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IRAN'S SEISMIC PUZZLE: BRIDGING GAPS IN EARTHQUAKE EMERGENCY PLANNING AND PUBLIC AWARENESS FOR RISK REDUCTION

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EXTENDED ABSTRACT

L'impatto devastante dei forti terremoti, caratterizzato da perdita significativa di vite umane, danni materiali e sconvolgimenti economici e sociali, assume una particolare rilevanza in Iran, un paese dove oltre il 90% del territorio è contraddistinto da una sismicità molto alta. Nonostante la frequenza di eventi sismici distruttivi nel corso della storia, il sistema di gestione delle catastrofi in Iran si è trovato di fronte a sfide significative, tra cui la carenza di risorse finanziarie e gli ostacoli tecnologici. Gli eventi sismici passati, come il terremoto di Manjil-Rudbar nel 1990 e il terremoto di Bam nel 2003, mettono in luce la necessità di un miglioramento nella pianificazione di protezione civile dell'Iran. Questo studio si pone l'obiettivo di esplorare lo stato attuale della pianificazione e della gestione delle emergenze nelle regioni sismiche dell'Iran, identificando lacune nella preparazione e proponendo possibili strategie per migliorare la prontezza e la resilienza. Attraverso un approccio multidisciplinare, che combina la revisione della letteratura, l'analisi dei dati sismici e un sondaggio nazionale tra la popolazione, questo lavoro ha lo scopo di offrire una visione olistica e dettagliata della situazione. L'analisi dei dati sismici, condotta utilizzando sistemi informativi geografici (GIS) e tecniche geostatistiche, permette di identificare tendenze e modelli temporali dal 1903, focalizzandosi sugli eventi di magnitudo superiore o uguale a 5.7 M_w nel periodo 2010-2023.

Il lavoro identifica e analizza dodici terremoti tra i più significativi degli ultimi dieci anni, ben distribuiti sul territorio iraniano. Tale analisi rivela disparità nel numero di vittime causate dai terremoti, dato influenzato da fattori come la densità di popolazione, la qualità delle infrastrutture e la prontezza nella risposta all'emergenza. Inoltre, un questionario online condotto su un campione casuale di 500 cittadini iraniani ha esaminato la consapevolezza pubblica, la preparazione e la percezione della pericolosità sismica nel paese. I risultati mettono in luce la percezione di una scarsa consapevolezza e preparazione pubblica, con solo l'11.5% dei partecipanti che si sente adeguatamente preparato per affrontare i terremoti. I risultati evidenziano le sfide e le lacune affrontate dal sistema iraniano di gestione delle catastrofi da terremoti, tra cui le limitazioni finanziarie, gli ostacoli tecnologici e la sfiducia pubblica. Tuttavia, emergono anche opportunità per migliorare la resilienza del territorio iraniano nei confronti dei terremoti, come il potenziamento della cooperazione tra le agenzie di gestione delle emergenze sismiche, gli investimenti in droni e nei sistemi di allertamento precoce, la promozione di politiche educative e l'implementazione di norme più rigorose per la pianificazione urbana e le costruzioni. La vasta panoramica dello stato attuale della pianificazione e gestione delle emergenze sismiche in Iran permette di sottolineare l'importanza di coinvolgere attivamente la comunità, per promuovere una "cultura di preparazione ai terremoti" e rafforzare la resilienza ai terremoti. Nel contesto dell'Iran e di altri paesi ad alta pericolosità sismica, la percezione del rischio può cambiare notevolmente a seconda delle esperienze passate e della memoria collettiva degli eventi sismici devastanti. È importante notare che questa percezione del rischio tende a diminuire rapidamente nel tempo dopo un evento catastrofico. Questo fenomeno è in parte dovuto all'istinto di autodifesa e alla resilienza umana, che spinge a dimenticare le esperienze negative. Per contrastare questa naturale tendenza e garantire che la preparazione non venga trascurata a causa di disinformazione o scarsa consapevolezza, è consigliabile lanciare campagne informative durante i periodi di tranquillità. In questi momenti, la popolazione è più propensa ad affrontare il tema con razionalità e meno emotività rispetto alle fasi di emergenza o post-emergenza. Questo approccio può contribuire a promuovere una cultura di preparazione ai terremoti anche in assenza di crisi imminenti, utilizzando strategie di comunicazione innovative, condivise e comprensibili per tutti, superando le barriere sociali e culturali. È evidente come la percezione del rischio sia inversamente proporzionale alla conoscenza. Pertanto, è cruciale garantire un'informazione accessibile a tutti. Questo approccio potrebbe giocare un ruolo fondamentale nel migliorare la resilienza alle emergenze sismiche in Iran e in altri contesti ad alto rischio sismico.

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ABSTRACT

Iran, one of the most seismically active countries globally, faces recurrent and devastating earthquakes, resulting in significant loss of life, and necessitating improved disaster management. This study adopted a mixed-methods approach, combining seismic data analysis and a nationwide survey, with the aim to assess Iran's emergency planning and management in seismically active regions. Seismic data, sourced from various studies, was analysed using a geographic information system (GIS) to identify trends and patterns since 1903, focusing on events with magnitudes larger than 5.7 M_w from 2010 to 2023. Concurrently, an online questionnaire was administered to a random sample of 500 Iranians, in order to explore public awareness, preparedness, and perceptions of the country's emergency readiness. Seismic analysis revealed disparities in the number of earthquake-related fatalities, depending on population density, infrastructure quality, and emergency response capabilities. The survey indicated a perceived lack of public awareness and preparedness, with only 11.5% of the respondents feeling adequately prepared for earthquakes. Findings indicated poor knowledge of active faults and mistrust in government initiatives related to seismic events. Despite recent advances, Iran's disaster management system faces challenges that are rooted in financial constraints, technological barriers, and public mistrust. Analyses converge on enhancing stakeholder cooperation, investments in early warning systems, and enforcement of stricter urban planning and construction standards. Bridging gaps in public awareness and trust-building measures is crucial to fostering a bottom-up "earthquake preparedness culture." The findings from this study can provide insights for policymakers, emergency managers, and stakeholders to strengthen Iran's resilience to earthquakes.

***Keywords**: Iran, earthquakes, seismic hazard, seismic risk, emergency management policies, risk reduction strategies, public awareness and perception*

INTRODUCTION

Strong earthquakes have devastating effects, causing significant loss of life, property damage, and disruption to economic and social stability. According to the United States Geological Survey (USGS), Iran, with more than 90% of its territory classified as seismically active, is one of the most earthquake-prone countries in the world (Raeesi *et alii*, 2017; Yariyan *et alii*, 2020; Zhang *et alii*, 2022a). Since 1900, more than 193000 people have lost their lives in disastrous earthquakes in Iran (Ashtari Jafari, 2016; Ghassemi, 2016). For instance, the 1990 Manjil-Rudbar earthquake killed over 40000 people and displaced over 60000 (Firuzi *et alii*, 2020). In 2003, the Bam earthquake struck southeastern Iran, killing more than 26000 people, injuring over 30000, and leaving an estimated 75,000 homeless (Ibrion *et alii*, 2015). In November 2017, a 7.3 magnitude earthquake hit the Iran-Iraq border, killing at least 630 people and injuring over 8100 in Iran alone (Mahsuli *et alii*, 2019). The latter events emphasise the potential benefits from improved emergency planning and readiness.

Despite the high seismic risk, Iran's disaster management system has encountered several obstacles. One of the most significant challenges has been the lack of funds of a lower-middle-income (https://worldpopulationreview.com/country-rankings/middle-income-countries), rapidly urbanising country, which has hindered the government's ability to invest in earthquake early warning systems, retrofitting of buildings, and public education and awareness initiatives (Amini Hosseini *et alii*, 2018; Hosseini & Izadkhah, 2020; Ibrion *et alii*, 2015; Lu & Xu, 2015). Other barriers have been of a technological nature, such as the difficulty in accurately estimating earthquake magnitudes and surface fault traces (Allen & Melgar, 2019; Ghassemi, 2016; Zafarani *et alii*, 2009). Although Iranians have shown a certain mistrust towards official authorities in handling emergencies (Seddighi, 2020), promising initiatives have been taken by the Iranian government and foreign groups to enhance the country's disaster resilience (Fekete *et alii*, 2020). Both the creation of the National Disaster Management Organization (NDMO) in 2013 and the approval of the Sendai Framework for Disaster Risk Reduction in 2015 reflect the national commitment to disaster resilience (Hosseini & Izadkhah, 2020; Yousefi Khoshsabegheh *et alii*, 2022). To intensify these efforts and increase earthquake resilience in Iran, many critical objectives must be addressed. The latter include identifying and assessing hazard and vulnerabilities in seismically active regions, developing effective risk reduction strategies and emergency response plans, and increasing public risk awareness and education (Ibrion *et alii*, 2015; Lofti *et alii*, 2022; Pasari, 2023; Rafiei *et alii*, 2022). Community-based emergency planning and preparation is critical to mitigating the risk caused by earthquakes in Iran's seismically active regions (Hosseini *et alii*, 2014) and offers new opportunities for improving disaster resilience (Sarker *et alii*, 2020). Community resilience, exemplified by stronger community ties, played a crucial role in post-earthquake rehabilitation (Ravankhan *et alii*, 2021). Addressing major research topics and goals can contribute to establishing effective risk reduction strategies and emergency response plans in order to better safeguard people's lives and livelihoods in the seismically active areas of Iran.

These areas face numerous challenges in terms of emergency management, such as limited resources and capacity for emergency response, lack of public awareness and preparedness, and complex legal and institutional frameworks for emergency management (Heidari *et alii*, 2020; Jamshidi

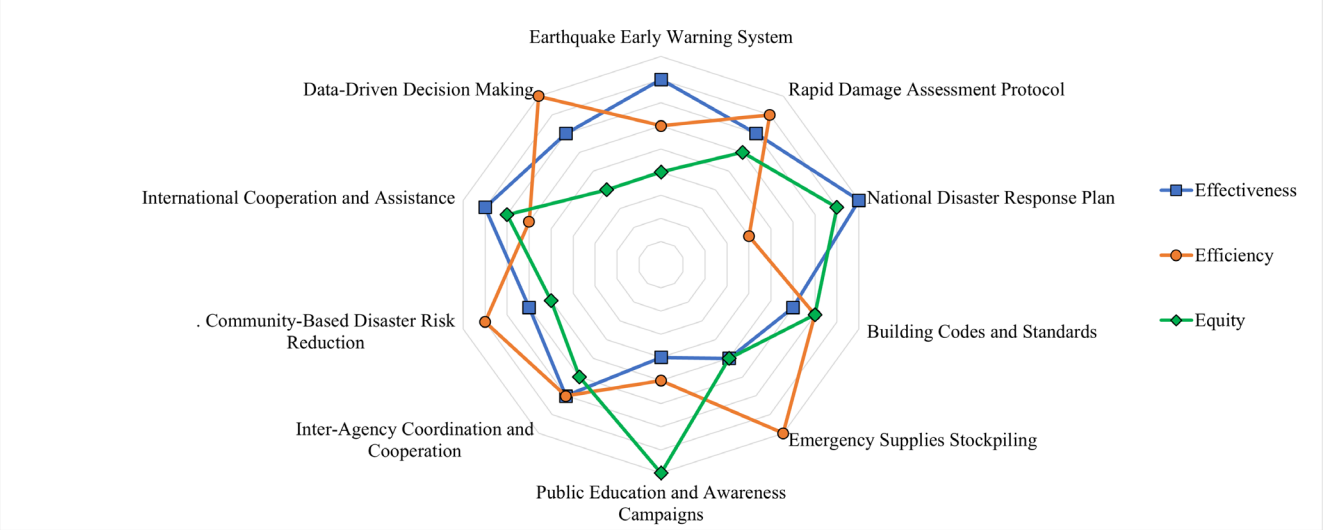

Fig. 1 - Radar chart comparing the strengths and weaknesses of different emergency management policies and procedures in Iran, based on criteria such as effectiveness, efficiency, and equity (MEHR NEWS AGENCY, 2012)

et alii, 2016; Zhuang *et alii*, 2021). Corrective measures, such as issuing adequate building codes, establishing public education and awareness programs on risks, improving coordination and communication among emergency response agencies, and harnessing technology and innovation to enhance preparedness and emergency response, are all essential steps to mitigate the impact of earthquakes (Amini-Hosseini & Hosseinioon, 2012). The earthquake emergency management policies mentioned above have been analyzed and classified in terms of effectiveness, efficiency, and equity by the Emergency Management Organization, the Red Crescent Society, the Fire Department, and the Health Department, highlighting strengths and weaknesses (MEHR NEWS AGENCY, 2012) (Fig. 1).

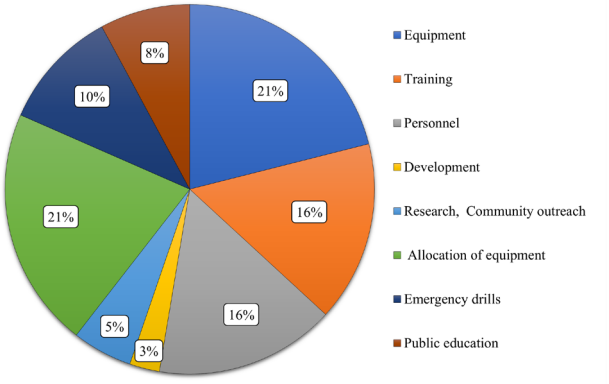

Fig. 2 - Pie chart illustrating the breakdown of resources allocated to emergency response agencies and organisations in Iran's seismically active regions (MEHR NEWS AGENCY, 2012)

To put in place effective emergency planning and preparedness policies, it is crucial to take into account social and cultural factors (Amini-Hosseini *et alii*, 2018; Hosseini *et alii*, 2014). An obstacle to effective emergency planning and preparedness is the lack of knowledge and communication skills (Al Thobaity *et alii*, 2017). Merely developing and implementing advanced technologies or systems is not enough; it is also essential to engage communities and stakeholders to ensure their understanding of earthquake risk and preparedness for a timely and efficient response (Amini Hosseini *et alii*, 2018; Lu & Xu, 2015). This entails the need to increase funding aimed at implementing community awareness initiatives, educational campaigns, and communication strategies for seismic risk awareness and mitigation (Hosseini & Izadkhah, 2020; Ibrion *et alii*, 2015). The analysis of the allocation of resources to emergency response agencies and organisations in Iran provided additional noteworthy insights, highlighting that only 13% of total investments were allocated to outreach initiatives (5%) and public initiatives (8%). The limited allocation of resources for research (5%), education (8%), and development (3%) reflects poor emphasis on research and education in Iran (MEHR NEWS AGENCY, 2012) (Fig. 2).

In this context, our study aimed to explore the current state of earthquake emergency planning and management in Iran's seismically active regions, identify gaps in preparedness, and reveal Iranians' perception of the country's readiness for earthquakes. We used existing literature, policy documents, georeferenced data on the recent earthquake history in the seismic regions of the country, and a questionnaire directed at a random sample of Iranians to investigate their common awareness of and

preparedness for earthquakes. Our comprehensive, coordinated, and participative approach has the goal of delving into the intricate interplay of Iran's seismicity, population thoughts, infrastructure, preparedness measures, education, temporal factors, and healthcare accessibility, contributing to the broader debate on seismic risk reduction and resilience in lower-middle income countries.

MATERIALS AND METHODS

Our study adopted a mixed-methods approach to evaluate the relevance of earthquake emergency planning and preparedness in Iran's seismically active regions. Our approach included a comprehensive investigation of earthquake data in Iran and a broad opinion poll among Iranians to measure their perceptions of the country's seismic emergency preparation and readiness. Our research used existing literature, policy documents, and an interview with Iranians to examine the perception of the country's current state of emergency management, identify gaps in preparedness, and propose strategies to enhance readiness and resilience in the face of earthquakes.

Our study relied on genuine data on the recent history of earthquakes in Iran, drawn from the USGS Earthquake Hazards Program catalog (https://earthquake.usgs.gov/earthquakes/search/). This entailed gathering information on the frequency, severity, and effect of earthquakes in the nation since 1903. Earthquake data from the above-mentioned source was studied in a geographic information system (GIS) environment to find trends and patterns in Iranian seismic activity, with emphasis on the most seismically active areas. The investigation included reviewing historical earthquake data and identifying magnitude descriptive statistics of earthquake events. Also, we conducted a thorough assessment of comparable magnitude earthquakes that have occurred in Iran since 2010, looking into various factors that might explain the disparity in the number of deaths caused by such seismic occurrences. The puzzling gap noted in mortality rates made it necessary to carefully investigate the intricate interaction of elements determining the seismic risk environment.

In addition to the analysis of selected earthquakes and their impact on lives, an opinion poll was carried out by using an online questionnaire that was administered to a random sample of 500 people in Iran. The questionnaire was created to gather answers and comments on the perception of the country's current status of earthquake disaster preparation and readiness. The interview on earthquake emergency planning in Iran, reported in full in the Supplementary Material, was prepared using a Google Form (https://www.google.com/intl/it/forms/about/). 290 men and 210 women were invited to respond to the 8 questions listed in the questionnaire, as follows:

1) How well do you know emergency preparedness?
2) How well prepared are you for natural disasters such as earthquakes?
3) How important is it to you?
4) How confident are you in your area's infrastructures in the face of these threats?
5) How confident are you in the present governament's position on this issue?
6) How much do you know about the current governament's budget for this issue?
7) How well do you know Iran's active faults?
8) What do you think is the main problem with earthquakes?
9) Open suggestions for improving emergency management in Iran in the event of an earthquake.

The age of the participants was quite diverse. Regarding men, 17.24% were under the age of 25, 29.65% were between 25 and 40 years old, 38.62% were between 40 and 60 years old, and 14.49% were over 60. Regarding women, 12.41% were under the age of 25, 32.07% were between 25 and 40 years old, 47.59% were between 40 and 60 years old, and 7.93% were over 60. The participants lived in various Iranian cities, spread across the entire national territory. The survey lasted an average of 5 to 7 minutes. The anonymous participants were casually selected and invited via email and WhatsApp, forwarding the link of the Google Form interview to friends and acquaintances living in Iran. The survey data was examined using statistical tools and graphs to discover patterns and trends in the answers and to investigate the awareness of Iranian citizens regarding seismic risk and earthquake preparedness.

RESULTS AND DISCUSSION

Seismicity of Iran and earthquake-related fatalities in the period 2010-2023

A digital map of earthquakes that occurred in Iran from 1903 to 2023 was obtained by georeferencing seismic events reported in the USGS Earthquake Hazards Program catalog (https://earthquake.usgs.gov/earthquakes/search/). The dataset included 7258 events with magnitudes ranging from 2.9 to 7.7 M_w. The spatial distribution of events (Fig. 1) outlines zones with a higher concentration of seismogenic structures (Bigi *et alii*, 2018; Carminati *et alii*, 2014; Carminati *et alii*, 2016; Nemati, 2018). The subdivision of the entire dataset into two subsets, considering a magnitude threshold of 5.7 M_w, reflects the findings of the statistical analyses reported below and shown in Fig. 3.

A frequency histogram graphically integrated with descriptive statistics of the distribution of events with different magnitudes provides an immediate visual depiction of the descriptive metrics of the dataset and the relevant insights for our study (Fig. 4). The entire dataset exhibits a distribution

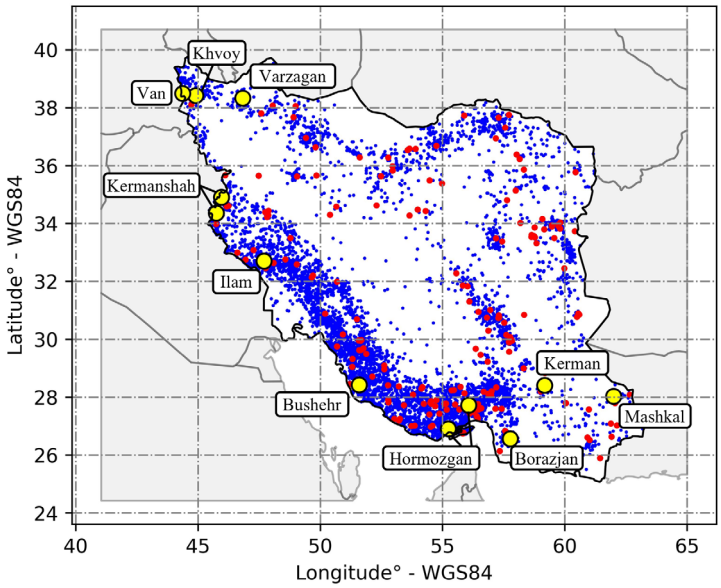

Fig. 3 - Thematic map showing the spatial distribution of earthquakes in Iran since 1903: the blue dots represent events with a magnitude ≤ 5.69, while the red ones correspond to earthquakes with a magnitude ≥ 5.7. The yellow labelled dots are the 12 events analysed in this study (see the text for details)

of magnitude values centered around a mean of 4.48, with a skewness value of 0.24. Events characterised by a magnitude ≥ 5.7 exceed the 96th percentile of the distribution relative to the entire dataset. These events, positioned at the right tail of a bell distribution, can be reasonably associated with a high socio-economic impact on the population, due to the number of

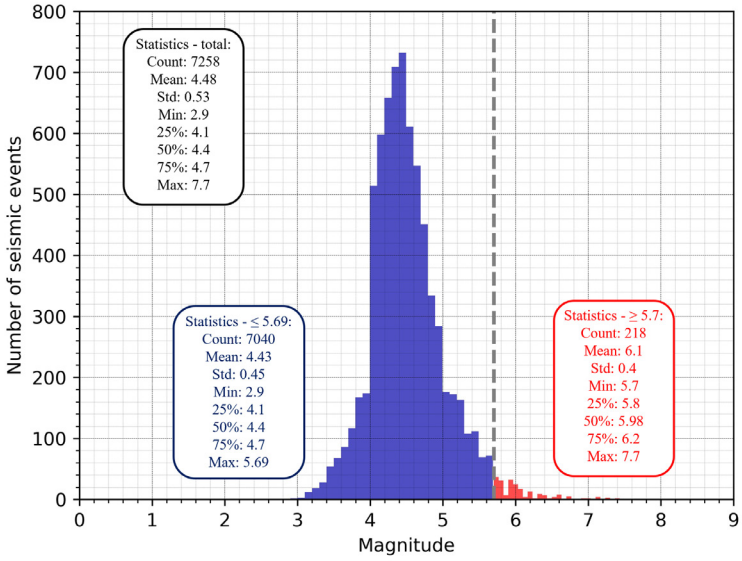

Fig. 4 - Frequency histogram of earthquake magnitudes in the seismically active regions of Iran with a graphical overlay of the main statistical metrics for three datasets (i.e., total, below 5.69 M_w, and above 5.7 M_w). Source: USGS Earthquake Hazards Program catalog (https://earthquake.usgs.gov/earthquakes/search/)

occurrences within the narrow timeframe under consideration. The number of seismic events with a magnitude equal to or greater than 5.7 amounts to 218. The average and maximum magnitudes for this subset correspond to 6.1 and 7.7 respectively (Fig. 4).

12 earthquakes with a magnitude equal or higher than 5.7, which occurred in the period from 2010 to 2023, were selected as the focus of this study. These seismic events appear to be fairly evenly distributed across the high seismicity regions of Iran (Fig. 3). These events are shown in chronological order in Fig. 5, focusing on the magnitude and fatalities of each earthquake.

of influencing factors. The correlation between population density, building quality, and earthquake mortality is known (He *et alii*, 2021; Zhang *et alii*, 2022b). Notably, the 2012 Varzagan earthquake, which struck a densely populated area with predominantly fragile structures, resulted in 306 fatalities (Mohammadi & Gheitanchi, 2016). In contrast, the 2010 Kerman earthquake, and the 2014 Ilam earthquake, which occurred in less densely populated areas, exhibited a significantly lower number of victims, 7 and 0 respectively (Abbaszadeh Shahri *et alii*, 2011; Nemati, 2015; Zare *et alii*, 2014). Also, differences in emergency response capabilities are known to

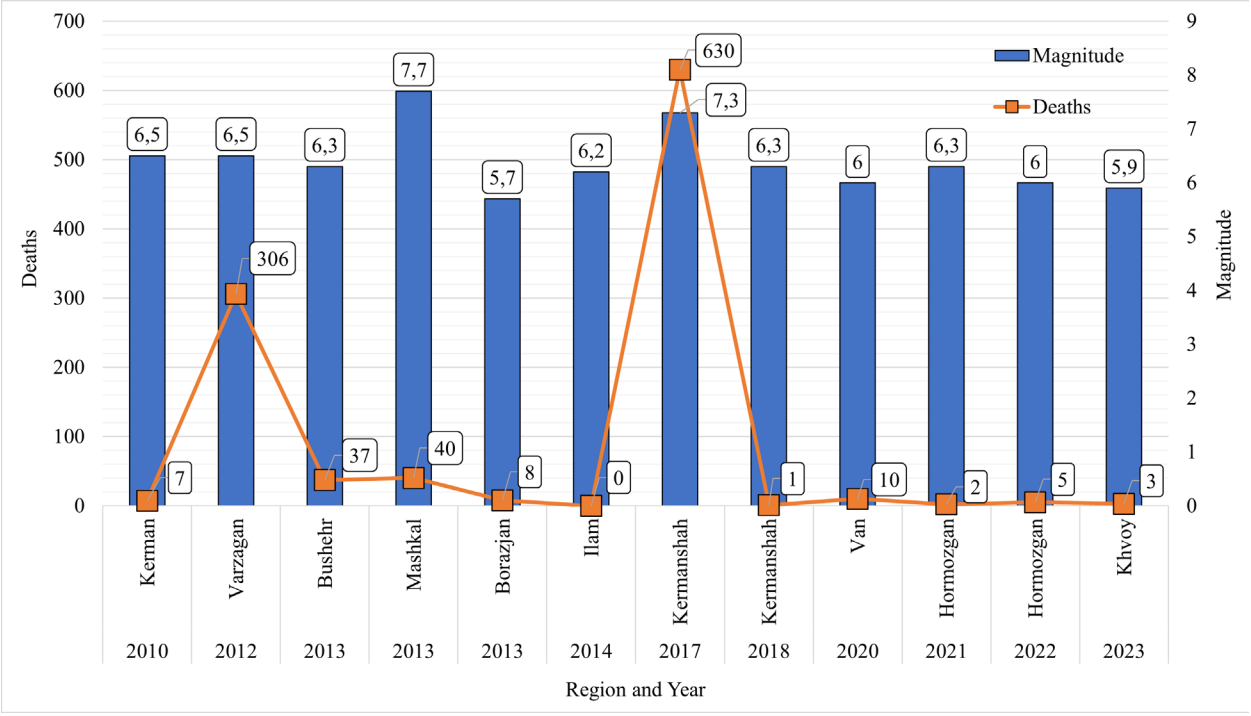

Fig. 5 - Histogram showing the location and magnitude of the analysed earthquakes and the number of victims for each of them (ABBASZADEH Shahri et alii, 2011; Firuzi et alii, 2022; INTERNATIONAL FEDERATION OF RED CROSS AND RED CRESCENT SOCIETY, 2022; Kazemi et alii, 2020; Lakbala, 2016; Maghsoudi & Moshtari, 2021; Mohammadi & Gheitanchi, 2016; Nemati, 2015; Zare et alii, 2014)

Although our study did not delve into the demographic-urban-building features of the affected areas, it can be noticed that there is no direct proportionality between the magnitude and number of victims. In particular, significantly higher death tolls are related to the seismic events of Varzagan (2012) and Kermanshah (2014), amounting to 306 and 630 victims, respectively.

Differences in the number of deaths caused by earthquakes with similar magnitudes can be attributed to a multitude of factors. A nuanced comprehension of seismic fatalities reflects an in-depth exploration of various elements and their intricate interplay with mortality rates and reveals a complex web

play a pivotal role in determining casualties (Amini-Hosseini *et alii*, 2018). For instance, the 2017 Kermanshah earthquake highlighted how the lack of coordinated effort among various non-profit, private, military, and government agencies, coupled with the numerous challenges faced by humanitarian logisticians during rescue operations such as needs assessment, procurement, warehousing, transportation, and last-mile distribution of relief supplies, tragically resulted in 630 casualties (Maghsoudi & Moshtari, 2021). Conversely, the 2022 Hormozgan earthquake, characterised by well-coordinated response measures, witnessed a toll of only 5 deaths (INTERNATIONAL FEDERATION OF RED CROSS AND RED CRESCENT SOCIETY, 2022). In

the Iranian context, geographic variations in public education and awareness initiatives related to seismic risk significantly influence individual preparedness during earthquakes (Amini *et alii*, 2021; Amini-Hosseini *et alii*, 2013; Yari *et alii*, 2019). Limited teaching programs and knowledge in Varzagan resulted in as many as 306 deaths caused by the 2012 earthquake (Firuzi *et alii*, 2022). Also, disparities in healthcare accessibility and adherence to construction standards substantially affect casualty rates (Fallah-Aliabadi *et alii*, 2020; Tierney *et alii*, 2005). Regions with more extensively developed medical facilities, exemplified by Hormozgan in 2021 and 2022, experienced far fewer casualties (7 deaths in total) than areas with insufficient health care infrastructure, such as Kermanshah (in which the 2017 earthquake caused 630 deaths) (Kazemi *et alii*, 2020; Lakbala, 2016). Additionally, stringent construction rules, as observed in the 2014 Ilam earthquake, effectively prevented casualties (Ataei *et alii*, 2018; Hassannejad *et alii*, 2022; Shakib *et alii*, 2021). On the other hand, a significant percentage of buildings in the Kermanshah region, both in urban and rural areas, were often built with masonry that incorporated steel or concrete elements. These structures frequently experienced severe damage and complete structural collapse, likely due to inadequate design, structural vulnerabilities, weak foundations, poor engineering, lack of bracing, low-quality concrete, insufficient reinforcement, or ground settlement, which were the primary causes of the disasters. In rare instances, structures demonstrated relatively successful performance (Saffarzadeh *et alii*, 2019).

Analysis of questionnaire outcomes and emergency management policies

The results of the questionnaire show a lack of knowledge and understanding of emergency planning and preparedness in the country. As shown in Fig. 6, only the 11.5% of respondents felt appropriately prepared for an earthquake, while 53.8% exhibited varied levels of fear and anxiety. While 80.8% of the respondents attributed a moderate (50%) to high (30.8%) importance to the country's emergency preparedness for seismic events and claimed to know this issue with a medium (73.1%) to high (7.7%) degree of confidence, 100% of all respondents expressed a moderate (30.8%) to low (69.2%) level of knowledge about active faults in Iran. This last question regarding active faults, deliberately technical in earthquake-related matters, highlights a lack of scientific knowledge in the population, which could be harmful for an evidence-based planning and preparation for seismic emergencies (Al Thobaity *et alii*, 2017). Furthermore, the questionnaire highlighted a low level of confidence and awareness of the population regarding the seismic vulnerability of the infrastructures in the area where they live (73.1%), the government's position on the matter (76.9%), and government funding for emergency preparedness and seismic event readiness (80.8%) (Fig. 6).

Although 69.2% and 30.8% of the respondents indicated a low and moderate level of knowledge about active faults in the country, respectively, it is intriguing to note that, when faced with a seismic threat, 96.2% of the respondents identified inadequate

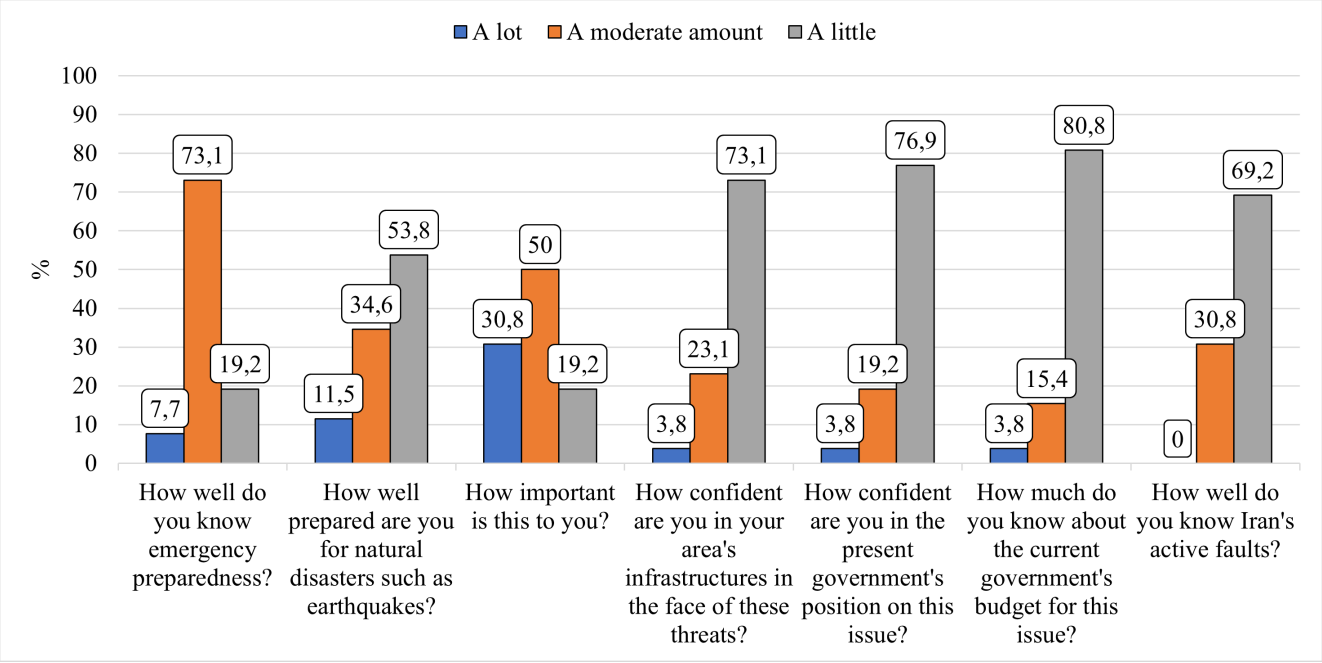

Fig. 6 - Grouped column diagram expressing the outcomes of interviewing Iranians about their perceptions of the country's emergency preparation and readiness for earthquake events

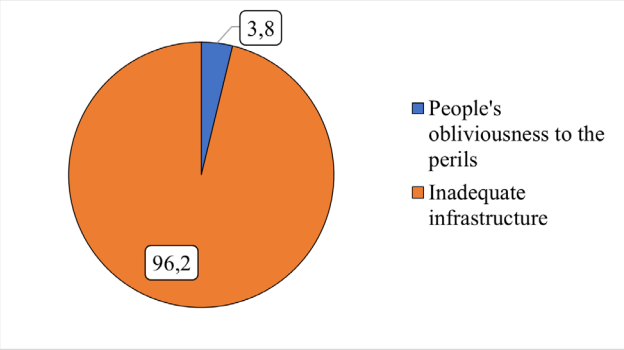

Fig. 7 - Pie chart illustrating questionnaire answers to the question "What do you think is the main problem with earthquakes?"

infrastructure as the primary issue rather than unawareness of the hazard (3.8%) (Fig. 7).

The respondents perceive to be fully aware of the vulnerability of structures. In literature, this vulnerability is often attributed to reasons such as poor construction quality, inappropriate connections between walls and structures, absence of wall posts, inadequate reinforcement of joints and critical ends of columns and beams, lack of transverse reinforcement, shear failure of short columns, poor construction quality, improper length or positioning of joints, low concrete compression strength, soft-story effect, and weak column/strong beam mechanism (Alavi *et alii*, 2018).

The open-ended answers to the question on ways to improve emergency management in Iran in the event of an earthquake were varied, but several common themes emerged. The questionnaire confirmed the mistrust of the public toward the government as already highlighted by Seddighi (2020). According to Heidari *et alii* (2020), to enable a more effective response, the common idea of enhancing cooperation between emergency response agencies and other stakeholders, such as non-governmental organisations (NGOs) and community organisations, came to the forefront. Participants in the survey also emphasised the importance of investing in early warning systems, which could significantly reduce the social effects of earthquakes in Iran according to Enferadi *et alii* (2021). Other technical alternatives were also suggested, such as employing drones for search and rescue operations and developing a nationwide emergency communication system (Hildmann & Kovacs, 2019; Qi *et alii*, 2016). The need to develop the use of drones and early warning systems also emerges from previous studies (Enferadi *et alii*, 2021; Mousavi *et alii*, 2022; Nazeri & Shomali, 2019).

Additionally, participants stressed the role of stricter rules and regulations, particularly in urban planning and building standards, to mitigate the adverse effects of earthquakes (Amini-Hosseini & Hosseinioon, 2012). Lastly, participants stressed the need for improving public education and awareness regarding earthquake preparedness and response as a pivotal step towards overall improvement in readiness (see also Jamshidi *et alii*, 2016; Zhuang *et alii*, 2021). Indeed, as seen before, literature reveals that a mere 13% of total investments in emergency response agencies and organizations in Iran were earmarked for outreach initiatives (5%) and public initiatives (8%) (MEHR NEWS AGENCY, 2012) (Fig. 2).

CONCLUSIONS

The findings of the study on Iranians' perception of the country's readiness and preparedness in case of seismic emergency suggests the existence of some critical gaps in disaster planning and preparedness in Iran's seismically active regions. These gaps are consistent with the analysis of emergency management policies in the country conducted by emergency response agencies and organisations, including the Emergency Management Organisation, the Red Crescent Society, the Fire Department, and the Health Department (MEHR NEWS AGENCY, 2012) (Fig. 1).

Based on our findings, we can make some final remarks. The individuals involved in the survey voiced numerous cognitive, social, physical, and financial hurdles. While educational initiatives can address many of these obstacles, some are beyond the means of households and necessitate government intervention. By proactively tackling challenges, implementing preventive measures, enhancing building construction and retrofitting practices to adhere to safety standards, and bolstering preparedness efforts, the number of victims in the aftermath of earthquakes in Iran can be reduced.

To enhance Iran's resilience against earthquakes, our analysis suggests the pursuit of intensified cooperation among stakeholders, investments in early warning systems, and the enforcement of stricter regulations in urban planning and construction standards as potentially viable solutions. Our study showed the importance and the potential of community engagement, education, and trust-building measures to bridge existing gaps in emergency preparedness. Increased funding for community awareness initiatives and involvement of personal experiences in decision-making processes can foster a bottom-up "earthquake preparedness culture". In conclusion, our study gives valuable insights into the issue of seismic risk mitigation in developing countries.

AUTHOR CONTRIBUTIONS

Conceptualisation, PC, SH, and TZ; validation, LMG and GSM; data curation, SH, TZ and LMG; writing-original draft preparation, PC and SH; writing-review and editing, LMG and TZ; supervision, PC and GSM; project administration, GSM.All authors have read and accepted the published version of the manuscript.

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