="checkbox"/> ₄	<input type="checkbox"/> ₃	<input type="checkbox"/> ₂	<input type="checkbox"/> ₁

8. Please describe the extent to which you agree or disagree with each of the following statements:

	Strongly Agree	Agree	Disagree	Strongly Disagree
Eastern Washington has experienced damaging earthquakes in the past	<input type="checkbox"/> ₄	<input type="checkbox"/> ₃	<input type="checkbox"/> ₂	<input type="checkbox"/> ₁
Eastern Washington will experience damaging earthquakes in the future	<input type="checkbox"/> ₄	<input type="checkbox"/> ₃	<input type="checkbox"/> ₂	<input type="checkbox"/> ₁
Eastern Washington does not have earthquake hazards	<input type="checkbox"/> ₄	<input type="checkbox"/> ₃	<input type="checkbox"/> ₂	<input type="checkbox"/> ₁

9. If you heard a warning for your community (e.g. a flood warning) what would you do? (Tick all that apply)

- | | |
|--|--|
| <input type="checkbox"/> ₁ Don't know (Go to Question 10) | <input type="checkbox"/> ₉ Contact your neighbours |
| <input type="checkbox"/> ₂ Listen to the radio | <input type="checkbox"/> ₁₀ Contact the County Emergency Management |
| <input type="checkbox"/> ₃ Listen to the TV | <input type="checkbox"/> ₁₁ Contact Washington State Emergency Management |
| <input type="checkbox"/> ₄ Check the internet | <input type="checkbox"/> ₁₂ Contact emergency services (911) |
| <input type="checkbox"/> ₅ Stay at home | <input type="checkbox"/> ₁₃ Evacuate at once |
| <input type="checkbox"/> ₆ Stay inside and wait to be told what to do | <input type="checkbox"/> ₁₄ Evacuate at a later stage |
| <input type="checkbox"/> ₇ Go and look to see what's happening | <input type="checkbox"/> ₁₅ Other (Please specify): _____ |
| <input type="checkbox"/> ₈ Meet at a designated evacuation centre or assembly point | |

10. Male / Female (circle one)

11. Year of birth _____

12. Where do you live? (town/city; State) _____



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