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Community preparedness for natural hazards in two Chilean coastal cities

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ABSTRACT

Chile is a country with high exposure to earthquakes and tsunamis. However, cities present different levels of community preparedness. Understanding the decision-making process for adopting preparedness measures is essential to motivating community participation while considering the local needs of each city. Considering the Protective Action Decision Model (PADM) to understand community preparedness, this study explores the role of risk perception, risk awareness, and trust in authorities in community preparedness in two coastal cities in Chile. A sample of 1093 inhabitants of two coastal cities, Valparaíso and Concepción, participated in the study. The results indicate significant differences between coastal cities' preparedness levels and their determinants, particularly risk perception and awareness. Despite these differences, our results show that trust in authorities is related to Chile's community preparedness levels in both locations.

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KEYWORDS
Risk awareness; risk perception; trust in authorities; preparedness

Introduction

In recent decades, international organizations for disaster risk reduction have highlighted the importance of improving coastal communities' preparedness to reduce the impacts of socio-natural disasters (UNDRR 2015). Community preparedness involves all formal and informal actions established between authorities and community members to mitigate, prepare, and respond when facing a disaster. Consequently, it includes planning, communication, and practice of evacuation processes (Sorensen and Sorensen 2007; Kusumastuti et al. 2022).

Chile is among the OECD countries that have suffered more significant impacts from disasters in the past decades. During the last 20 years, natural disasters have caused more than 700 casualties in Chile and economic losses estimated to be more than 30 billion dollars (EM-DAT 2023). Within natural hazards, earthquakes and tsunamis have caused the most significant financial and human impact (ONU 2018; EM-DAT 2023). Although the entire country is highly exposed to earthquakes and tsunamis, previous studies indicate significant differences in

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household, workplace, and community preparedness depending on the city under study (Bronfman et al. 2019; Castañeda et al. 2020).

Understanding the decision-making process for adopting preparedness measures is essential to motivating community participation while considering the local needs of each city. The Protective Action Decision Model (PADM) is among the models that explain preparedness behavior and recognizes the role of threat knowledge and assessment as well as the perception regarding the role of stakeholders and authorities as relevant factors in understanding the risk assessment and adoption of preparedness measures (Lindell and Perry 2012).

In threat perception, several studies highlight the positive impact of risk perception on preparedness (Bronfman and Cifuentes 2003; Siegrist et al. 2007; Lindell and Hwang 2008). However, some studies suggest that this relationship is not always significant and may even be null due to the lack of information about the threat (Bubeck, Botzen, and Aerts 2012; Shapira, Aharonson-Daniel, and Bar-Dayan 2018). Some authors suggest that people's information and beliefs correspond to a different cognitive process: risk awareness (Bubeck, Botzen, and Aerts 2012; Ivčević et al. 2020; Cisternas et al. 2023). Despite the importance of risk awareness, previous studies tend to use it as a synonym for risk perception, and only a few of them have been able to differentiate its impact on preparedness (Scolobig, De Marchi, and Borga 2012; Esteban et al. 2013; Luís et al. 2016).

On the other hand, the PADM model recognizes that in community preparedness measures, the perception of stakeholders is fundamental to understanding people's participation in community actions to mitigate the impact of disasters (Lindell and Perry 2012). Previous studies indicate that trust in authorities positively impacts preparedness, especially evacuation knowledge (Basolo et al. 2009; Kim and Oh 2015). In Chile, previous studies indicate medium levels of trust in the institutions in charge of emergency and disaster management, so it becomes relevant to observe how this perception impacts community preparedness (Bronfman et al. 2016, 2022).

Given the importance of these factors in adopting preparedness measures, this study aims to explore the role of risk perception, risk awareness, and trust in community preparedness in two coastal cities in Chile. This investigation pretends to explore if the relationship of risk perception and risk awareness with preparedness is stable between cities with different characteristics and damage experiences in the face of earthquakes and tsunamis. To achieve this, this work also addresses the damage experienced by both cities in the last earthquake. Also, it recognizes the role of sociodemographic variables that allow us to identify each city's inhabitants' characteristics. Identifying how threat perception and perception of stakeholders change depending on the city context is fundamental to establishing strategies that motivate the community to adopt preparedness behaviors, considering their characteristics and needs.

Threat perception: risk perception and risk awareness

Risk perception is one of the most studied variables to understand the adoption of preparedness measures against natural hazards, chemical products and toxins, technological hazards, and health risks (Bronfman and Cifuentes 2003; Siegrist et al. 2007; Lindell and Hwang 2008). Risk perception is a cognitive and emotional evaluation of the probability and impact of the hazards (Sjoberg 2000; Loewenstein et al. 2001; Kohn et al. 2012; Slovic 2016). Previous studies found that the relationship between risk perception and disaster preparedness is complex. Some studies state that higher risk perception is associated with greater adoption of preparedness actions, such as having a survival kit and seeking information (Grothmann and Reusswig 2006; Lindell, Arlikatti, and Prater 2009).

Regarding evacuation behavior, previous findings indicate that risk perception affects planning measures within the home, such as recognizing evacuation routes or establishing a family plan to evacuate in case of a tsunami (Thompson, Garfin, and Silver 2017). Researchers agree that a higher perception of risk promotes peoplés involvement in their communities and

preparedness actions such as drills or seeking information, as well as the adherence to plans proposed by the authorities (Abunyewah, Gajendran, and Maund 2018; Lechner and Rouleau 2019; Ao et al. 2021).

However, some studies suggest that the relationship between risk perception and preparedness may be null or negative for some hazards, such as floods and earthquakes (Bubeck, Botzen, and Aerts 2012; Wachinger et al. 2013; Shapira, Aharonson-Daniel, and Bar-Dayan 2018). Some studies have even indicated that risk perception negatively affects preparedness (Kirschenbaum 2005).

On the other hand, one explanation for null relationship between risk perception and preparedness may be the lack of knowledge regarding the hazards; without information about the consequences of the hazards, people cannot assess or respond to the risk (Siegrist and Árvai 2020; Valenzuela et al. 2020). Lindell and Perry (2012) suggest that before a person decides to adopt preparedness measures, they must first know about the hazards, be aware of them, and be able to evaluate the potential damage they can cause. Consequently, hazard awareness is crucial for assessing potential risk (Paton et al. 2008; Bronfman et al. 2020).

Disaster preparedness research has less studied risk awareness (Mondino et al. 2020). In some studies, awareness has been considered equivalent to risk perception or as a dimension of risk (Kellens, Zaalberg, and De Maeyer 2012; Bandecchi et al. 2019). However, despite being related concepts, some researchers suggest that they correspond to different cognitive processes (Luís et al. 2016; Cisternas et al. 2023). Researchers who differentiate these constructs define risk awareness as the active process of seeking information regarding natural threats present in the territory and the behaviors to respond to them (Scolobig, De Marchi, and Borga 2012; Esteban et al. 2013). Awareness is related to hazard knowledge and is potentially necessary for perceiving a risk; people must be aware that a particular threat exists to assess it and decide the need to protect themselves (Borowsky and Oron-Gilad 2013; Luís et al. 2016). Therefore, risk awareness is defined as people's information and knowledge about the hazards in their territory (Luís et al. 2016).

On the other hand, the PADM suggests that people's information and beliefs about the hazard influence the process of risk identification and risk assessment. Lindell and Perry (2012) suggest that what people think about natural hazards, their knowledge about them, and the frequency with which they think about them affect how they identify their probability of occurrence and consequences. Based on these proposals, in this study we understand risk awareness as people's beliefs and knowledge about the hazard. It is also a process different from risk perception.

Researchers who have studied risk awareness reported that greater risk awareness relates to higher preparedness levels (Ao et al. 2021; Maidl, Bresch, and Buchecker 2021). There is consensus that as people know more about the hazards in their place, they will search for information on how to face them (Luís et al. 2016; Harnantyari et al. 2020). Moreover, studies indicate that people exposed to disaster education programs learn how to identify hazards where they live and become aware of these; they also learn about individual and collective preparedness strategies and actions (Cubelos et al. 2019; Osberghaus and Hinrichs, 2021).

Other studies suggest that risk awareness impacts preparedness through identification with the environment (Bonaiuto et al. 2016). Ivčević et al. (2020) found that people who identify more with their environment report higher risk awareness and greater preparedness. They argue that people who value the environment they live in are more interested in learning about hazards and participate more in preparedness activities.

This study assessed threat perception through risk perception and risk awareness. We consider risk perception as the probability of occurrence and damage from earthquakes and tsunamis. Risk awareness is understood as beliefs and information about the natural hazards in the city (Lindell and Perry 2012; Luís et al. 2016). Due to the extensive experience of earthquakes and tsunamis in Chile and, consequently, the knowledge of the inhabitants about these hazards,

we expect that both risk perception and awareness have a significant relationship with preparedness in both cities.

Perception of stakeholders: trust in authorities

The perception of stakeholders involved in community preparedness is crucial for the decision process of adopting preparedness measures (Lindell and Perry 2012). Trust in authorities is part of the indicators of this perception, and it is generally recognized that higher trust in authorities increases the adoption of preparedness measures (Basolo et al. 2009; Wei, Sim, and Han 2019; Bronfman et al. 2022). Eiser, Donovan, and Sparks (2015) found that when authorities act effectively and quickly after a disaster, people perceive them as actors with the necessary skills to protect them against these events. This is essential when these actions require cooperation between authorities and the community.

Trust in authorities also promotes a cooperative climate in society, encouraging people to adopt the suggested preventive measures (Wachinger et al. 2013; Eiser, Donovan, and Sparks 2015). Collective preparedness measures are more accepted when trust in authorities is high because they consider that authorities have better knowledge and capacities for responding to disasters (Samaddar, Misra, and Tatano 2012). Zhang et al. (2022) suggest that when communities trust their authorities, people report more knowledge about evacuation plans and evaluate the measures as more effective in reducing damage. Similarly, Kim and Oh (2015) argues that trust in authorities is associated with compliance with the government's evacuation alerts and orders.

Trust is crucial because authorities provide information on preparedness for earthquakes and tsunamis, deliver information about the city's evacuation plans, and declare the alert (Paton 2008; Vicente et al. 2014; Maidl et al. 2021). If people do not trust their authorities, they may not act and take longer to evacuate, affecting their response to disasters (Basolo et al. 2009; Kim and Oh 2015).

This study integrates the measurement of trust in the authorities since it is recognized that they have a crucial role in community preparedness actions, such as making the evacuation plan and establishing safe zones, among others. Consequently, we expect that trust has a significant relationship with community preparedness in Valparaíso and Concepción.

Other factors: damage experience

The PADM model recognizes that experience moderates threat perception (risk perception and awareness) and the decision to adopt preparedness measures (Lindell and Perry 2012). People who have suffered disaster material damage report greater levels of preparedness (Becker et al. 2017; Bronfman et al. 2020). Previous studies show that damage experience influences people's risk perception and concern about the impact of events, influencing preparedness behaviors (Miceli, Sotgiu, and Settanni 2008; Terpstra 2011).

The experience directly affects preparedness behaviors by making more available memories of the event and the coping measures used (Lindell and Whitney 2000; Becker et al. 2017; Maidl et al. 2021). Thompson, Garfin, and Silver (2017) argue that people with previous disaster experience have more excellent knowledge about evacuation and intend to do it in the future.

Experience also allows people to communicate with others about the disasters they have encountered and exchange information about preparedness actions across generations (Akama, Chaplin, and Fairbrother 2014). Consequently, experience increases awareness about the event, motivates people to participate in their community, and gets involved in actions that contribute to preparedness.

Chile is a country with high exposure to earthquakes and tsunamis. Although the entire Chilean population has experienced earthquakes and tsunamis, the frequency of occurrence and damage caused by these events differ among the country's cities. Valparaíso is one of the most important coastal cities in Chile. The largest earthquakes recorded in the area were in 1985 and 2010, and the most recently in 2017 (CSN 2020). The 2010 earthquake affected Valparaíso with a magnitude of VI MMI, with twenty-six deaths reported (OPS 2010). The 2017 earthquake was classified as a slow earthquake because more than 100 earthquakes of lower magnitude were recorded before it. Despite its magnitude of 6.9 Mw, this earthquake did not leave serious consequences; only authorities declared a preventive alert to evacuate safe areas (Ruiz et al. 2017).

On the other hand, Concepción has been affected by two of the largest earthquakes ever recorded in the history of humanity, including the 1960 earthquake with tsunami waves of 25 meters. In 2010, Concepción registered an earthquake of 8.8 Mw, causing 130 regional deaths and severe damage to the infrastructure, which isolated the city for more than two weeks (OPS 2010). In addition, during this earthquake, a tsunami was recorded with waves of up to 5 meters, which caused several casualties (Comisión Económica para América Latina y el Caribe, 2010). Since the February 2010 earthquake, Concepción has not been affected by another large-magnitude earthquake (CSN 2020).

Considering the role of experience in perception, awareness, and community preparedness, this study aims to examine how the experience of damage is related to the knowledge of the city's evacuation plans. In addition, it intends to explore how experience influences the perception of threat in two cities, Valparaíso and Concepción, with different previous experiences of earthquakes and tsunamis in terms of magnitude and consequences. Exploring these differences is essential to establish strategies that motivate adopting preparedness behaviors according to each city's characteristics and needs.

Sociodemographic characteristics

Despite the weak relationship between sociodemographic variables and preparedness, they are still relevant to identifying the groups with the lowest levels of preparedness (Heller et al. 2005). Research indicates that women report higher levels of community preparedness because of the caregiver role assumed within families (Tyler and Fairbrother 2018; Bronfman et al. 2019). Women also tend to participate more in community and educational instances, thus obtaining more information on preparedness (Akama, Chaplin, and Fairbrother 2014; Hung 2018). Regarding age, there are contradictory findings regarding preparedness. In some studies, older adults report lower levels of preparedness because of the physical and monetary requirements to participate in community networks (Howard, Blakemore, and Bevis 2017). On the contrary, McNeill and Ronan (2017) have reported that young adults declare lower levels of preparedness because they participate less in community activities for disaster preparedness. In contrast, other researchers state that youth is associated with greater adoption of planning actions in the event of a disaster (Thompson, Garfin, and Silver 2017).

Higher-income individuals adopt more preparedness measures, particularly those requiring financial investment, such as mitigation measures within the home, (Maryani, Erliyandi, and Murtianto 2022. Wehde and Nowlin (2021), in a study conducted in the United States, found that higher-income people adopted preparedness measures at home because they were responsible for preparing for a Hurricane over the federal government.

Concerning educational level, Hoffmann and Muttarak (2017) report a direct relationship with preparedness behaviors due to the ease of accessing and understanding information about disaster mitigation.

Finally, researchers have found that people with children or a partner report higher preparedness levels due to more significant concern about caring for others (Ronan et al. 2015; Shapira, Aharonson-Daniel, and Bar-Dayan 2018). Similarly, time spent living in the city was

related to the adoption of preparedness measures: people who have lived in a place for more extended periods usually have more previous experience and, consequently, greater access to information on how to prepare (De Dominicis et al. 2015; Bonaiuto et al. 2016; Castañeda et al. 2020). Given the differences found in the levels of preparedness according to sociodemographic characteristics, they are incorporated in this study to explore their role in the knowledge of evacuation plans and to identify those groups that require more significant support t to engage in community preparedness.

Materials and methods

Study area

Chile is a country with a large coastal area that reaches more than six thousand km in length. The country's economic activity and urban settlements are concentrated in this area, which is highly exposed to disasters. This study includes two coastal cities that comprise a large part of the country's population and have also been the scene of several earthquakes and tsunamis: Valparaíso and Concepción (Figure 1).

Valparaíso is in the country's central area, with over 15 km of beaches, where 10.3% of the national population resides (INE 2017). The average age of its inhabitants is 37.4 years, being mostly women. Regarding the educational level, 95% of the population has completed primary school, but only 43% have access to university. In addition, the average income is 775 USD (INE 2017). About the risk of earthquakes and tsunamis, it is estimated that more than 64 thousand people and 25% of the dwellings are in a tsunami threat zone (ONEMI 2018).

Concepción is in the south of Chile and is the second most populated area of the country (INE 2017). It is a mainly urban city between the coastal mountain range and the Bío-Bío River. 52.1% of the population are women, the average age is 36 years, and the population reaches 12 years of schooling (primary and secondary education). The city's income is around USD 722 (INE 2017).

Survey

We used already collected data for this study. The original study aimed to evaluate preparedness levels to respond to earthquakes and tsunamis among the coastal population in Chile. A survey on a representative sample of Valparaíso and Concepción was implemented. All scales and measures used in this study are described below.

Risk perception was measured with a 6-item questionnaire, previously validated and implemented in other studies in Chile (Bronfman et al. 2016, 2020). This section evaluates two dimensions of risk perception (Table 2). The first one measures the perception of personal, family, and societal risk against earthquakes, with a response scale from 1 to 7, (1) "no risk" to (7) "totally risky." The second one measures the probability of suffering damage from an earthquake and tsunami, from 1 to 7, (1) "not at all likely" to (7) "totally likely".

Risk awareness was measured using five statements from previous studies (Kellens, Zaalberg, and De Maeyer 2012; Scolobig, De Marchi, and Borga 2012) that measured information and beliefs about earthquakes and tsunamis in the cities. For each statement, respondents were presented with an agreement scale from 1 to 5 (1 "totally disagree" to 5 "totally agree").

Six items were used to assess trust in authorities (Table 3). For each question, participants were asked to indicate their degree of agreement on a scale between 1 "totally disagree" and 5 "totally agree." This scale has been previously used in Chile (Bronfman et al. 2016).

Damage experience was measured using 13 items from previous studies (Lindell, Arlikatti, and Prater 2009; Bronfman et al. 2020; Table 3) that asked about the physical and material damage caused by the last earthquake and tsunami in the city (the 2010 earthquake and tsunami for both cities). For each, the participants had to answer yes (1) or no (0).

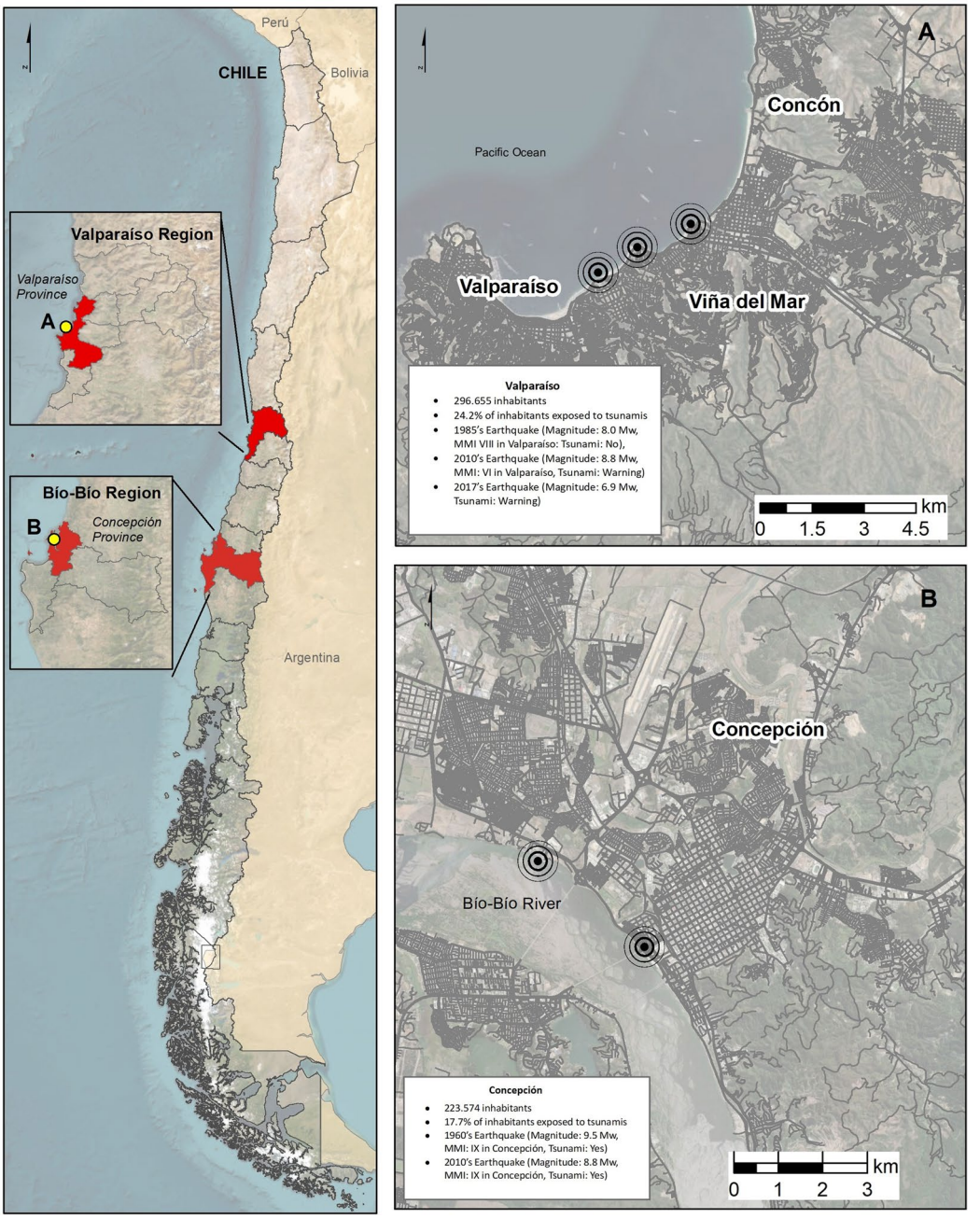

Figure 1. Valparaíso and concepción study area. This figure shows the characteristics of Chile's coastal cities and their experience with earthquakes and tsunamis. Note: the data were obtained from the U.S. Government service.

In the study, community preparedness is understood as all those measures that occur in the interaction between different social actors (Sutton and Tierney 2006). Consequently, community preparedness was measured with four items: (1) Do you know if your city has an action plan for an earthquake and tsunami?; (2) Do you know how your citýs plan in the event of an earthquake and tsunami works?; (3) In the event of an earthquake or tsunami, do you know where the safe zone is in your city?; (4) Do you know which route to take to reach the safe

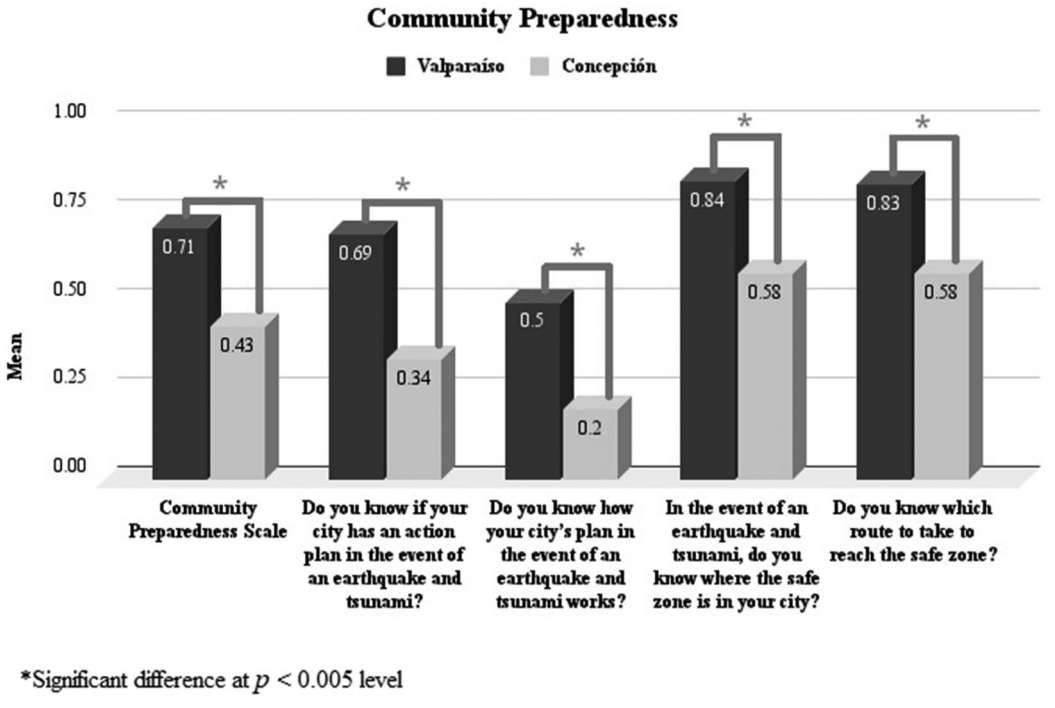

Figure 2. Community preparedness: Differences by city.

zone?. The response options were yes or no. The scale obtained a Cronbach's alpha of α = 0.79 (Figure 2).

We assessed several sociodemographic characteristics: sex, age, partner relationship, presence of children at home, years living in the city, educational level, and family income. Age, years living in the city, educational level, and family income were regrouped into four categories. Age ranges used were: 18–29 years, 30–44 years, 45–59 years, and over 60 years. Years living in the city were recorded into these categories: 0–2 years, 3–20 years, 21–39 years, and more than 40 years (Castañeda et al. 2020). Educational level was recoded into elementary (8 years or less), secondary (12 years), technical (12 to 14 years), and college education or more (16 to 19 years). Family income was converted from Chilean pesos to USD and categorized into 519 USD, 519–779 USD, 779–1558 USD, and 1558 USD or more.

Procedure and participants

Data were collected between December 2018 and April 2019. The sample was stratified by socioeconomic level. Trained interviewers administered the questionnaire in person at the participants' homes. Before completing the survey, all participants signed an informed consent form stating their participation was voluntary, anonymous, and confidential. No incentive was given to participate in the study. All procedures were approved by the Ethics Committee of Andrés Bello University (Act of Approval Code 008/2018).

1,093 people participated in the study: 521 inhabitants of Valparaíso and 572 people from Concepción. Of these, 53.1% were females, the average age was 47 years (SD = 18.34) and they declared living an average of 35 years (*SD* = 19.9) in the city (Table 1).

Table 1. Description of the sample.

Category		All sample	Valparaiso	Concepción
	N	1093	521 (47.7%)	572 (52.3%)
Sex	Man	46.9%	45.5%	48.3%
	Women	53.1%	54.5%	51.7%
Age	18–29	23.7%	21.4%	25.7%
	30–44	23.0%	21.2%	24.7%
	45–59	23.6%	25.4%	21.9%
	> 60	29.7%	32.0%	27.7%
Partner Relationship	Married–Living with a Partner	47.1%	45.8%	48.3%
	Single–Separated–Divorced–Widowed	52.9%	54.2%	51.7%
Children at Home	Yes	56.1%	42.2%	45.4%
	No	43.9%	57.8%	54.6%
Educational level	Elementary (8 years)	10.6%	10.7%	10.4%
	Secondary (12 years)	27.8%	26.9%	28.6%
	Technical (12 to 14 years)	14.1%	12.7%	15.4%
	University (16 to 19 years)	47.5%	49.7%	45.6%
Family Income	519 USD	28.8%	26.5%	30.6%
	519–779 USD*	24.6%	25.6%	23.8%
	779–1558 USD	24.9%	26.0%	24.0%
	> 1558 USD	21.8%	21.9%	21.7%
Years living in the city	0 to 2 years	3.30%	2.90%	3.70%
	3–20 years	24.1%	24.1%	24.0%
	21–39 years	30.8%	28.6%	32.8%
	> 40 years	41.8%	44.4%	39.5%

*This is the average family income in Chile.

Data analysis

Cronbach's Alpha was used to assess the reliability of all measures included. Alpha greater than 0.65 was obtained for all the scales, indicating appropriate reliability for all measures (Table 2 and Table 3). The trust in authorities scale had the highest alpha level ($\alpha = 0.92$), and the risk awareness scale had the lowest ($\alpha = 0.65$). These alpha values are similar to those obtained in previous studies for risk perception and trust scales (Bronfman et al. 2016; Han, Liu, and Wu 2021; Bronfman et al. 2022).

Descriptive analyses were performed for each measure (Risk perception, Risk Awareness, Trust, and Community Preparedness). The experience scale was constructed using the average damage for each participant. In consequence, a higher average means a greater experience of damage from the 2010 earthquake and tsunami.

Then, a mean differences analysis was conducted to compare risk perception, risk awareness, damage experience, trust in authorities, and community preparedness levels between Valparaíso and Concepción. An independent samples *t*-test analysis was performed, and the assumptions of normality of the variables and homogeneity of variance were verified.

A correlation analysis was carried out for each city to verify the relationship between the variables involved in the study. It was observed that risk awareness and risk perception were significantly related ($p < 0.05$) in Valparaíso but not in Concepción ($p = 0.14$). However, the value of the correlation for both cities was close to 0 (Valparaiso: $r = 0.16$; Conception: $r = 0.06$), indicating that they are related concepts but that they evaluate independent processes.

Finally, a hierarchical regression analysis was carried out to analyze the relationship of the variables involved in the study with the levels of community preparedness.

Table 2. Descriptive analysis of cognitive factors: risk perception and risk awareness.

	Valparaiso		Concepción		Mean Dif.
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	*p*
Risk Perception scale α = 0.84	4.58	1.31	4.79	1.18	0.002*
How much earthquake and tsunami risk do you believe you are exposed to?	4.45	1.82	4.91	1.60	0.001*
How much earthquake and tsunami risk do you believe your family, friends and colleagues are exposed to?	4.79	1.71	5.13	1.50	0.001*
How much earthquake and tsunami risk do you believe the national population is exposed to?	5.76	1.38	5.78	1.24	0.412
How likely is it that your home will suffer major earthquake and tsunami damage in the next 10 years?	4.13	1.94	4.39	1.70	0.008*
How likely are you or any member of your household to suffer major physical damage from an earthquake and tsunami in the next 10 years?	4.15	1.79	4.30	1.65	0.069
How likely are you or a member of your household to suffer health problems from an earthquake and tsunami in the next 10 years? (Sleep disorders, anxiety attacks, post-traumatic stress)	4.20	1.98	4.27	1.83	0.028*
	Valparaiso		Concepción		Mean Dif.
	$\bar{x}$	*SD*	$\bar{x}$	*SD*	*p*
Risk Awareness Scale α = 0.65	4.35	0.61	3.90	0.73	0.001*
I am aware of the risk associated with earthquakes and tsunamis to which the population living on the coast of this city is exposed.	4.60	0.80	4.33	0.96	0.001*
Before the last earthquake and tsunami, I experienced in this city, I believed something like this could happen here.	3.96	1.29	3.20	1.48	0.001*
I believe that an earthquake and tsunami similar to the last one I experienced in this city could happen here again.	4.62	0.72	4.36	0.97	0.001*
Sometimes I think about the risks associated with earthquakes and tsunamis on the coast of this city	4.17	1.09	3.78	1.19	0.001*
For people like me, the risks associated with earthquakes and tsunamis in the city are well known.	4.40	0.92	3.89	1.15	0.001*

Note: *α*: Cronbach's Alpha indicator; $\bar{x}$: Average Scale: *SD*: Standard deviation.
*Significant differences between cities at $p \leq 0.05$ level.

Results

Descriptive analysis

Concepción and Valparaíso samples declared high-risk perception and high awareness regarding earthquakes and tsunamis. However, the inhabitants of Concepción declared a significantly higher perception of risk ($p < 0.001$) than the inhabitants of Valparaíso (Table 2). While the inhabitants of Valparaíso declared greater awareness of risk ($p < 0.001$) than the inhabitants of Concepción. These differences were valid for each item of each risk scale (Table 2).

Table 3. Descriptive analysis of trust in authorities and damage experience.

Damage Experience Scale $a = 0.73$	Valparaiso 0.23 ($SD = 0.16$)		Concepción 0.41 (SD = 0.17)		Mean Dif 0.001*
	%Yes	%No	%Yes	%No	*p*
Did you suffer significant physical injuries due to the earthquake and tsunami?	1.8%	98.2%	8.1%	91.9%	0.001*
Did you need medical attention during or immediately after the earthquake and tsunami?	1.8%	98.2%	7.1%	92.9%	0.001*
Was any member of your household, friend, neighbor, or co-worker physically injured by the earthquake and tsunami?	11.3%	88.7%	19.9%	80.1%	0.001*
Have you suffered the loss of any member of your family, friends, colleagues, etc. due to the earthquake and tsunami?	4.5%	95.5%	7.4%	92.6%	0.027*
Were you affected by important material losses (home, job, car, etc.) due to the earthquake and tsunami?	16.8%	83.2%	36.8%	63.2%	0.001*
Did your home suffer major damage from the earthquake and tsunami?	20.7%	79.3%	36.5%	63.5%	0.001*
Did any relative, friend, neighbor or co-worker suffer damage to household property due to the earthquake and tsunami?	36.0%	64.0%	54.3%	45.7%	0.001*
Did you have to move to live in another neighborhood or city?	5.3%	94.7%	15.0%	85.0%	0.001*
Did you sleep outdoors, in the street or in the fields?	8.8%	91.2%	30.9%	69.1%	0.001*
Were you looted, or did you organize with others to defend yourself against possible looting?	9.4%	90.6%	47.5%	52.5%	0.001*
Were you left without communication to talk with family and friends?	70.9%	29.1%	92.5%	7.5%	0.001*
Did you run out of water or food?	50.7%	49.3%	83.3%	16.7%	0.001*
Were you without power or electricity for more than two days?	63.4%	36.6%	93.9%	6.1%	0.001*
	Valparaiso		Concepción		Mean Dif
	X-	*SD*	*X-*	*SD*	*p*
Trust in Authorities Scale a = 0.92 In the event of a natural disaster, I trust that the *Government and the Local Authorities…*	2.94	1.07	2.70	1.06	0.001*
[…] Will provide all relevant information for the health and safety of the public.	2.98	1.23	2.65	1.22	0.001*
[…] Will maintain open and transparent communication with the public.	2.84	1.25	2.58	1.22	0.001*
[…] Will act without political or private commitments or pressures.	2.70	1.27	2.58	1.26	0.057
[…] Have the necessary competencies to make good decisions	2.95	1.26	2.77	1.22	0.006*
[…] Have the necessary competencies to solve potential problems.	3.09	1.26	2.84	1.24	0.001*
[…] Have the necessary competencies to adequately communicate the associated risks	3.12	1.29	2.82	1.25	0.001*

Note: *a*: Cronbach's Alpha indicator; $\bar{x}$: Average Scale: *SD*: Standard deviation.
*Significant differences between cities at $p \leq 0.05$ level.

On the other hand, participants from both cities declared medium levels of trust, but those from Valparaíso showed higher levels of trust in authorities than Concepción ($p < 0.001$). This result is valid for all questions except for question 3 (Table 3).

Regarding the damage experience, participants of Concepción reported significantly more significant damage and more negative consequences of the 2010 earthquake and tsunami than those from Valparaíso ($p < 0.001$) (Table 3).

Finally, more than half of the participants declared they knew the safe zone and the route. However, participants from Valparaíso knew more about evacuation plans to face an earthquake and tsunami, the safe zone, and the route to get there.

Hierarchical regression

Given the significant differences between Valparaíso and Concepción in threat perception, trust, damage experience, and preparedness, we ran separate regression models for each city. The variables were entered in the order that they appear in the model.

It should be noted that sociodemographic variables were incorporated into the regression since previous studies recognized their relationship with preparedness.

Valparaíso

Table 4 summarizes the regression results for the Valparaíso sample. The final model explained 7% of the variance, where age, years living in the city, risk awareness, risk perception, and trust in authorities were significantly related to community preparedness. Community preparedness declared by the participants from Valparaíso increased with the years of living there, risk awareness, and trust in authorities. Age and risk perception are negatively associated with preparedness. Figure 3 shows that participants aged 45 to 59 years had greater preparedness levels, and those 60 years and older had the lowest levels of community preparedness.

According to the regression model, there was no significant association between the damage experience and community preparedness.

Concepción

The regression model for the Concepción sample explained 4.6% of the variance. The statistically significant factors were educational level, family income, risk perception, and trust in authorities (Table 4).

More educated people declared excellent knowledge about the city's preparedness measures. On the other hand, family income negatively affected community preparedness. Figure 4 shows that middle-income people declare a higher level of community preparedness. Also, participants who declared family income in the extreme ranges (people in income ranges less than 519 USD and more than 1558 USD) reported the lowest knowledge of city evacuation plans.

Finally, risk perception and trust in authorities maintained a positive and significant relationship with community preparedness, suggesting that the higher risk perception and trust in authorities, the higher the levels of community preparedness. Also, as in Valparaíso, damage experience did not significantly correlate with preparedness.

Discussion

Understanding the decision-making process for adopting preparedness measures in different contexts is essential to designing strategies that motivate the community to engage in earthquake and tsunami preparedness. Our results indicate that despite the exposure in Chile to earthquakes and tsunamis, there are significant differences between cities in the perception of hazards, the perception of stakeholders, and, consequently, the levels of community preparedness. Concepción inhabitants declared less knowledge about the city's plan when facing an earthquake and tsunami. Also, while in Valparaíso, risk awareness and risk perception were

Table 4. Hierarchical regression models of community preparedness.

		Valparaíso				Concepción			
Model	Predictors	Adjusted R^2	F	p-value	Δ R^2	Adjusted R^2	F	p-value	Δ R^2
1	Sociodemographic Characteristics	0.019	2.016	0.052	0.038	0.022	2.473	0.017*	0.037
2	Damage Experience	0.017	1.808	0.538	0.001	0.023	2.357	0.218	0.003
3	Risk Awareness	0.041	2.757	0.002*	0.026	0.026	2.342	0.141	0.005
4	Risk Perception	0.051	2.972	0.032*	0.012	0.038	2.779	0.011*	0.014
5	Trust in Authorities	0.070	3.513	0.004*	0.021	0.046	2.985	0.029*	0.010

		Standardized Coefficients Valparaíso			Standardized Coefficients Concepción		
Model	Predictors	*B*	*t*	*p*-value	*B*	*t*	*p*-value
1	Intercept		5.060	0.000		2.590	0.010
	Sex	−0,017	−0,314	0.754	0.017	0.358	0.720
	Age	−0,206	−3.168	0.002**	−0.034	−0.524	0.601
	Partner Relationship	0.056	0.990	0.323	0.018	0.340	0.734
	Children at home	−0.002	−0.038	0.969	0.074	1.505	0.133
	Education Level	0.007	0.120	0.905	0.179	3.164	0.002**
	Family Income	0.040	0.665	0.507	−0.162	−2.903	0.004**
	Years living in the city	0.127	2.171	0.031*	−0.019	−0.325	0.745
2	Intercept		5.059	0.000		2.067	0.039
	Sex	−0.018	−0.335	0.738	0.015	0.313	0.754
	Age	−0.205	−3.145	0.002**	−0.031	−0.480	0.631
	Partner Relationship	0.053	0.933	0.351	0.017	0.335	0.738
	Children at home	0.002	0.041	0.967	0.070	1.418	0.157
	Education Level	0.005	0.087	0.931	0.179	3.175	0.002**
	Family Income	0.040	0.656	0.512	−0.164	−2.937	0.003**
	Years living in the city	0.125	2.131	0.034*	−0.012	−0.212	0.832
	Damage experience	−0.032	−0.616	0.538	0.058	1.235	0.218
3	Intercept		1.678	0.094		0.880	0.379
	Sex	−0.027	−0.505	0.614	0.020	0.415	0.678
	Age	−0.199	−3.097	0.002**	−0.037	−0.563	0.574
	Partner Relationship	0.064	1.143	0.254	0.017	0.332	0.740
	Children at home	−0.011	−0.201	0.841	0.074	1.500	0.134
	Education Level	−0.004	−0.061	0.951	0.180	3.197	0.001**
	Family Income	0.045	0.755	0.451	−0.166	−2.984	0.003**
	Years living in the city	0.129	2.218	0.027*	−0.014	−0.238	0.812
	Damage experience	−0.045	−0.862	0.389	0.064	1.363	0.174
	Risk Awareness	0.164	3.160	0.002**	0.069	1.474	0.141
4	Intercept		2.184	0.030		0.049	0.961
	Sex	−0.039	−0.748	0.455	0.008	0.159	0.874
	Age	−0.209	−3.258	0.001**	−0.032	−0.497	0.620
	Partner Relationship	0.065	1.173	0.242	−0.004	−0.072	0.943
	Children at home	−0.003	−0.053	0.958	0.077	1.584	0.114
	Education Level	−0.020	−0.328	0.743	0.191	3.401	0.001**
	Family Income	0.032	0.539	0.590	−0.157	−2.830	0.005**
	Years living in the city	0.139	2.394	0.017*	−0.010	−0182	0.856
	Damage experience	−0.016	−0.293	0.769	0.044	0.922	0.357
	Risk Awareness	0.184	3.510	0.001**	0.061	1.305	0.192
	Risk Perception	−0.120	−2.158	0.032*	0.122	2.540	0.011*
5	Intercept		1.563	0.119		−0.211	0.833
	Sex	−0.042	−0.809	0.419	0.008	0.177	0.859
	Age	−0.235	−3.662	0.000**	−0.042	−0.650	0.516
	Partner Relationship	0.062	1.135	0.257	−0.011	−0.207	0.836
	Children at home	0.011	0.206	0.837	0.077	1.589	0.113
	Education Level	−0.015	−0.249	0.803	0.177	3.141	0.002**
	Family Income	0.021	0.360	0.719	−0.158	−2.859	0.004**
	Years living in the city	0.148	2.572	0.011*	−0.008	−0.146	0.884
	Damage experience	0.013	0.249	0.804	0.051	1.072	0.284
	Risk Awareness	0.164	3.138	0.002**	0.049	1.042	0.298
	Risk Perception	−0.112	−2.046	0.041*	0.119	2.489	0.013*
	Trust in Authorities	0.153	2.883	0.004**	0.103	2.192	0.029**

Note: *Significance at $p \leq 0.05$ level; **Significance at $p \leq 0.01$ level.

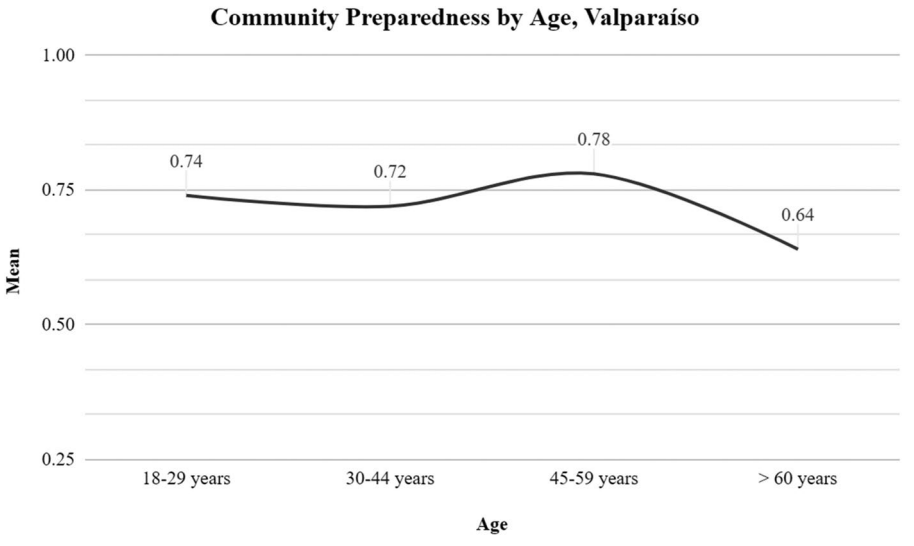

Figure 3. Level of community preparedness according to age in valparaíso.

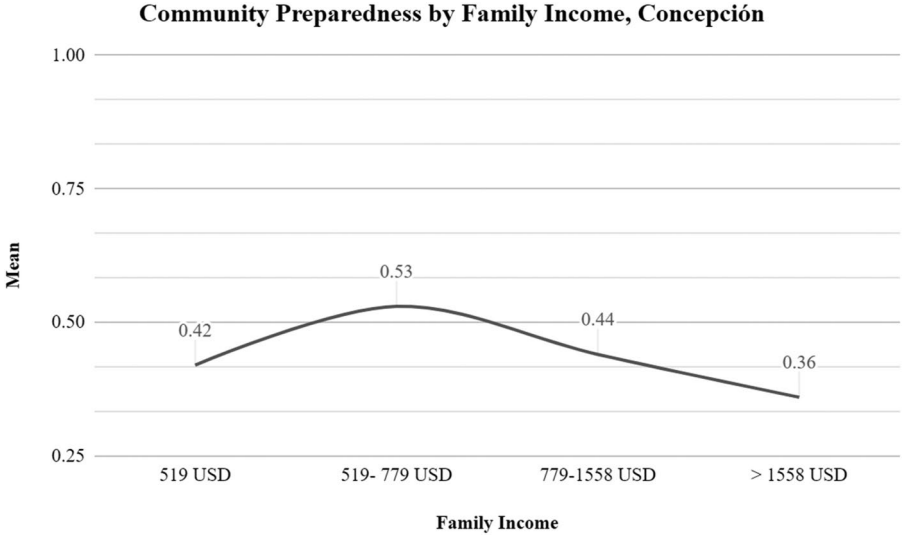

Figure 4. Level of community preparedness according to family income in concepción.

significant, in Concepción, only risk perception was significant. Finally, trust in authorities is associated with preparedness in both cities. These findings and their implications are discussed in the following sections.

Community preparedness: a context-dependent dimension of preparedness

Although Chile is highly exposed to earthquakes and tsunamis, community preparedness differed between the cities studied; Valparaíso participants declared higher preparedness levels than Concepción.

One explanation for this result is related to recent experience. In Valparaíso, the last earthquake occurred in 2017, one year before this study was implemented, while in Concepción, the last earthquake occurred in 2010, more than nine years before this study. Previous studies indicate that a recent disaster experience is an opportunity for people to learn how to respond to these events, generating higher levels of preparedness (Thompson, Garfin, and Silver 2017; Castañeda et al. 2020). Consequently, for Valparaíso inhabitants, their experience about how the city plan worked, the authorities responded, and the location of the safe zone was more available in their memory.

The opportunities to practice the evacuation plan through drills can also clarify these differences. In Valparaíso, four drills were implemented two years before the data collection. In Concepción, the most recent drill was carried out six years before the present study (ONEMI 2022). This suggests that drills are essential for increasing knowledge about preparedness measures, as reported previously (Simpson et al. 2002). Ning et al. (2021) argue that when people practice preparedness actions (e.g. drills), they increase their knowledge and skills to respond effectively to a disaster, and consequently perceive they can perform and implement preparedness actions. Consequently, fewer drills and the lack of practice in the evacuation process in the city can lead the inhabitants of Concepción to know less about evacuation plans and be less prepared in case of an earthquake or tsunami.

Threat perception and community preparedness

Risk awareness and perception were associated with community preparedness in Valparaíso, while in Concepción, only risk perception was.

The relationship between risk awareness and community preparedness in Valparaíso has been reported previously in studies showing that people more aware of the hazards declare adopting more preparedness measures (Harnantyari et al. 2020; Ao et al. 2021; Maidl, Bresch, and Buchecker 2021). The relevance of awareness in Valparaíso can be related to the recent earthquake experience among the inhabitants, which occurred one year before the survey. Recent disaster experiences are a source of information that makes people aware of the hazards and can motivate them to learn about the preparedness measures (Becker et al. 2017; Ivčević et al. 2020).

The geography of Valparaíso may also affect participants' risk awareness. Inhabitants of Valparaíso can see the sea from multiple locations, which is part of their daily experience. This can remind them that a tsunami may occur and be aware of this. Moreover, the sea's proximity can help people recognize evacuation routes and safe zones. This finding is consistent with previous studies that suggest that risk awareness is affected by how people identify with the place they live, influencing knowledge about the threats (Mishra, Mazumdar, and Suar 2010; Bonaiuto et al. 2016; Ivčević et al. 2020).

Risk perception is found to have a significant and negative relationship with preparedness in Valparaíso. This result shows that the relationship between risk perception and preparedness is complex and not always linear (Bubeck, Botzen, and Aerts 2012; Wachinger et al. 2013). One of the explanations for this result is that the recent experience in Valparaíso had minor consequences for the population, so despite habitants perceiving a risk, it does not necessarily motivate the adoption of preparedness behaviors. Wachinger et al. (2013) point out that experience is part of the factors that explain the risk perception paradox. Experience can change the relationship between perception and preparedness, especially when the population has experienced low damage. These results indicate the need to explore further how other variables may moderate this relationship and suggest that other strategies must be taken to motivate preparedness.

On the other hand, for Concepción, we found that a higher risk perception was associated with greater community preparedness. Asgarizadeh and Gifford (2022) argue that risk assessment

makes people more willing to participate in networks and activities that collectively help them to face a disaster. This greater risk perception among Concepción participants can be affected by the severe consequences experienced during the 2010 earthquake and tsunami, and they raise their concern that it could happen again (Miceli, Sotgiu, and Settanni 2008; Terpstra 2011). Maidl et al. (2021) suggest that living an experience of harm increases people's perceived risk and, consequently, the adoption of preparedness measures.

Finally, these differences across cities on the role of risk perception and awareness in community preparedness may suggest that these are different processes. Furthermore, our results indicate the relationship between threat perception and preparedness changes in cities and contexts with different experiences. This suggests that different strategies must be adopted to motivate the adoption of preparation measures, depending on the context in which it is studied. It also reinforces the need to measure risk awareness and perception as two different variables to understand their role in the adoption of preparedness measures better.

The common factor: trust in authorities

Despite these city differences, trust in authorities is a common factor influencing community preparedness. This finding is consistent with PADM, which points out that the perception of social actors is critical in understanding the process of adopting preparedness measures. Also, these findings relate to previous studies that conclude that greater trust in the authorities is related to a higher level of preparedness (Terwel et al. 2009; Wei, Sim, and Han 2019).

The significant relationship between trust in authorities and community preparedness highlights an essential challenge for institutions in charge of implementing disaster preparedness strategies since trust can significantly impact people's motivation to adhere to measures proposed by the authorities.

This becomes particularly relevant in the current crisis of trust in institutions in charge of responding to different threats (Bronfman et al. 2022). If people report low trust in authorities, inadequate behaviors in earthquake and tsunami response processes may increase and decrease participation in activities such as drills essential to improving response (Basolo et al. 2009; Kim and Oh 2015). Consequently, our results show the importance of protecting the integrity and strengthening the capacities of authorities and institutions to respond effectively to disasters.

Finally, it should be noted that implementing strategies to promote community participation in preparedness actions may improve trust in authorities. When people perceive that they are included and can participate, they perceive that the responsibility for mitigation measures is not individual but part of a shared action with authorities that care for them.

Sociodemographic characteristics and community preparedness

We found differences between Valparaíso and Concepción regarding the sociodemographic variables of community preparedness. For Valparaíso, age and years of life in the city had the most significant explanatory power for community preparedness. For the Concepción sample, educational level, and family incomewere significantly related to community preparedness.

For Valparaíso, people over 60 declared the lowest levels of knowledge regarding the city's evacuation plans. This result has been reported in previous studies, indicating that older adults have more significant difficulties participating in activities that allow them to access information regarding the measures established by the authorities (Howard, Blakemore, and Bevis 2017; Castañeda et al. 2020). Regarding years living in the city, our results are consistent with the literature; living longer in the same place increases exposure to disasters and knowledge of preparedness strategies (Castañeda et al. 2020). Likewise, years of living in the city allow one

to develop more support networks and participate in community preparedness activities (De Dominicis et al. 2015).

In Concepción, we found that participants from higher education backgrounds reported more significant preparedness measures since they may have the resources and abilities to understand better information about preparedness (Hoffmann and Muttarak 2017). Consequently, preparedness strategies should incorporate information that groups from different educational backgrounds can understand. Concerning family income, we found that people with the lowest and highest incomes appear less prepared. This trend contradicts previous research that indicates higher-income groups report higher preparedness levels (Ao et al. 2021; Maryani, Erliyandi, and Murtianto 2022). These differences can be explained by the preparedness actions measured in these studies, which require monetary expenses, such as mitigation strategies at home. In contrast, community preparedness does not directly require economic resources but participation in collective activities. This finding suggests that social capital also plays a role in these actions and emphasizes the role of connections within communities when a disaster strikes. Also, it is likely that people with higher income attribute preparedness measures to their responsibility so that they may dismiss the actions proposed by the authorities (Wehde and Nowlin 2021).

Understanding the importance of socio-demographic factors is crucial to realizing that community preparedness is not solely an individual's responsibility. Rather, institutions must integrate each person into risk management. Additionally, it enables targeted strategies to be implemented in groups with more significant difficulties in engaging in community preparedness measures.

Conclusion

Our results indicate differences in the factors and levels of community preparedness between the coastal cities of Chile. These suggest strategies to increase knowledge about city plans, which should target different groups based on their experience with disasters, knowledge about earthquakes and tsunamis, and sociodemographic factors. This is very relevant regarding older adults and lower-income groups because it may amplify or reduce communities' vulnerability to earthquakes and tsunamis.

Conversely, our results indicate that risk awareness can be relevant for community preparedness among groups with recent experience with earthquakes and tsunamis with low impact. In contrast, risk perception can be relevant for groups that suffered more damage in the last event. These differences also suggest the importance of adopting different strategies to facilitate decision-making in adopting preparedness measures. While for some cities, it is essential to provide information about the threat around them, for others, it is important to remember the effectiveness of knowing the evacuation plans of the cities.

Additionally, the study shows the importance of trust in the authorities when implementing collective preparedness strategies. The importance of trust indicates that the integrity and performance of authorities are essential for people to engage in preparedness actions. Generating stakeholder ties is crucial for drills, evacuation plans, and other actions.

In this study, the difference between cities indicates how context and experience can moderate the relationship between hazard perception and preparedness. In this study, measuring the experience through the damages suffered in the last event was only possible. However, in future studies, it is necessary to differentiate how the years since the last event or the number of drills carried out in the city are related to community preparedness.

Finally, we measure community preparedness as the knowledge of the city's evacuation plan. However, future studies should explore incorporating other dimensions of community preparedness measures, such as participation in workshops or organizations dedicated to disaster risk reduction and their relationship with threat perception, trust, and damage experience.

Disclosure statement

The authors do not have competing interests to declare.

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