Geohazard Risk in South-Central Chile: Perceptions and Preparedness in the Land of Temblores y Tefra

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Major Findings: Perceptions of geohazard risk in South-Central Chile are roughly aligned with actual risk levels, with a strong relationship between perceived risk and disaster preparedness that suggests that individuals and communities with more accurate perceptions of risk are better prepared for disasters. Furthermore, individuals who have experienced a disaster's negative effects firsthand are more likely to have taken adaptive responses. These patterns suggest that accurate risk perception and disaster experience are key factors in increasing disaster preparedness, and that disaster experience may provide the link between simply understanding a risk and preparing for it.

Background

This study explores the relationships between risk perception, risk exposure, and disaster preparedness in the disaster-prone setting of south central chile, where the list of historical earthquakes, tsunamis, and volcanic eruptions is extensive. The study addresses the question of what factors inform risk perception and how risk perception influences disaster preparedness. Past studies suggest that education and risk awareness are not always adequate avenues for acheiving accurate risk perception and appropriate preparedness levels (Lindell and Hwang 2008; Palm 1981;Perry 1979; Slovic 1987).

Driving Questions:

1.) To what extent does perceived geohazard risk align with actual risk exposure, and what explains patterns in alignment/misalignment?
2.) How does perception of risk influence preventative action?
3.) What might move inaccurate risk perception toward reality in regions affected by geohazards?

Questions like these are relevant worldwide for regions affected by geologic hazards, as well as regions more frequently affected by hurricanes, tornadoes, floods, and other hazards.

With a better understanding of what causes perceived risk to be aligned with actual risk, we can:

- more effectively evaluate methods of hazard education
- create better risk awareness
- make communities more resilient to geohazard disasters.

Disaster resilience, not limited to geohazard-triggered events, is a crucial component to creating more generally resilient populations.

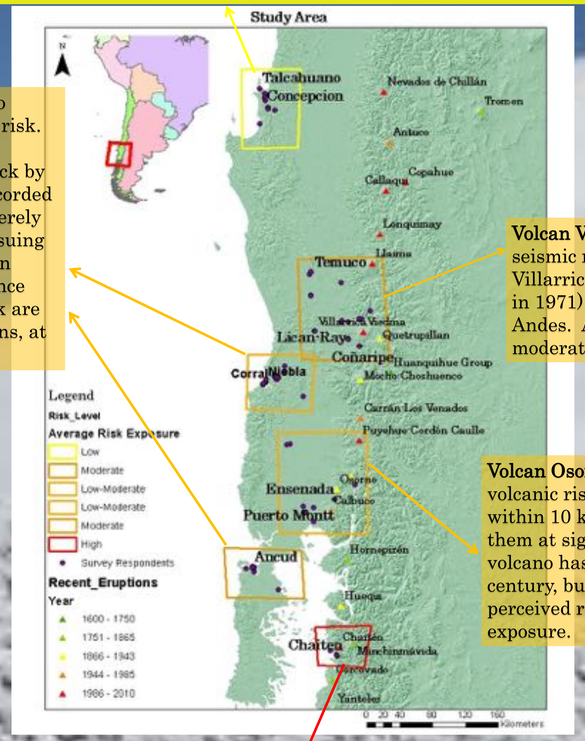
Methodology

This study analyzes a combination of spatial GIS data and sociological survey data from 136 respondents, located between Concepcion and Chaiten, to analyze perceptions of geohazard risk in south central Chile, starting in Concepcion and finishing in Chaiten. Julian Cross and I administered the 45-question survey throughout the study area in December 2012. Actual (objective) risk exposure is defined for each respondent using GIS by a combination of earthquake, tsunami, and volcanic risk exposure. Data representing perceived risk and disaster preparedness were compared to the actual risk rating for each respondent, then summarized using statistical analyses. The table below provides a scale for rating geohazard risk exposure.

Numerical Value	Objective Risk Rating System	Possible Interpretation of Perceived Risk Rating
3 = High Risk	**Seismic**: Respondent located on top of poor quality surface substrate, as defined by SERNAGEOMIN. **Volcanic**: Respondent located within 20 km of summit cone AND in topographically defined hazard zone, OR in a high-risk zone defined by SERNAGEOMIN. Direct lahar, lava, and pyroclast risk. **Tsunami**: Respondent located inside 8-meter tsunami inundation zone and within 25 vertical meters of sea level.	Risk is immediate and certain, with negative consequences. Proximity to hazard ensures negative consequences in hazard event.
2 = Moderate Risk	**Seismic**: All regions in the study area exposed to moderate seismic risk due to the frequency of earthquakes. **Volcanic**: Respondent located between 20 and 30 km of summit cone, OR within moderate-risk zone defined by SERNAGEOMIN. Moderate to low lahar, lava, or pyroclast risk. **Tsunami**: Respondent located within 100m of 8m tsunami inundation zone and within 25 vertical meters of sea level.	Risk is certain, but not immediate. Proximity to hazard may or may not produce negative consequences in hazard event.
1 = Low Risk	**Seismic**: No region in the study area is exposed to low seismic risk, due to the frequency of earthquakes. **Volcanic**: Respondent located between 30 and 50 km away from summit cone. Only exposed to risk of ashfall, and in rare cases, airborne pyroclasts. **Tsunami**: Respondent located within 1 km of 8m tsunami inundation zone and 25 vertical meters of sea level.	Risk is neither certain nor immediate. Proximity to hazard is not likely to produce negative consequences.
0 = No Risk	**Seismic**: All regions have at least a rating of 2 for seismic risk. The value of zero does not apply to any area. **Volcanic**: Farther than 50 km from summit cone. Only exposed to ashfall in rare high-volume eruptions. **Tsunami**: Farther than 1 km from 8m tsunami inundation zone, and above 25 vertical meters from sea level.	Risk is nonexistent in respondent's area, outside dangerous proximity.

Concepción: Exposed to low seismic and tsunami risk; severely affected by 2010 quake and tsunami. Concepción has not only the highest perceived-to-actual risk ratio (moderate perceived, low actual), but also the highest preparedness level.

Valdivia and **Ancud:** Exposed to moderate seismic and tsunami risk. Bothregions have similar risk attributes; the former was struck by the largest earthquake ever recorded in 1960, and the latter was severely affected by shaking and the ensuing tsunami. Neither area has been strongly affected by disaster since then. Perceived and actual risk are nearly equal in these two regions, at moderate levels.



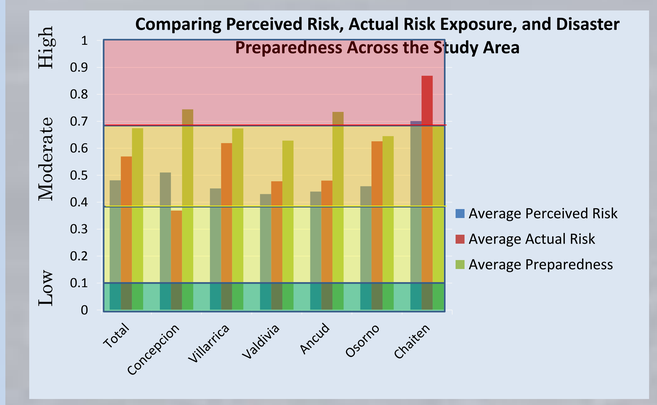
Volcan Villarrica: Exposed to moderate seismic risk and high volcanic risk. Villarrica Volcano (last major eruption in 1971) is among the most active in the Andes. Average perceived risk is low-moderate.

Volcan Osorno: Exposed to seismic and volcanic risk. Respondents live mainly within 10 km of the summit cone, putting them at significant volcanic risk. The volcano has not been active for over a century, but its risk profile is low-moderate perceived risk and moderate-high actual risk exposure.

Perceived Risk, Risk Exposure, and Preparedness

Most perceived risk and risk exposure levels are within the "moderate" range in the bar graph to the right. Preparedness levels are higher where disasters have happened in the past decade, namely in Concepción and Chaitén. Concepción has the highest relative preparedness level, scoring an average of 0.72 out of 1.0. Chaitén also has a moderately high preparedness level, but it is not the highest in the study area. Residents of Ancud were not severely affected by the tsunami, but Ancud is well-prepared. Severe disasters have not happened within the past decade in Valdivia, Osorno, Ancud, or Villarrica. Correlations and T-tests show that there is no statistically significant relationship among perception, exposure, and preparedness, but geographical patterns provide the results at right.

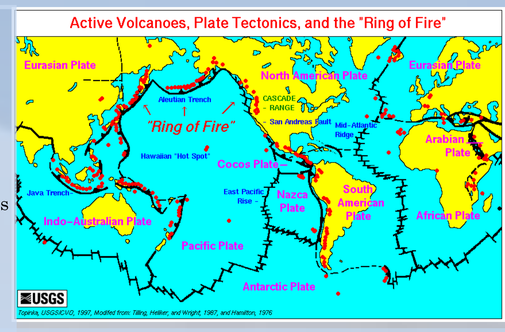
Chaitén: Exposed to Seismic, volcanic, and tsunami risk. Chaiten has the highest actual risk value at 0.86 (high risk), as well as the highest perceived risk value at 0.69 (moderate-high). Chaitén earns this actual risk rating because it is located directly in the drainage of Chaitén volcano, which has been active since its 2008 eruption. The town is also at risk of tsunamis, as it is located on the coast.



Discussion

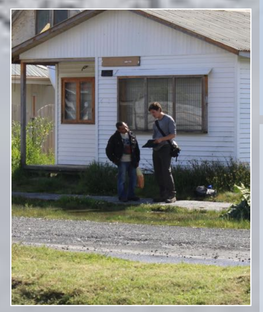
Global Implications

Geohazard disasters related to subduction zone activity happen all over the world in places with varying socioeconomic settings and capacities to deal with them. Chile, Indonesia, Alaska, the Phillippines, Japan, and the Pacific Northwest have particularly active tectonic settings that produce earthquakes, tsunamis, and volcanic eruptions relatively frequently. The map below shows the Ring of Fire, the seismically and volcanically active plate boundaries that border the Pacific Basin. Tectonics in these areas are responsible for the magnitude 9.6 Valdivia Earthquake of 1960, the 2004 Indian Ocean Earthquake and Tsunami, and the magnitude 9.2 1964 Alaskan Earthquake.



Since perceived risk aligns roughly with actual risk in south central Chile, it is possible that other places exposed to geohazards exhibit similar alignment. Risk perception stems from a multitude of sources: disaster experience, government-run hazard education programs, emergency simulations, and cultural familiarity with geohazard disasters. We can conclude that disaster preparedness is positively related to risk perception, but not confidence in the government, which raises the question of how to increase disaster preparedness where it is insufficient. Apart from experiencing a disaster firsthand, there may not be a way to truly understand the need to take preventative action ahead of time. Indeed, for risks of many kinds, the "probability threshold"—the probability of risk at which someone is more likely to take adaptive action—is so low that it is treated as zero, when the consequences of the risk are severe. In these cases risk must be re-evaluated and steps must be taken toward mitigation.

In conclusion, this study shows that there are limitations to educating people about hazards, and that experiencing a disaster firsthand may have more of a positive effect on household disaster preparedness efforts than not experiencing a disaster. Future similar studies could be conducted around the Pacific Rim to evaluate risk perception in places with different cultural and socioeconomic settings.



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Data Sources

- Volcano Data from Smithsonian Global Volcanism Project
- DEM from NASA's Shuttle Radar Topography Mission 90-m DEM database