Landslide disaster risk perception in times of COVID-19: A student's perspective

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ABSTRACT

This study aimed to understand landslide risk perception among 15 to 20-year-old students in Teziutlán, Puebla, from 2018 to 2022 during the COVID-19 pandemic, a period in which communicating risks and providing information to the public were of utmost significance. The research involved a quantitative approach, using structured questionnaires to measure the level of risk perception within a specific population of young people residing in mountainous regions prone to landslides. A representative sample of 77 students from Antonio de Mendoza High School was interviewed using intentional sampling based on location and age. The study followed a comprehensive, multi-phase approach, which included developing indicators, obtaining informed consent, administering the questionnaire, ensuring voluntary participation, and data analysis. Young individuals interviewed showed a higher level of knowledge about the occurrence of landslides than what previous studies had reported. However, the global crisis resulting from the COVID-19 pandemic overshadowed the dissemination of information about landslides and other hazards.

KEYWORDS

landslides; disaster risk; risk perception; COVID-19; landslide disaster risk reduction

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1. Introduction

1.1 The COVID-19 pandemic and its impact on disaster risk perception

The COVID-19 pandemic, which dominated global attention from 2020 to 2022, exposed societal vulnerabilities across multiple sectors, including health, economy, education, and governance. Beyond its immediate health impacts, the pandemic disrupted daily life and altered how individuals and communities perceived various risks, including those unrelated to the virus. This unprecedented crisis highlighted the interconnectedness of global disasters and revealed the cascading impacts across societal systems (Maskrey et al. 2023).

While the pandemic brought attention to global health vulnerabilities, it inadvertently overshadowed the ongoing risks of other hazards. Previous studies showed that during crises, financial and immediate survival concerns often overshadow the perception of other risks, including environmental hazards (Kirsch-Wood et al. 2022). This shift in risk priorities during the pandemic led to a diminished focus on preparedness for other types of hazards, such as landslides, which remain a critical issue in regions like Teziutlán, in the state of Puebla.

1.2 The Mexican experience with COVID-19

In Mexico, the COVID-19 pandemic had a devastating impact, with millions of confirmed cases and hundreds of thousands of deaths. As of March 10, 2023, the pandemic has had a devastating effect on Mexico, with official data reporting over 7,483,444 infections and 333,188 deaths (Johns Hopkins University 2023). However, additional sources claimed a more significant impact. Wang et al. (2022) estimated 798,000 excess deaths in Mexico by December 2021, while 600,590 deaths in excess were estimated by Palacio-Mejía et al. (2022). Both estimates placed it among the seven countries with the highest excess mortality in the world.

The country's healthcare and economic systems struggled under the weight of the crisis, revealing pre-existing inequalities and structural issues (Arellano Morales 2022). The education sector was particularly affected, with many students, especially those from disadvantaged backgrounds, forced to abandon their studies due to a lack of resources and infrastructure for remote learning (OECD 2022; INEGI 2021).

These disruptions to education and daily life had significant consequences for young people, who faced economic and social instability. Still, they were also exposed to new forms of vulnerability, including mental health challenges (Glowacz and Schmits 2020). For communities already at risk of natural hazards, such as landslides, this period further complicated efforts to maintain awareness and preparedness for these threats.

1.3 Landslide risk perception during the COVID-19 pandemic

Despite the global focus on the pandemic, natural hazards posed significant community risks. Landslides, which frequently affect Teziutlán, Puebla, are a persistent threat, particularly during intense rainfall. However, during the COVID-19 pandemic, attention to such hazards diminished as the global health crisis consumed public discourse and governmental resources.

Between 2018 and 2022, Teziutlán experienced several significant landslide events, with notable incidents in 2018, 2020, and 2021 (El Sol de Puebla 2018, 2020; Zepeda 2021). These events caused infrastructure damage and disrupted local communities, including schools and public facilities, which often serve as emergency shelters (Hassan et al. 2020). However, the pandemic made it more challenging to address these events effectively, as disaster response systems were stretched thin, and public attention was diverted.

Understanding how young people perceive landslide risks during such complex crises is essential for designing effective disaster risk reduction strategies. The educational disruptions caused by the pandemic and the overshadowing of local hazards by the global health emergency may have altered students' awareness and preparedness for landslides.

This study explores how young students aged 15 to 20 in Teziutlán, Puebla, perceived the risk of landslides between 2018 and 2022, a period heavily influenced by the COVID-19 pandemic. The goal is to highlight the importance of maintaining disaster risk communication on various hazards, even during global crises, and to identify potential gaps in students' understanding of local environmental risks. This research seeks to contribute to more resilient disaster preparedness frameworks that address health-related and environmental vulnerabilities by analyzing the intersection of pandemic-related disruptions and landslide risk perception.

2. Landslide risk perception

2.1 Risk perception: a brief introduction

Although the Sendai Framework for Disaster Risk Reduction (UNISDR 2015) does not include the concept of risk perception, the Global Assessment Report 2022 (Kirsch-Wood et al. 2022) states that it is essential to evaluate and study it in different social contexts and with different age groups because, in risk situations, risk perception can become a cognitive bias that influences decision-making in the face of disasters.

Risk perception involves various cognitive factors, such as information selection, organization, and

interpretation. It is a measurable concept that can be evaluated psychometrically. Risk perception also involves heuristics and cognitive biases that affect how we think about and understand risk, especially in uncertain situations (Slovic 2016).

As a multifaceted process, risk perception considers individual and collective factors. These aspects work together to understand the danger and give it meaning. According to this approach, risk perception encompasses nine dimensions: whether the risk is voluntary or involuntary, how immediate its effects are, the level of personal and scientific knowledge about the risk, the risk potential, the type of risk (including the level of fear it generates), the perceived severity or potential for disaster, the level of exposure to the risk, and how new or unfamiliar the risk is (Fischhoff et al. 1978).

Risk perception is rooted in the influence of cultural norms, values, and practices on how different social groups perceive risk. Risk perception is shaped by the beliefs and practices established and exemplified by diverse cultural groups during specific historical periods (Douglas and Wildavsky 1983).

How people perceive risks can be influenced by various factors, including the type of information or experiences and the social and cultural context in which they live. Those with firsthand disaster experience tend to have a more nuanced understanding of potential risks. In contrast, those with less experience may rely on sources like the media, social networks, or intuition to form their opinions and judgments (Wachinger et al. 2010).

Studying risk perception can provide insights into how various cultures and groups of people perceive risk and help develop better strategies for managing risk in different situations. Research on disasters has incorporated the concept of risk perception to highlight the gaps in disaster risk management and the limited understanding of these risks among the general public and government officials. This lack of knowledge often leads to inadequate mitigation and prevention measures.

2.2 Landslide risk perception

Mountain regions are vital for sustainable development and climate stability, offering essential resources, biodiversity, and cultural richness. However, they are often exposed to landslide risks, severely affecting local populations (Adler et al. 2022). Reducing landslide risk requires strategies based on the community's perception of these risks (Alcántara-Ayala and Moreno 2016).

Landslide disaster risk awareness, preparedness, and knowledge

Numerous studies have highlighted various factors that influence landslide risk perception. For example, in Bangladesh, Alam (2020) found that communities in landslide-prone areas are often unaware of the risks, which leads to inadequate preparedness and resistance to relocation. Development levels, property ownership, ethnicity, gender, and economic status shape these behaviors. The study underscores the importance of considering livelihood and social dynamics when planning relocation strategies.

In La Paz, Bolivia, residents, local leaders, and planners often underestimate or deny the risk of landslides, complicating efforts to implement prevention strategies. Nathan (2008) pointed out that risk perceptions are multifaceted and cannot be addressed through a singular approach, illustrating the complexity of community attitudes toward landslide threats.

Chinese farmers, for example, are vulnerable to landslides due to limited disaster preparedness and a lack of access to information. Gao et al. (2020) emphasized that these farmers need training in terrace restoration and conservation, which is essential for building long-term resilience and fostering trust in local authorities. Similar dynamics are found in other rural areas worldwide, where access to education and resources is critical in shaping risk perception.

Education also plays a critical role in landslide risk perception. In Pakistan's Murree area, Qasim et al. (2018) found that residents' awareness of landslide risks is closely tied to their social and economic conditions and past experiences. The study identified education as a key factor influencing household preparedness and attitudes toward risk.

In contrast, residents in Frosinone, Italy, despite being aware of landslide risks, do not view them as a significant threat. Gravina et al. (2017) highlighted a critical gap in preparedness, driven by a lack of knowledge about prevention and protection measures, reflecting a common issue where perceived risks do not translate into actionable preparedness.

In Malaysia, public concern is higher for technological hazards than natural disasters, though floods and landslides are frequent concerns. Sim et al. (2023) observed that socioeconomic factors like gender, education, and occupation influence risk perception, particularly regarding landslides. While floods are considered more widespread, landslides tend to be perceived as localized, affecting how people assess their risk.

Landslide disaster risk communication

Effective communication is essential to ensure public safety from landslide risks (Alcántara-Ayala and Moreno 2016). Examining landslide risk perception can help develop strategies to convey information about hazards and risks to the public clearly and comprehensively. Clear and accurate communication can motivate people to take preventive measures. People's perception of risk directly influences their behavior. Gaining insights into how individuals are likely to respond to warnings, evacuation orders, or other risk mitigation measures can help tailor educational

programs and outreach efforts, ultimately minimizing the impact of potential landslides.

Also, in Italy, Calvello et al. (2016) stated that Sarno residents are not aware of the risks of landslides despite recently experiencing a landslide disaster. Better communication strategies are needed to improve their knowledge of measures to minimize regional landslide risk.

Yik et al. (2023) conducted a study to understand the public's knowledge of landslides and their perception of the Landslip Early Warning System (LEWS). They also explored the usefulness of the multi-tiered LEWS concept. Accordingly, only 37% of the participants linked landslides to global warming. Most believed slope safety improved (88%), and landslides were rare (91%). 90% knew about LEWS, but only 28% were concerned as it did not affect them. The idea of a multi-tiered LEWS was well-received, but the study suggested that more research is needed to ensure public awareness about landslides improves.

Understanding how communities perceive the risks of landslides is crucial in making informed decisions on urban planning and land use management. Proper planning can minimize the impact of landslides. Early warning systems aligned with people' s perceptions can aid in timely responses. The study of landslide risk perception can help develop strategies to enhance community resilience. Insights from these studies can shape land use, building standards, and emergency management policies to reduce vulnerability and exposure to landslide events.

Landslide disaster risk governance

A study by Finlay and Fell (1997) found that people in Australia and Hong Kong underestimate the impact of landslides. They support regulating development on landslide-vulnerable land and believe that experts and the government should set acceptable standards for landslide risk. Vulnerable groups are anxious about landslides, which are seen as uncontrollable and deadly.

Landslide-related disasters expose the inadequacy of disaster risk reduction policies in many countries. A recent study by Barreto de Mendonca and Gullo (2020) found that effective communication between government agencies and local residents in Brazil is crucial. Residents often assess the risk of landslides alongside other hazards and opportunities and tend to underestimate their ability to mitigate landslide risks.

Landslides in southeast Bangladesh have caused over 700 deaths since 2000, with informal settlements being the most affected. Despite government claims to implement risk reduction, the number of deaths is increasing due to political-economic factors such as land management, illegal deforestation, and unplanned development activities. A study was conducted by Alam and Islam (2023) to identify shortcomings in early warning systems and suggest ways to improve evacuation procedures, rescue operations, relief efforts, and risk reduction strategies. The findings culminated in recommendations for effectively implementing landslide risk reduction measures in the country.

3. Methodology

3.1 Methodological approach

This study employed a quantitative approach, using structured Likert-type questionnaires with dichotomous and open-ended questions to measure and assess landslide risk perception among young students. The focus on this demographic stemmed from their vulnerability to disaster events due to their developmental stage and potential lack of experience, as well as their critical role as future leaders and community members who can champion disaster risk reduction efforts. Several key factors guided the decision to survey students aged 15 to 21:

1. Youth as a Target Population: This age group is significant due to its high capacity for learning and adaptation, particularly regarding environmental and risk-related education. Furthermore, as students in this region have lived through multiple landslide events during their lifetime, they are likely to have formed perceptions of risk. Specific recall questions were designed to assess whether they had clear memories of significant regional landslide events. This ensured that their responses reflected either direct experience or knowledge gained through their community, school, or media.

2. Access and Representativeness: The Antonio de Mendoza High School was chosen because it is located in a landslide-prone area (Murillo-García and Alcántara-Ayala 2017), making its students an ideal population for this research. Although convenience sampling was employed due to the school's proximity to landslide-prone zones, selecting participants was intentional (Fig. 1). It aimed to ensure that the respondents had experiential exposure to landslides and ongoing educational engagement. This dual criterion maximizes the relevance of their risk perception in the study context.

3. Previous Knowledge and Recall of Events: Special attention was given to whether the respondents could recall past landslides. This was tested through specific questions to evaluate their direct or indirect exposure to landslide events. These questions assessed their ability to describe particular incidents or express knowledge acquired through various sources, ensuring that their responses were grounded in tangible experiences.

77 students were surveyed in June 2023, and the process was carried out in several phases. First, indicators were prepared based on previously validated landslide risk factors, as outlined in comparable studies (Hernández-Moreno and Alcántara-Ayala 2017).

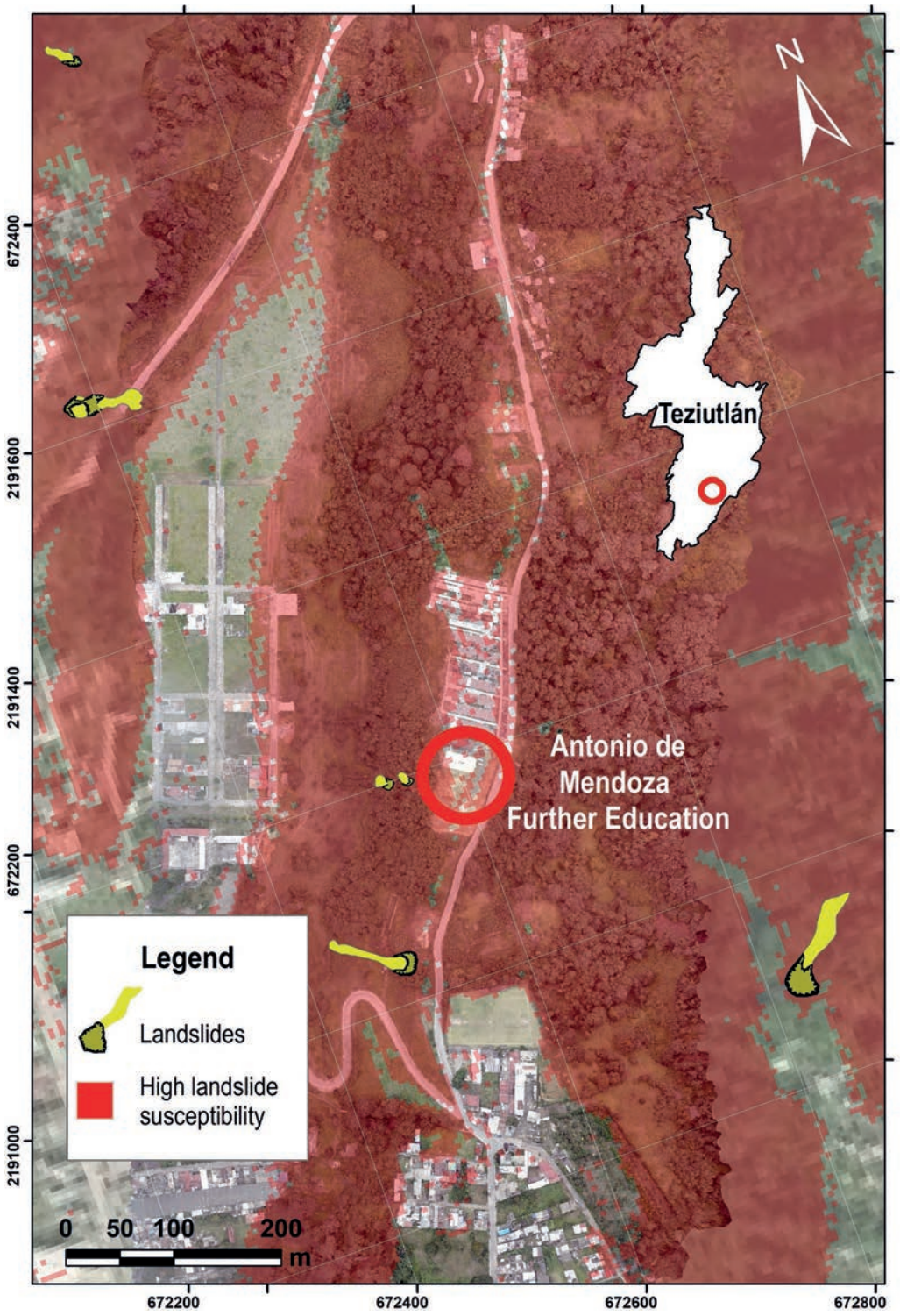

Fig 1. Landslide context in which Antonio de Mendoza High School is located.

Second, the study's objectives were communicated to the students, and informed consent was obtained from all participants to ensure ethical research standards were met. Third, the questionnaires were administered in person at Antonio de Mendoza High School, providing an opportunity for direct engagement with the students (Fig. 2) (Table 1). Fourth, participation was voluntary, and no incentives were offered, ensuring the responses remained unbiased. Finally, the collected data was analyzed using SPSS 21 statistical software. This allowed for both descriptive statistics and analyses, such as cross-tabulation, which helped evaluate patterns in risk perception across different age groups and levels of prior experience.

The decision to use SPSS 21 enabled a data analysis, offering significant insights into the relationships between variables such as age, prior knowledge, and

Fig. 2 Application of the questionnaire at the Antonio de Mendoza High School, Teziutlán, Puebla, México.

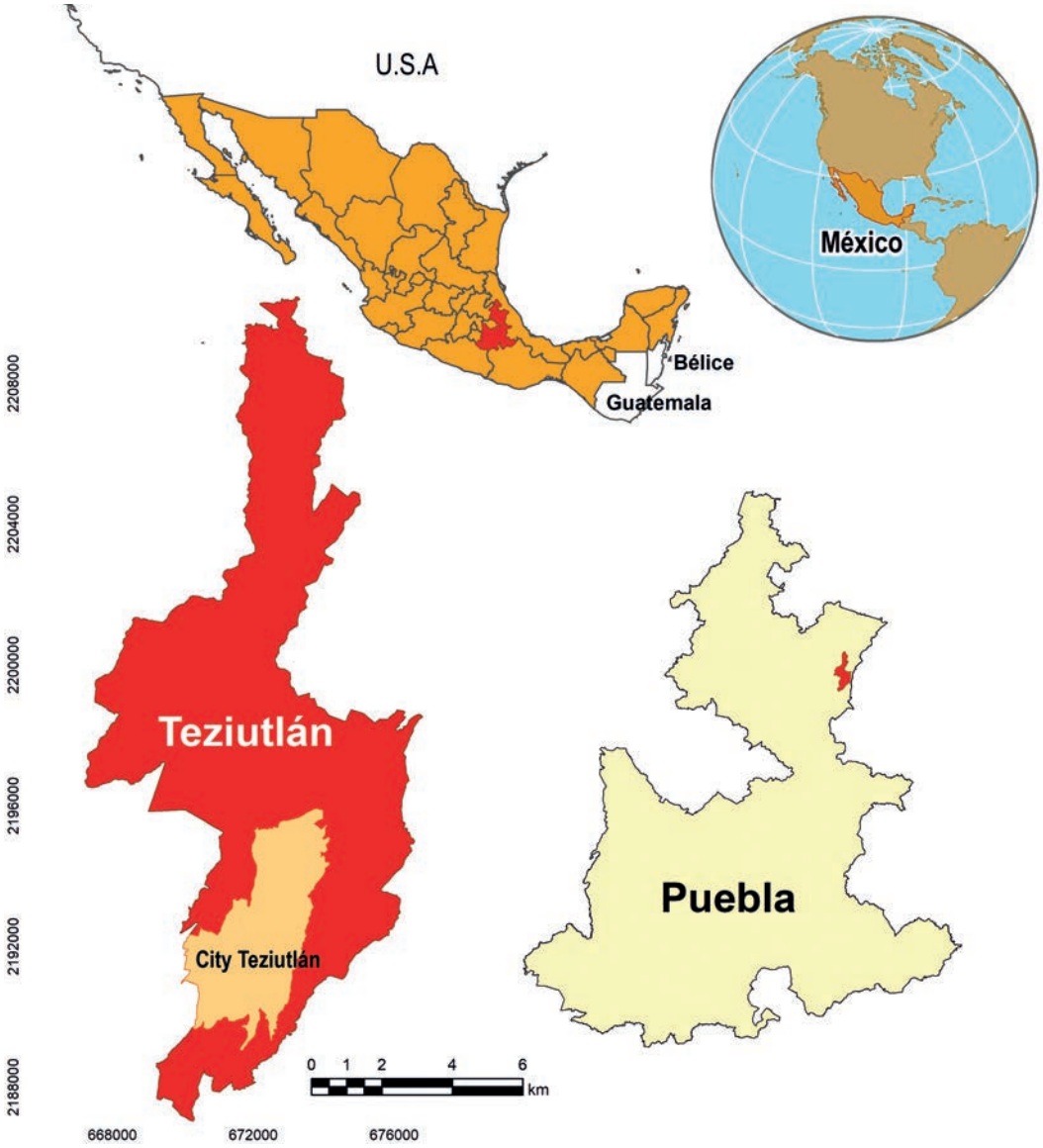

Fig. 3 Location of the study site.

Tab. 1 Description of the parameters included in the surveys.

Sociodemographic data	Age	Open answer
	Occupation (employee or student only)	
	School grade	
	The neighborhood where the interviewee lives	
Knowledge and risk identification	Knowledge about the occurrence of different hazards	Dichotomous scale
	Knowledge about the most frequently occurring hazards	Multiple choice
	Knowledge about the occurrence of a landslide	Dichotomous scale
	Situations that could trigger a landslide	Multiple choice
	Colony that is considered to be of highest risk	Open answer
Disaster Response Preparedness	Information about disaster response preparedness measures before the pandemic	Likert scale
	Information about disaster response preparedness measures during the pandemic	Likert scale
Experience with landslides	Personal experiences with landslides before or during the pandemic	Dichotomous scale and open answer
	Indirect experiences with landslides before or during the pandemic	Dichotomous scale and open answer
COVID-19 experience	Direct or indirect experience with COVID-19 infection	Dichotomous scale and open answer
	Perception of access to medical services	Likert scale
	Perception of the level of contagion by COVID-19 in the area where you live	Likert scale
	Action measures taken during the pandemic	Likert scale
Information and media	Perception of the quality of information received from the authorities through the media about COVID-19	Likert scale
	Perception of the quality of the information received from the authorities through the media about hazards that occurred before and during the pandemic	Likert scale
Landslide Preparedness in Time of COVID-19	Perception of the degree of risk that homes have in the face of landslides	Likert scale
	Perception of the degree of risk that students and others have in the face of landslides	Likert scale
	The frequency with which landslide preparedness actions were undertaken during the pandemic	Likert scale
	Preparedness actions in case landslides occurred during the pandemic	Likert scale
	The frequency with which preparedness actions against COVID-19 were undertaken during the pandemic	Likert scale
Communication of the population with stakeholders	Identifies the authorities responsible for risk management	Dichotomous scale
	Receive information on what to do in case of landslides from the authorities	Dichotomous scale
	Perception of the degree of responsibility of the actions of authorities in case of risk due to landslides	Likert scale
	Perception of the degree of responsibility of the actions of authorities to prevent COVID-19 infections	Likert scale
	Perception of the degree of responsibility of authorities when they responded to a landslide before the pandemic	Likert scale
	Perception of the degree of responsibility of authorities when they responded to a landslide during the pandemic	Likert scale

exposure to educational interventions. Future stages of the study, with a larger sample, will incorporate additional statistical tests to assess whether these factors significantly influence landslide risk perception.

3.2 Study design and area selection

Teziutlán is a municipality in the northeastern Sierra of Puebla, with an altitude range of 1221 m to 2660 m (Fig. 3). The region's climate is warm and temperate, with an average temperature of 15.5°C and precipitation of around 1658 mm (INEGI 2010). The area is part of the Trans-Mexican Volcanic Belt, an east-west-oriented volcanic arc produced by the subduction of the Cocos tectonic plate beneath the North American tectonic plate.

The geology of Teziutlán is directly linked to Los Humeros, a central Mexican caldera volcano and one of the Pleistocene silica centres. The Xaltipan ignimbrite was formed due to the final activity of the first active phase and the Los Humeros caldera subsidence. Most of the ignimbrite deposits found in the study area are non-welded and composed of aphyric high-silica rhyolite material, which can be explicitly identified as ash-pumice flow deposits (Alaniz-Álvarez et al. 1998; Alva-Valdivia et al. 2000; Dávila-Harris

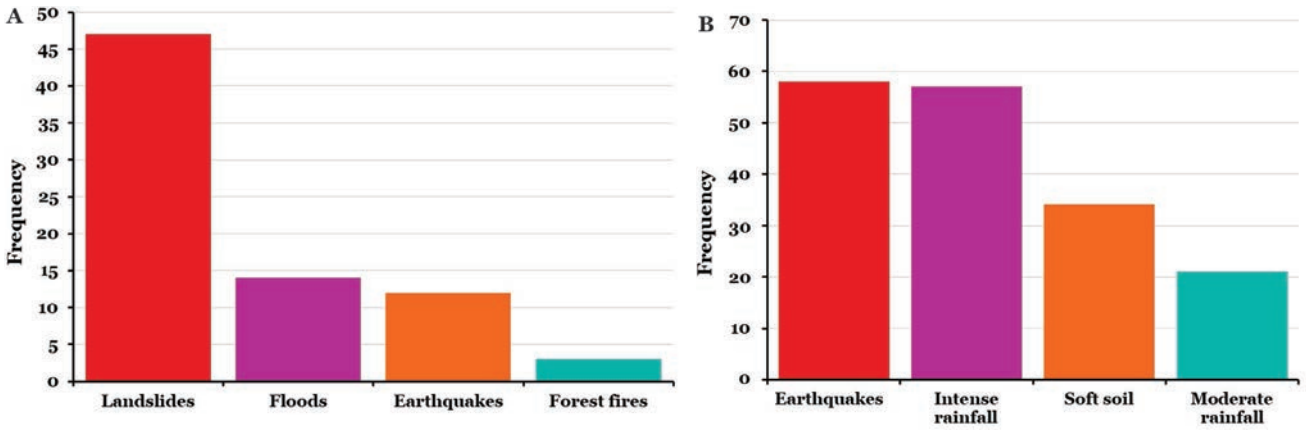

Fig. 4 Knowledge and risk identification: Hazard occurrence (A) and landslide triggering mechanisms knowledge (B).

and Carrasco-Núñez 2014). Residual shallow soils associated with the Xaltipan ignimbrite are formed on steep slopes by decomposing poorly consolidated rock materials with high clay content and high-water retention capacity, leading to mass movement processes (Flores and Alcántara-Ayala 2002).

The municipality is home to a population of 103,583 inhabitants. Of this population, 48,649 are men (47%) and 54,934 are women (53%). It encompasses 34 localities, with five being urban areas. The population can be categorized by age range as follows: 16.8% of the population is between the ages of 0 and 9, 18.2% belong to the age group of 10 to 19 years old, 24.2% are between 20 to 34 years old, 19.5% are aged 35 to 49, and 20.1% of the population is 50 years old or older. As for education, in 2020, 23% of the population had completed primary education, 25.8% had completed secondary education, and 23.2% had finished high school or higher education (INEGI 2020).

The urban locality of Teziutlán presents levels of marginalization from very low to medium, depending on the type of community. As the municipality's social and economic conditions differ, vulnerability and landslide exposure vary (Alcántara-Ayala et al. 2018; González-Sánchez et al. 2017).

Landslides are frequent in Teziutlán due to heavy rainfall. Flows and complex movements are the most common types of landslides. Notable events from 1944, 1955 and 1999 stand out in particular due to their severity and the socio-economic impact they caused. Large landslides occur after one day of cumulative precipitation with over 300 mm of rain, while smaller ones happen during the rainy season (Murillo-García and Alcántara-Ayala 2017).

4. Results

4.1 Sociodemographic data

The samples consisted of 34 males and 43 females. Among the total, 58 (71.6%) were between 15 and 17 years old, while 17 (21%) were 18 to 20. Six interviewees did not provide an answer regarding their age. 31.2% (N = 24) of the students were in 1st grade at the time of the survey, while 29.9% (N = 23) were in 2nd grade and 39% (N = 30) were in 3rd grade. Apart from being students, 25 also reported having a job. According to the updated landslide susceptibility map created by Murillo-García and Alcántara-Ayala (2017), 42 interviewees resided in areas highly prone to landslides, while 28 individuals lived in unsusceptible areas. Seven students did not provide any response regarding their respective areas.

4.2 Knowledge and risk Identification

Out of the entire sample, 83.1% of the respondents stated that they were aware of the potential hazards in their municipality. 94.8% of the respondents knew what a landslide is, and 61% of the participants believed that landslides are the most common hazard in their area. In contrast, floods and earthquakes were considered more frequent hazards by only 18.2% and 15.6% of the respondents, respectively (Fig. 4A).

Likewise, 71.6% of those surveyed believe that earthquakes have the potential to set off landslides, while 70.3% identified heavy rainfall as another contributing factor. Only 25.9% of those surveyed believed moderate rainfall could lead to landslides. Furthermore, 42% of respondents reported that areas with soft or weak soil are more prone to landslides (Fig. 4B).

The participants' perceptions of neighborhood risk show some alignment with the actual hazard profile, though differences are evident. Of the 77 students surveyed, 20 (25.97%) identified La Aurora, the site of a significant 1999 landslide, as the most susceptible neighborhood, while 17 (22.08%) viewed Xoloco as the area most at risk. Eleven students (14.28%) considered La Cantera the most concerning despite its lower historical landslide incidence than La Aurora and Xoloco. In contrast, only four students (5.19%) mentioned Taxcala, and two (2.59%) identified the city center as high-risk zones, with minimal records

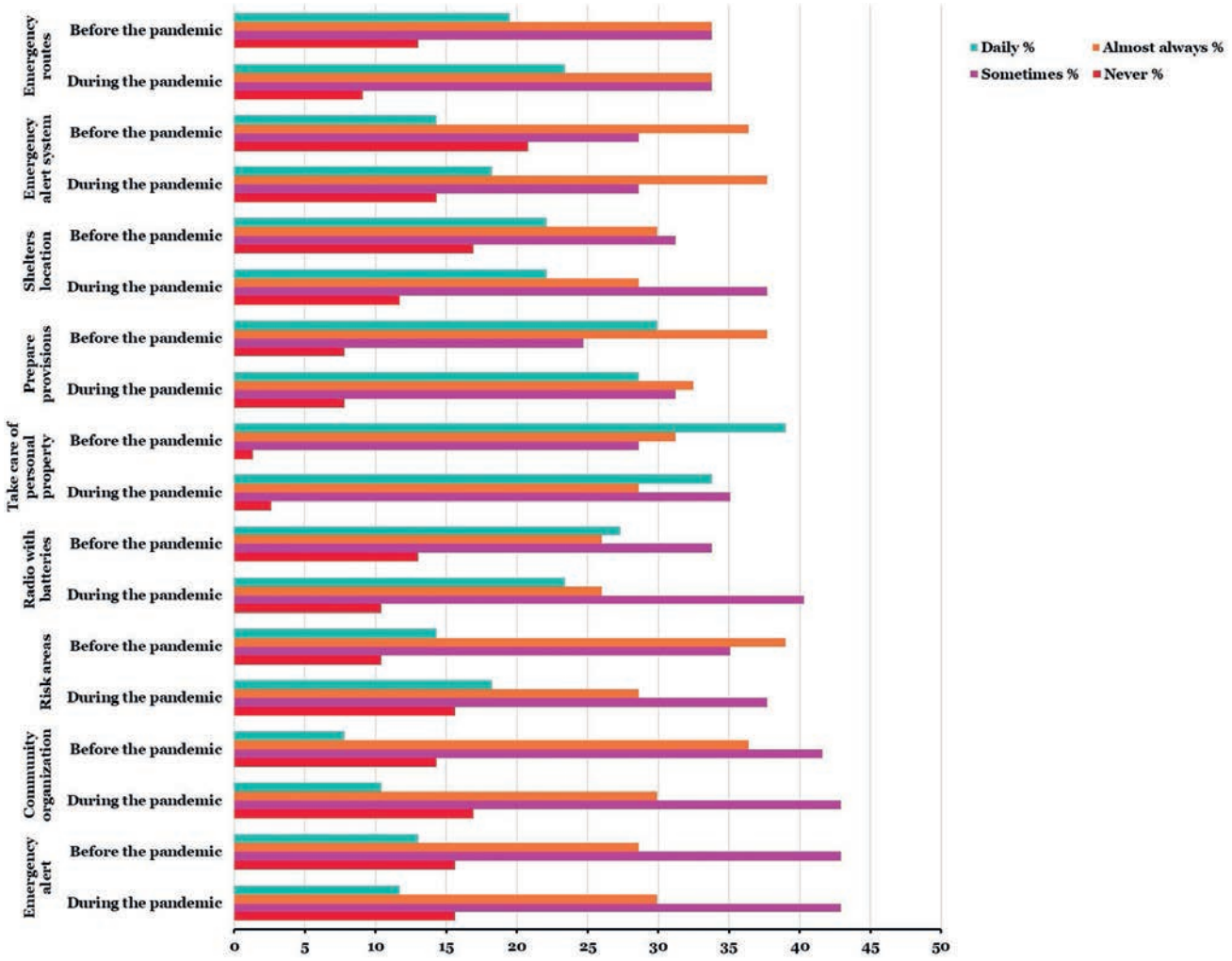

Fig. 5 Information regarding disaster response preparedness before and during the pandemic.

of landslide activity. This indicates that while student perceptions generally align with documented risk areas, some discrepancies likely stem from varying levels of awareness or differing interpretations of risk.

4.3 Disaster response preparedness

Access to information by inhabitants regarding reading or hearing recommendations to respond to disasters associated with any hazard was also heterogeneous. The highest scores, 39% and 34%, corresponded to the interviewees' information on how to take care of their personal property daily before and during the pandemic, respectively. Daily information concerning knowledge of emergency routes increased from 19.5% to 23.4% during the pandemic. Likewise, information about emergency alert systems also increased for the same period from 14.3% to 18.2%.

During the pandemic, the percentage of students who reported sometimes receiving information about the location of shelters increased from 31% to 38%. Perceptions on preparing provisions, the need for radios with batteries, how to organize the community, and emergency alerts remained unchanged. Daily information on areas at risk increased from 14% to 18% during the pandemic (Fig. 5).

The findings derived from a cross-tab analysis of responses concerning the frequency of exposure to emergency preparedness recommendations before the pandemic revealed significant gender disparities and varying levels of awareness among participants. In emergency routes, women reported higher frequencies of daily or almost daily engagement with this information, reflecting a proactive stance toward emergency preparedness. In contrast, a considerable proportion of men indicated that they access such information only occasionally, suggesting a less consistent awareness of emergency protocols. When examining alert systems, men demonstrated a greater tendency for daily engagement, indicative of their familiarity with these mechanisms; however, a notable percentage of women reported never encountering such recommendations, underscoring a potential gap in effective communication tailored to this demographic. Regarding safe places, men again reported more frequent daily engagement, while women exhibited

a more balanced distribution across the response categories, suggesting a nuanced understanding of safety protocols. The data on provisions preparation further accentuates these trends, with women displaying greater preparedness and awareness, particularly in the "daily" and "almost always" categories.

Likewise, the analysis of responses during the pandemic unveiled significant gender differences and varying levels of awareness among participants. Women exhibited higher daily engagement rates with emergency routes, constituting 66.7% of those accessing this information regularly, suggesting a proactive approach to preparedness. Similarly, women reported more significant engagement with alert systems, with 64.3% indicating daily exposure. At the same time, a notable percentage of women also reported never encountering such recommendations, indicating potential gaps in targeted communication strategies. Regarding safe places, men displayed a higher frequency of daily engagement (58.8%), yet many women indicated they had never received information, highlighting the need for improved outreach. The data on provisions preparation further underscores these trends, with 68.2% of women engaging daily compared to their male counterparts, reflecting heightened vigilance during the pandemic.

A comparison of responses regarding exposure to emergency preparedness recommendations before and during the pandemic showed significant shifts in engagement levels and gender dynamics. Overall, while women maintained higher levels of engagement before and during the pandemic, the crisis context amplified their proactive approach to preparedness, underscoring the need for targeted outreach and education to address communication gaps and enhance community preparedness.

4.4 Experience with landslides

Before the COVID-19 pandemic, 32.5% of participants reported having direct experience with landslides, while 22.1% indicated indirect experience. These figures decreased significantly during the pandemic, with only 6.5% reporting direct experience and 5.2% reporting indirect experience. This decline likely reflects reduced exposure and mobility due to pandemic-related restrictions, limiting interactions with landslide-prone areas.

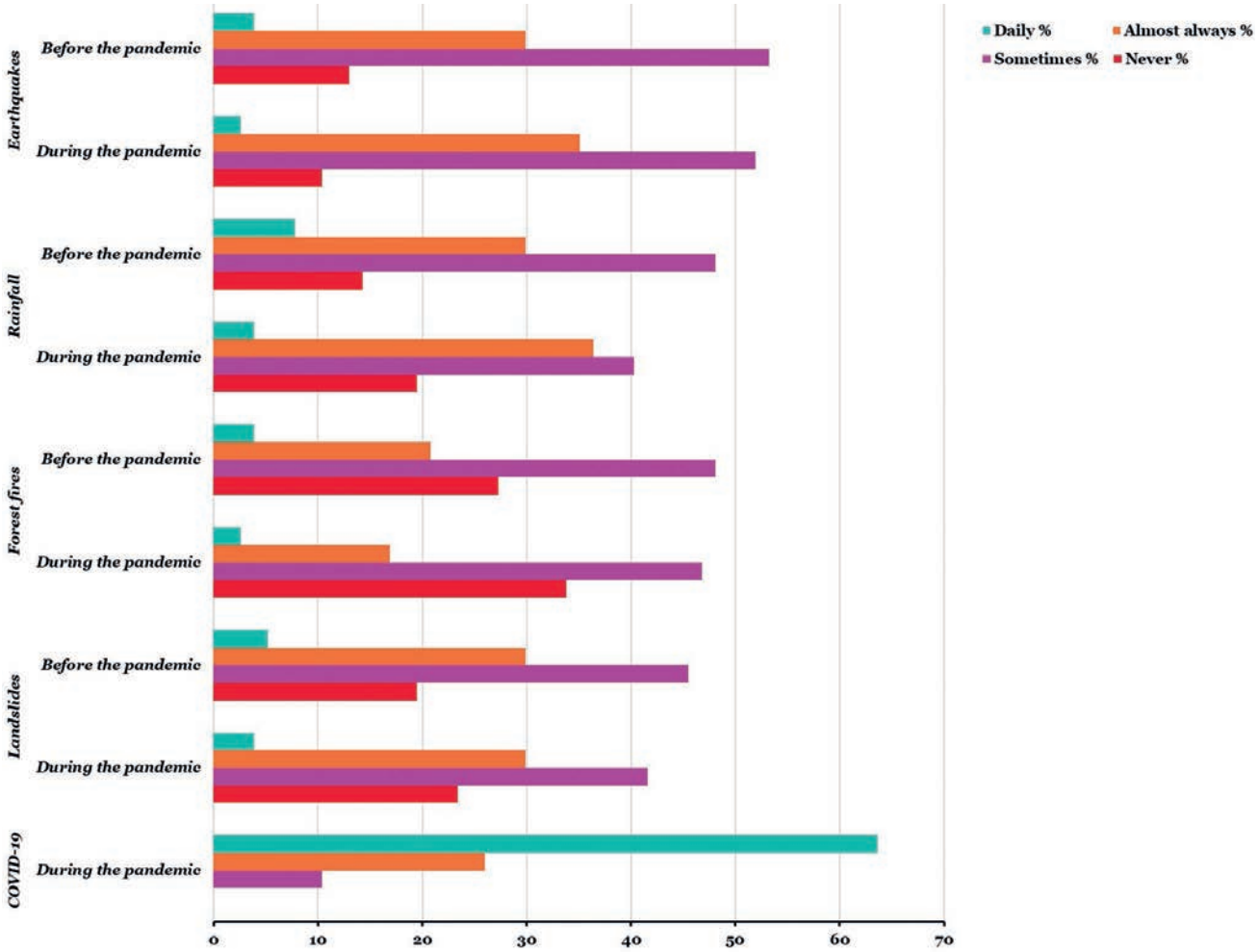

Fig. 6 Perception of the quality of information received from the authorities through the media about hazards that occurred before and during the pandemic.

4.5 COVID-19 experience

It was found that 76.6% of the students who participated knew someone who had contracted COVID-19. Out of the respondents, 61% reported that access to health services was sometimes available, while 35.1% indicated they had permanent access. Only 3.9% of the respondents reported that they had no access to health services at all. Likewise, 76.6% of respondents believed COVID-19 infections were low in their neighborhood. 66.2% reported visiting family sometimes during the pandemic, 31.2% visited friends, 28.6% visited their neighbors, and 32.5% organized parties or gatherings.

During the pandemic, 14.3% of students gave up studying due to various reasons such as job search (2.6%), lack of motivation (3.9%), lack of concentration (2.6%), inaccessibility to the internet (1.3%), inaccessibility to a computer or telephone (3.9%), and little space inside their homes to take online classes (1.3%).

4.6 Information and media

The survey also showed that 19.5% of respondents found the information provided by authorities on what to do in case of COVID-19 infection excellent, 50.6% found it good, and 28.6% regular. Similarly, 22.1% found information on where to go if infected was excellent, 48.1% found it good, 22.1% found it regular, and only 6.5% found it inadequate.

53.2% of respondents indicated that before the pandemic, they sometimes received information on earthquakes from the authorities, while 13% indicated they never received it. Regarding rainfall, 48.1% sometimes got the information, while 14.3% never received it. Similar numbers were reported for forest fires, with 48.1% and 27.3%. In terms of landslides, 45.5% of respondents indicated they sometimes received information, 27.3% never, and 20.8% reported almost always receiving information (Fig. 6).

Participants received inconsistent information involving preventive measures for different hazards during the pandemic. Concerning COVID-19, 63.6% of respondents received daily updates, 26% received them almost constantly, and 10.4% received them sometimes. In the case of earthquakes, only 2.6% received daily information, 35.1% almost always, 51.9% sometimes, and 10.4% never received any information. For rainfall, 3.9% received daily updates, 36.4% almost always, 40.3% sometimes, and 19.5% never received any information. Regarding forest fires, 2.6%, 16.9%, 46.8%, and 33.8% of participants reported receiving updates, respectively. Lastly, for landslides, 3.9% received daily information, 29.9% almost always, 41.6% sometimes, and 23.4% never received any information (Fig. 6).

The cross-tab analysis showed significant gender disparities in awareness and engagement with preventive measures before the pandemic. For earthquakes, while 29.9% of participants reported accessing information "almost always," a higher proportion of women (65.2%) engaged consistently compared to men (34.8%). This trend is further evidenced by the fact that women comprised 90% of those who reported never receiving information. In the context of rainfall, women exclusively reported daily access to preventive measures, indicating a notable gap in information access for men, who predominantly indicated "almost always" (47.8%) and "sometimes" (51.4%). Similar patterns emerged for fires, with women accounting for all daily information recipients and men reporting higher engagement in the "almost always" and "sometimes" categories. Regarding landslides, women again exhibited greater daily engagement (100%), while a significant proportion of men reported never receiving information (40%).

Moreover, the same analysis during the pandemic revealed significant gender differences in engagement with various safety protocols. For COVID-19, most respondents indicated daily access to information, with women constituting 63.3% of this group compared to 36.7% of men. While 55% of men reported receiving information "almost always," women's engagement in this category was lower at 45%. In the context of earthquakes, most participants indicated they received information "almost always," with 59.3% of women compared to 40.7% of men; however, daily access was minimal, with only women reporting such access. In terms of rainfall prevention, women exclusively reported daily access to information. Fire prevention responses were more balanced, yet a significant percentage of women reported never receiving information (65.4%). For landslide prevention, women represented 66.7% of those receiving daily information, further indicating their engagement in safety measures.

The comparison of responses on receiving information about preventive measures before and during the pandemic revealed changes in gender engagement and awareness. The findings showed that even though the pandemic increased awareness and access to important safety protocols, there are still disparities in how information is shared, especially among men in certain situations. This highlights the urgent need for communication strategies that are inclusive and ensure that everyone, regardless of gender, has equal access to information. This will help improve preparedness and response to different emergencies.

4.7 Landslide preparedness in time of COVID-19

The survey results revealed that respondents generally had good knowledge about the risk of homes being affected by landslides. According to the survey, 35% and 38% of respondents considered areas located in downtown Teziutlán to be very low and low risk, respectively. Houses built with sun-dried bricks or

Tab. 2 Perception of the degree of risk homes have of being affected by landslides.

Homes	Perceived risk of homes being affected by landslides			
	Very low risk (%)	Low risk (%)	Moderate risk (%)	High risk (%)
They are located in downtown Teziutlán	35.1 (N = 27)	37.7 (N = 29)	19.5 (N = 15)	7.8 (N = 6)
They are built with sun-dried bricks or sheet materials	9.1 (N = 7)	28.6 (N = 22)	48.1 (N = 37)	14.3 (N = 11)
They are near the river	10.4 (N = 8)	6.5 (N = 5)	32.5 (N = 25)	49.4 (N = 38)
They are built by the government	6.5 (N = 5)	39.0 (N = 30)	44.2 (N = 34)	10.4 (N = 8)
They are at the foot of the slope	5.2 (N = 4)	13.0 (N = 10)	28.6 (N = 22)	53.2 (N = 41)
They are located in areas where landslides have already occurred	10.4 (N = 8)	3.9 (N = 3)	23.4 (N = 18)	58.4 (N = 45)
They are relocated	6.5 (N = 5)	44.2 (N = 34)	39.0 (N = 30)	7.8 (N = 6)
They are next to roads	10.4 (N = 8)	42.9 (N = 33)	35.1 (N = 27)	10.4 (N = 8)
They are on the edge of slopes	6.5 (N = 5)	11.7 (N = 9)	32.5 (N = 25)	48.1 (N = 37)
They are reinforced with columns, walls	9.1 (N = 7)	41.6 (N = 32)	36.4 (N = 28)	10.4 (N = 8)
They are at the top of the slope	3.9 (N = 3)	7.8 (N = 6)	36.4 (N = 28)	49.4 (N = 38)
Trees surround them	7.8 (N = 6)	20.8 (N = 16)	45.5 (N = 35)	24.7 (N = 19)

sheet materials were perceived as a moderate risk by 48% of the interviewees. In comparison, those near the river were considered moderate and high risk by 32% and 49%, respectively, while those at the foot of the slope were perceived as moderate and high risk by 29% and 53% of the students. Additionally, 44% believed that the risk of government-built houses was moderate. Relocated houses were perceived as low and moderate risk by 44% and 39%, respectively, while those in areas that have already experienced landslides were considered moderate (23%) and high (58%). Housing on the edge and at the top of the slopes was conceived of as high risk by 48% and 49%, respectively. Interestingly, houses located next to roads were perceived as low risk by 43%, while those surrounded by trees were considered moderate (45%) and high risk (25%) (Table 2).

Based on the interviewees' responses, individuals residing in Puebla (57%) and Teziutlán (54%) are considered at moderate risk during a landslide. Similarly, residents of other neighborhoods (56%) are also perceived to face moderate risk. In contrast, participants rated the risk to themselves (27.3%) and their families (19.5%) as very low (Fig. 7).

During the pandemic, students infrequently engaged in landslide preparedness actions. Nevertheless, some reported occasionally noticing signs indicative of potential landslide risks, such as cracks in the ground (52%), leaning poles and trees (52%), and evidence of prior landslides (52%). They also paid attention to the accumulation of rainwater (48%), signs of humidity (37%), and improperly closing doors and windows (34%). More than 50% of respondents indicated that they had never observed the river rising (Fig. 8).

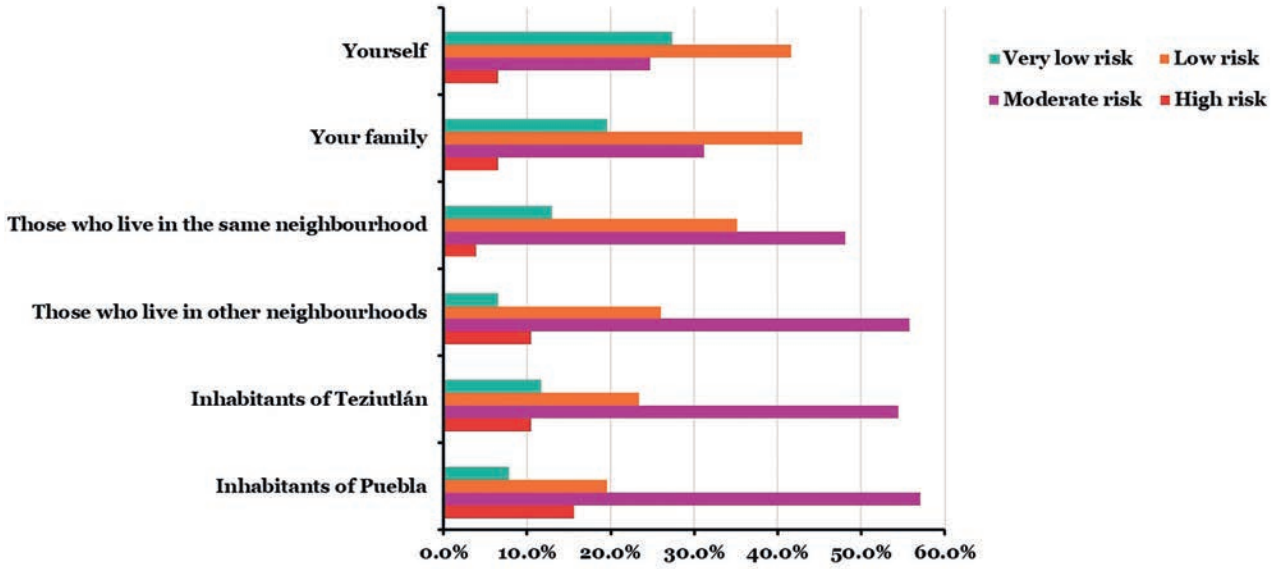

Fig. 7 Perception of the degree of risk students and others have in the face of landslides.

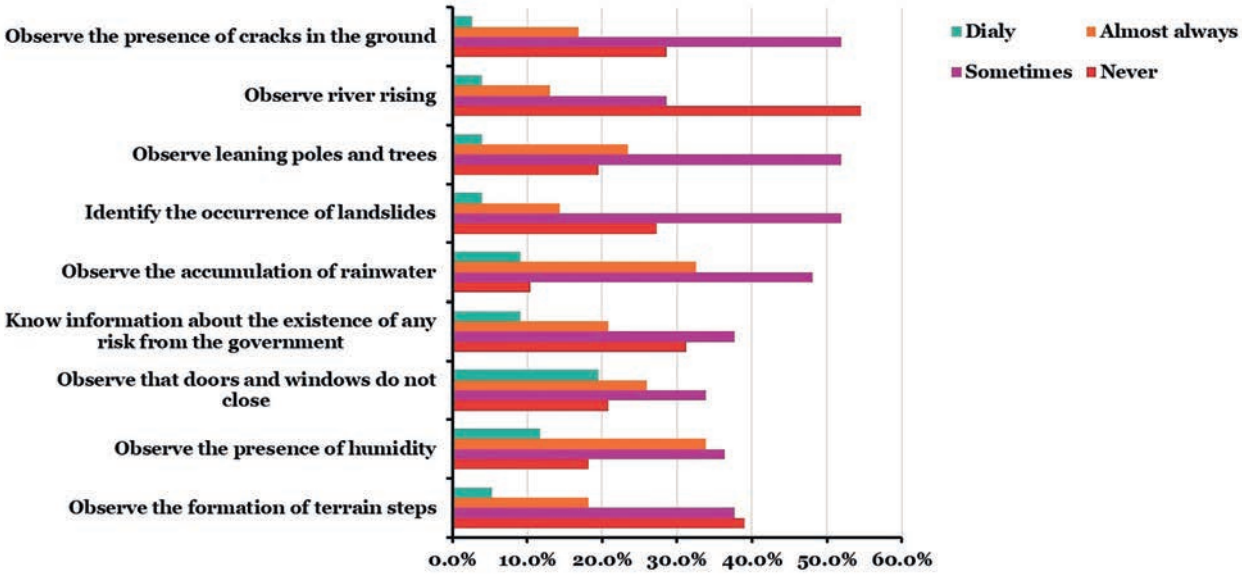

Fig. 8 Frequency with which landslide preparedness actions were undertaken during the pandemic.

Regarding preparedness actions for potential landslides during the pandemic, students agreed on several key areas: 61% reported knowing how to protect themselves. In comparison, 67% felt confident in their ability to ensure their safety. Additionally, 51% acknowledged the importance of preparedness prior to an emergency, 64% recognized the need to maintain their homes in good condition, and 44% were aware of the locations of safe places (Fig. 9).

The study unveiled that 71% of the interviewees reported washing their hands daily, while 64% consistently wore face masks in public settings. When authorities mandated stay-at-home orders, 44% of respondents adhered to this directive. Additionally, 56% indicated that they remained at home if they exhibited symptoms of COVID-19. Notably, 42% of those who experienced symptoms did not seek medical attention at a hospital (Fig. 10).

4.8 Communication of the population with stakeholders

It was found that 70.1% of those interviewed were familiar with the civil protection personnel of their municipality or neighborhood. Additionally, 49.4% of respondents had received information from civil protection authorities or the municipality on identifying symptoms before a landslide. Furthermore, 54.5% had received information from these authorities on what to do during a landslide.

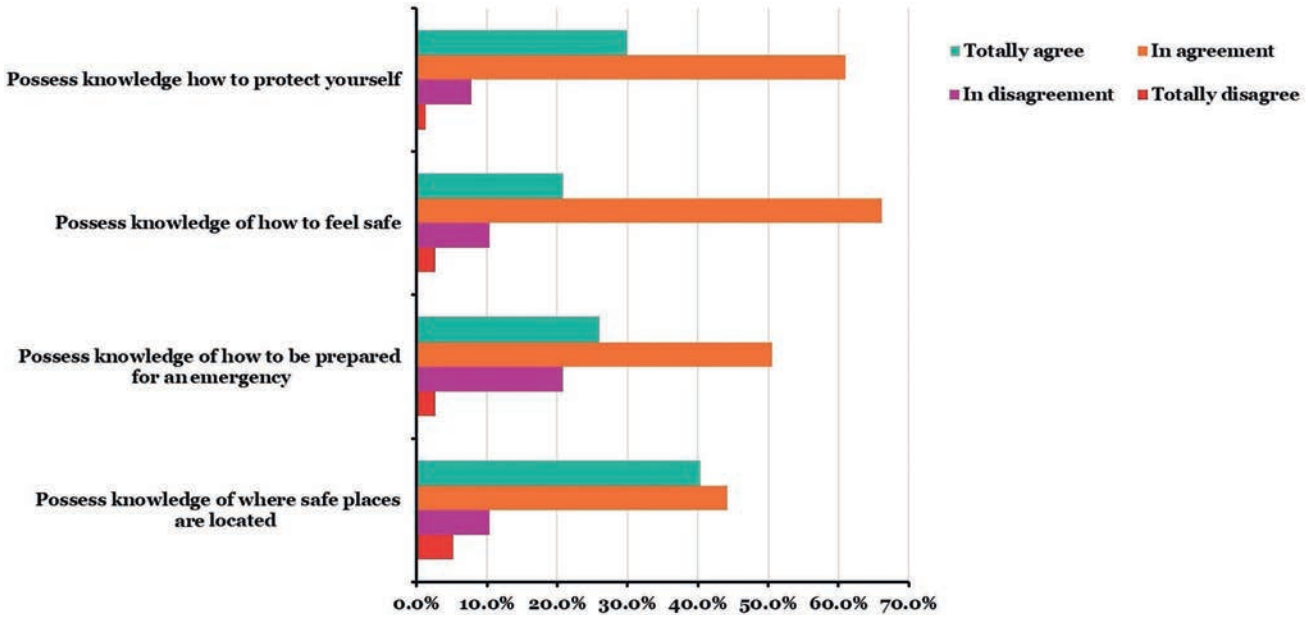

Fig. 9 Preparedness actions in case landslides occurred during the pandemic.

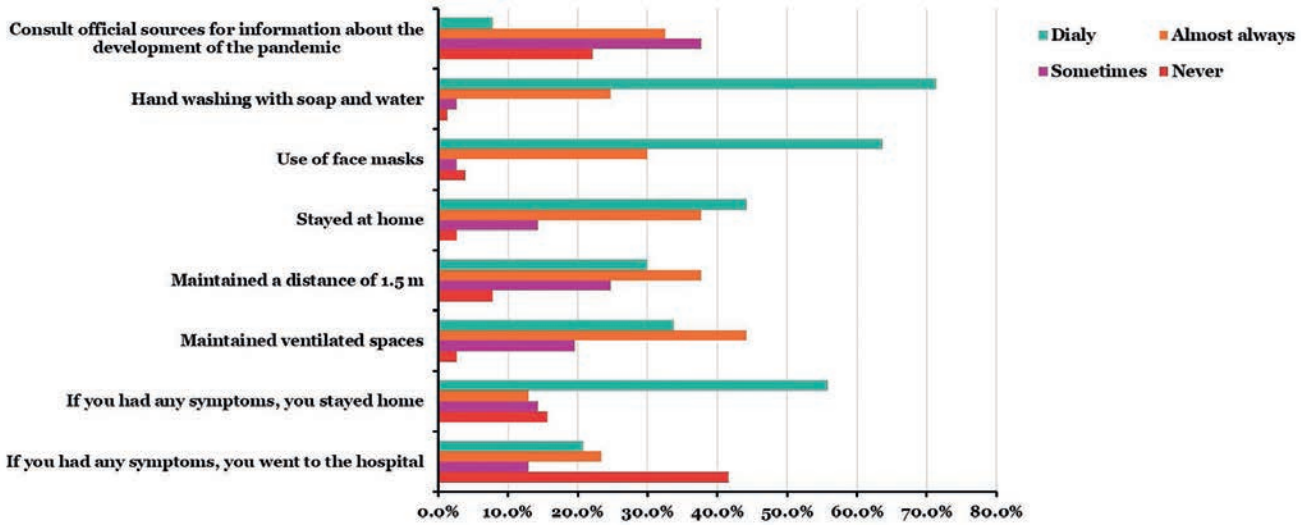

Fig. 10 Frequency with which preparedness actions against COVID-19 were undertaken.

When experiencing the appearance of cracks, floods, or rivers rising near the area in which they live, 58.4% of those surveyed go to the civil protection unit, while 24.7% contact the municipal government.

Perception of the degree of responsibility of diverse actors in the event of a landslide was also evaluated. Before the pandemic, civil protection and the Red Cross were considered very good by 23% and 21% of the respondents, respectively. During the pandemic, municipal government and health personnel were considered good by 52% and 48%, respectively. They were followed by civil protection, the Red Cross, the Mexican army (47%), scientists (42%), and the community (40%). Mexico Lions Club was the worst evaluated, as 30% and 34% of the interviewees considered their performance bad before and during the pandemic (Fig. 11).

Before the pandemic, the cross-tab analysis revealed notable gender differences in perceived responsibility among students regarding various management actors' responses during or after a landslide. Women generally viewed the response of the municipal government, civil protection, local police, health personnel, and the Red Cross more positively than men. For instance, women were more likely to rate the performance of the municipal government, civil protection, and local police as "very good." At the same time, men tended to assess these actors' responses as "acceptable" or "bad." The same trend is seen with health personnel and the Red Cross, where women overwhelmingly viewed their efforts as "very good," and men were more represented in the lower categories, particularly "acceptable."

Similarly, in the context of the pandemic, the same analysis showed a generally positive sentiment towards their responses. Notably, the Municipal Government and Civil Protection received high ratings, with most respondents indicating "very good" or "good" evaluations. The data suggests that women tended to rate these entities more favorably than men, highlighting a possible greater trust or reliance on these institutions during crises. Similarly, the Local Police, Health Personnel, and the Red Cross also garnered pżredominantly positive assessments. However, there were noteworthy discrepancies, particularly with Health Personnel receiving a significant portion of "very good" ratings predominantly from female respondents.

The analysis of perceptions concerning the responses of different management personnel during and after landslides indicated a consistent impact of gender in both pre-pandemic and pandemic scenarios. These findings suggest that positive sentiments towards management actors have remained stable across both periods. However, the pandemic has amplified recognition of their essential roles in crisis management, particularly among female respondents. This underscores the importance of considering gender dynamics in evaluating disaster response effectiveness and suggests implications for enhancing disaster management strategies to meet the needs of diverse populations better.

5. Discussion

Perceived risk significantly influences protective actions in response to disaster warnings. Effective warning systems rely on the quality and quantity of information provided, directly and indirectly influencing risk perception. Understanding disaster risk before a hazard event enhances community response to warnings, and demographic factors—such as age, gender, and ethnicity—can also affect perceptions (Mileti and O'Brien 1992).

In Teziutlán, previous research analyzed landslide risk perception through experience, awareness,

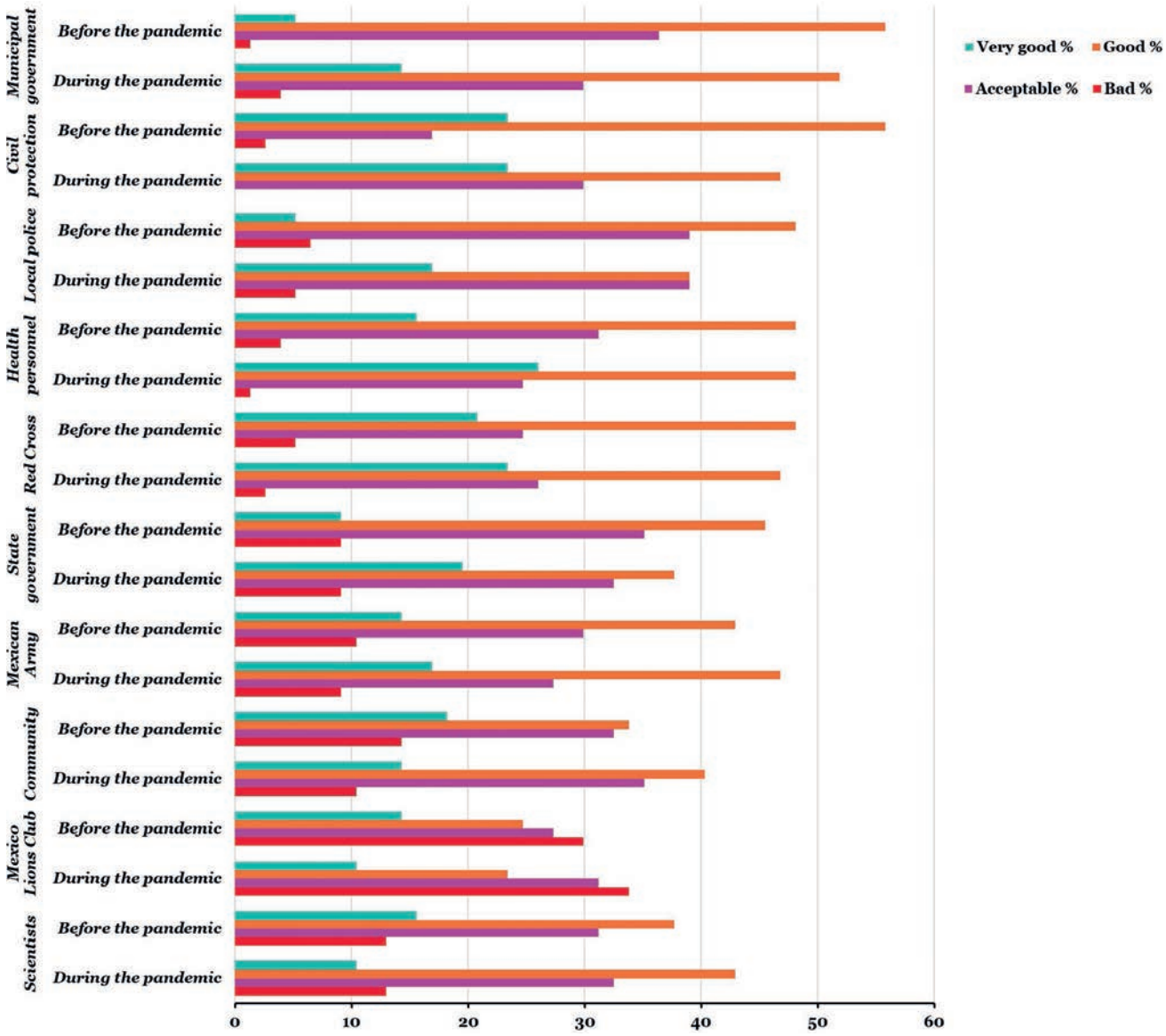

Fig. 11 Perception of the degree of responsibility of diverse actors in a landslide event.

exposure, preparedness, communication, and trust. Findings indicated that not all community members had direct experiences with landslides, and there was a notable lack of information on management strategies, revealing gaps in institutional coordination (Alcántara-Ayala and Moreno 2016).

Residents who experienced landslides exhibited heightened awareness of potential risks, often accepting higher levels of risk due to perceived benefits, such as better access to resources (Landeros-Mugica et al. 2016). Furthermore, while community members recognized landslide risks, they deemed homes in the city center as safer, emphasizing a need for initiatives focused on disaster risk reduction (Hernández-Moreno and Alcántara-Ayala 2017).

Soft soils are a critical precondition for landslides, significantly influencing their occurrence and severity. In the study area, the prevalence of soft soils creates conditions conducive to slope failure, particularly when combined with additional factors such as rainfall and seismic activity. Furthermore, anthropogenic activities, including deforestation, urban development, and land-use changes, can influence landslides. These human interventions often destabilize slopes, exacerbating the susceptibility to landslides. By recognizing the interplay between soft soil conditions and human activities, a more comprehensive understanding of landslide risk can be achieved, underscoring the need for targeted disaster risk reduction strategies.

During the COVID-19 pandemic, disasters continued, as evidenced by severe flooding in September 2021 (Castañeda-Ovando et al. 2022). Valverde and Valverde (2022) noted that COVID-19 outcomes in Puebla were linked to factors like marginalization and social resilience.

This research aimed to assess landslide risk perception among young people in Teziutlán before and during the COVID-19 pandemic, a demographic notably affected during the health crisis. Understanding how these experiences shape perceptions is essential for updating risk reduction strategies.

Young individuals today have greater access to information about potential hazards, yet community engagement in preparedness remains critical. Findings showed that Antonio de Mendoza High School students recognized landslides as common hazards. They received more information about COVID-19 prevention measures (63.6%) than other risks, underscoring the need for broader educational initiatives.

Awareness of emergency routes increased from 19.5% before the pandemic to 23.4% during it, alongside rising awareness of community disaster organization efforts and evacuation risk areas. Students perceived the authorities' responses positively, noting improvements in the perceived effectiveness of municipal and state governments and local organizations during the pandemic.

Examining landslide risk perception in the context of COVID-19 highlights the intersection of disaster management and public health. This research contributes to understanding how these domains inform one another, revealing the complex relationships between societal responses and environmental hazards.

Given the pandemic's effects on daily life, social interactions, and information access, people's attitudes towards natural hazards may experience notable changes. Risk perception studies can examine these shifts to reveal the interplay between psychological influences, societal responses, and environmental hazards, providing valuable insights into risk perception dynamics, disaster preparedness, and resilience strategies.

6. Concluding remarks

The COVID-19 pandemic underscored the urgent need for clear risk communication, yet its global scale overshadowed the communication of risks related to hazards like earthquakes, floods, and landslides. In Teziutlán, Puebla, as in many places, the pandemic diluted focus on disaster risk management, particularly concerning these hazards. This research highlights the importance of investigating how young people perceive such risks during the pandemic, as this insight is vital for developing disaster risk reduction strategies.

This study found that despite young people in Teziutlán showing greater awareness of landslide risks than reported in previous studies, information about these hazards was often minimized by the pandemic. The research highlights that disaster risk management remains overly reactive, focusing on emergency response rather than prospective risk mitigation and public awareness of preventive measures. Better communication and trust between authorities and the community is crucial, as this bond forms the foundation for effective disaster risk management strategies and emergency responses.

Effective risk communication is pivotal in shaping public perception and decision-making regarding landslides. However, young individuals often rely on intuition and cognitive shortcuts, leading to poor decision-making (Kirsch-Wood et al. 2022; Gravina et al. 2017). Addressing this through improved communication offers an opportunity to enhance disaster resilience at the community level.

The analysis found gender differences in engagement with emergency preparedness. Women show higher awareness and involvement than men, emphasizing the need for tailored communication strategies to improve overall community preparedness. By recognizing these gender-based engagement patterns, stakeholders can develop more effective outreach initiatives. Furthermore, the pandemic has raised awareness of emergency protocols, but there are still gaps in information, especially among men. Inclusive outreach programs are needed to ensure equal access to crucial emergency information for all genders, improving preparedness and response effectiveness in crisis situations.

This study has several limitations. The focus on young students in Teziutlán, Puebla, from 2018 to 2022 limits the generalizability of the findings, as the sample may not represent broader populations. The reliance on self-reported data introduces potential biases, including recall bias, which may affect the accuracy of participants' recollections. The broad focus on multiple hazards could also dilute specific insights into landslide risk.

Additionally, the research provides a snapshot of perceptions during the pandemic without tracking changes over time. These elements limit understanding of how perceptions evolve, particularly about preparedness actions. Future studies could expand the sample, focus more on specific hazards, and adopt a longitudinal approach for deeper insights.

While this research cannot be generalized, it offers valuable insights into youth perceptions of government responsibility in managing local hazards. This opens pathways for engaging young people in innovative disaster risk reduction strategies. Further interdisciplinary collaboration is essential to developing comprehensive risk management approaches that integrate scientific and local knowledge. Future research should focus on refining these strategies and addressing this study's limitations.

By aligning risk communication with public perceptions, policymakers can enhance the effectiveness of disaster risk management efforts and ensure more resilient communities.

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