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A Longitudinal Study of Hospital Safety From Disasters in Kermanshah Province, Iran: Insights for Disaster Risk Reduction

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Original Research

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Abstract

Objective: The Hospital Safety Index (HSI) developed by the World Health Organization (WHO) was adopted by most countries to evaluate the safety of hospitals against disasters. This study aimed to assess the status of hospital safety from disasters between 2016 and 2022 in Kermanshah province in Iran.

Methods: This is a retrospective longitudinal study which investigated HSI data from 23 hospitals. Data were gathered by Farsi Hospital Safety Index (FHSI) and analyzed with a repeated measures analysis of variance (ANOVA).

Results: The risk of hydro-meteorological (from 43.1 to 32.7) and biological hazards (51.3 to 35.5) significantly decreased. Although structural safety remained constant (from 67.8 to 70.1), nonstructural (from 51.5 to 71.2), and functional (from 47.1 to 71.2) safety scores increased significantly over study period.

Conclusions: The findings revealed hospitals safety in Kermanshah province gradually improved. However, the health-care stakeholders should pay the necessary attention to improving the structural safety of hospitals.

Over the years, the number of disasters caused by both natural and man-made hazards has been increasing significantly.[1,2] They, for example, include natural disasters like earthquakes, floods, landslides, heatwaves, etc., and, on the other hand, explosions, fire outbreaks, terror attacks etc. These disasters often result in numerous health impacts, including disease outbreaks, displacements, posttraumatic stress disorders (PTSDs), and above all, disruption of health-care systems, etc., within societies.[3,4] Given these challenges imposed on the health-care needs of affected people by these disasters, hospitals play an important role in responding to them.[5]

Hospitals have a critical role in responding during disasters, and thus, they ought to remain operational and maintain their normal functions to meet ongoing health-care needs.[6] Unfortunately, many hospitals have been destroyed or rendered dysfunctional by some disasters. This has been a particular challenge in Iran and in other countries, which are prone to different types of disasters.[7–9] For example, during the 2017 Sarpol Zahab earthquake, which was reported to have partially or completely destroyed a total of 8 hospitals and 62 medical centers.[10]

Due to the increasing occurrence of disasters over the past few years, the World Health Organization (WHO) took the initiative to promote the safety of hospitals. A safe hospital is a facility that can continue to provide medical care and support to patients during and after an emergency or disaster.[11] According to the Hyogo Framework for Action (HFA), hospital safety can be achieved by building new hospitals at a level that is safe and also by implementing relevant mitigation strategies in old hospital buildings, which can allow them to function in case of any disasters.[11] As a result, the first version of the Hospital Safety Index (HSI) was published in 2008 by the Pan American Health Organization (PAHO) and WHO. Thereafter, health authorities across all WHO regions collaborated to adapt and apply the HSI tool in their settings.[11] In Iran, Ardalan et al. (2011) translated the HSI tool into the Persian language (Farsi Hospital Safety Index (FHSI)) and adopted it into Persian language and checked it validity and reliability (Ardalan et al. 2011).[12] Finally, it is integrated as one of the Hospital Accreditation item (Ardalan et al. 2015).[13] Since then, the hospital committees for disaster risk reduction annually use FHSI to assess the safety of hospitals against disasters.[9,13]

Since the adoption of HSI, some studies have been undertaken both at the local and national levels to examine the safety of Iranian hospitals from disasters. In 1 of the studies conducted in

Table 1. Hospital characteristics that reported Hospital Safety Index during the study period

Hospital service	Frequency	Percentage
Educational	7	30.4
Community	10	43.5
Private	2	8.7
Military	2	8.7
Social Security Organization	2	8.7
Hospital service		
General	19	82.6
Specialized	4	17.4
Hospital Size		
>100 Beds	10	43.5
≤100 Beds	13	56.5
Average age of hospital buildings/years	36.48 ± 18.45 (11–66)	

by Ardalan et al. (2012), the mean safety score of 224 hospitals was revealed to be 32.4 out of 100.[9] Again, in another national study carried out by Ardalan et al., in 2015, the mean safety score of 421 hospitals against disasters was indicated at 43 out of 100.[13] Ghafouri et al., in 2018, reported that the mean safety score of 21 hospitals in Tabriz province was 67 of 100.[7] Other recent studies from Tabriz, Tehran have reported the safety of hospitals against disaster to be at a medium level.[14,15] Although the safety of all hospitals is assessed annually, no recent studies have been undertaken to evaluate the progress of hospital safety after using the FHSI for nearly a decade, specifically for Kermanshah province. This is why this longitudinal study was conducted to examine the trends and patterns in hospital safety between 2016 and 2022 in Kermanshah province in the west of Iran. The results of this study are anticipated to help identify areas for hospital safety improvements beyond Kermanshah province.

Methods

Study Method and Setting

This retrospective longitudinal study was performed based on hospital safety data that were gathered by the Disaster Risk Reduction (DRR) Office of the Treatment Deputy at Kermanshah University of Medical Science (KUMS) from 2017 to 2022. This study design is appropriate to observe the variation in results over time.[16] KUMS oversees monitoring health delivery in Kermanshah Province, located in the west of Iran. This province, apart from being prone to annual dust storms, experienced a mega earthquake with a magnitude of 7.3 on November 12, 2017. Data were retrieved from a sample of 23 hospitals located within Kermanshah Province, and their characteristics are presented in Table 1.

Study Tool

The second edition of FHSI, which contains 151 items, was used. The FHSI consists of 4 main modules: hazard analysis (4 main types of hazards), structural safety (2 sub-modules and 18 items), nonstructural safety (4 sub-modules and 93 items), and emergency and disaster management (7 sub-modules and 40 items). Their details are shown in Table 2. Each item is evaluated based on 3 safety levels: low (0), moderate (1), and high (2). All items in modules and sub-modules in FHSI have equal value. Furthermore, all the safety scores are normalized to a 100-point scale for easy interpretation and comparison in FHSI.[12] Finally, the hospital safety total scores were classified into 3 categories: low (0-34), moderate (34.1-66), and high (>66.1). It should be noted that module 1 is not included in the hospital safety index calculation. FHSI was designed and adopted from HSI by a multi-disciplinary expert team cutting across engineering, medical science, and disaster management. This team initially translated HSI to the Persian language before its content was validated and approved. Its analysis was done using a Microsoft Excel spreadsheet (MS Excel). Finally, it was tested at the Tehran University of Medical Sciences.[12] In 2017, both the first and second versions of the FHSI were used to assess the safety of hospitals against disasters in Iran. This study is based on the second version of FHSI.

Data Collection and Analysis

Data considered in this study were gathered by the committee members of hospital disaster management. Then, the data were entered in a specific Microsoft Excel spreadsheet that was designed by the FHSI developer team. The collected data from each hospital were reported to and restored in the disaster management office of the Treatment Deputy at KUMS. Then, the research team had access to restored data after the KUMS review board approved the study proposal. Afterward, the information about hospital characteristics, hazard assessment scores, and safety scores (structural, nonstructural, and functional attributes) was imported into SPSS software version 24. The missing data for each unreported item were completed using the previous year's HSI data from the hospital. The safety scores were calculated and presented in descriptive statistics such as frequency, mean, and standard deviation. Repeated measures analysis of variance (rANOVA) was used to determine whether there were any changes in the hospital safety scores over the study period.

Results

Hospital affiliations, their size, and the services they provide are presented in Table 1. Nearly two-thirds of the hospitals considered in this study were educational and community-related centers. Most of the hospitals were delivering general services, and nearly half of them had fewer than 100 beds. The mean age of hospital buildings was more than 30 y old.

The mean score of different hazards is presented in Table 2. Although the risk of geological, societal, and human-made hazards did not change significantly over time, the risk of hydro-meteorological and biological hazards declined significantly over the study period. In 2017, the risk of meteorological and biological hazards sharply declined, and in the following years, the mean risk score of hydro-meteorological hazards remained in the range of 32-34. Apart from 2017, when the risk score for biological hazards decreased sharply (from 51.3 to 27.3), in subsequent years it gradually increased (35.5). The total risk fell sharply in 2017 (from 40.4 to 33.5) and then gradually increased in the next years (Figure 1).

The descriptive analysis showed the mean scores of structural hospital safety (67.8 ± 22.2) were of high-level rank (Table 3). The rANOVA test indicated that the mean score for structural safety of hospitals did not change significantly. With time, however, the score constantly increased (70.1 ± 16.4). As shown in Table 3, the total mean scores of non-structural (51.5 ± 23.9) and functional safety (47.1 ± 28.8) at the beginning of the study were recorded at a

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Table 2. Risk of different type of hazards in selected hospitals

Parameter	2016	2017	2018	2019	2020	2021	2022	*P*-Value
Geological hazards	30.9 ± 2	31.05 ± 13.3	36.1 ± 16.7	34.2 ± 15.2	34.2 ± 14.1	32.09 ± 13.01	31.9 ± 14.7	0.565
Hydro-meteorological hazards	43.1 ± 14.1	30.9 ± 12.4	32.3 ± 13.6	33.9 ± 13.4	33.9 ± 12.4	32.7 ± 11.09	32.7 ± 11.1	0.001
Societal hazards	39.1 ± 20.9	39.2 ± 20.8	39.8 ± 21.2	35.9 ± 16.6	37.9 ± 18.2	36.3 ± 16.6	37.6 ± 17.08	0.235
Biological hazards	51.3 ± 25.7	27.3 ± 11.7	28.6 ± 11.5	30.8 ± 12.4	34.05 ± 11.7	33.7 ± 10.8	35.5 ± 9.8	0.001
Human-made hazards	42.5 ± 21.7	39.3 ± 16.8	41.3 ± 14.9	39.9 ± 13.9	40.7 ± 14.1	39.9 ± 13.8	40.5 ± 14.1	0.502
Total risk	40.4 ± 17.1	33.5 ± 12.6	35.5 ± 12.7	34.9 ± 11.8	36.2 ± 12.1	34.4 ± 10.5	35.6 ± 11.4	0.195

Table 3. Means scores of hospital safety dimensions from 2016 to 2022 in all of hospitals

Parameter	2016	2017	2018	2019	2020	2021	2022	*P*-Value
Structural	67.8 ± 22.2	68.8 ± 19.4	66.1 ± 20.8	68.4 ± 18.6	69.7 ± 19.5	71.5 ± 17.4	70.1 ± 16.4	0.765
Non-structural	51.5 ± 23.9	56.7 ± 15.7	65.1 ± 17.4	68.7 ± 12.4	69.8 ± 13.6	69.7 ± 14.2	71.2 ± 12.2	0.001
Functional	47.1 ± 28.8	59.5 ± 19.03	68.4 ± 17.9	71.2 ± 15.5	70.9 ± 16.2	71.2 ± 17.8	73.9 ± 13.5	0.001
Total safety	57.8 ± 20.6	63.3 ± 13.5	66.2 ± 16.2	69.3 ± 11.3	70.01 ± 12.4	70.9 ± 9.5	71.2 ± 8.5	0.110

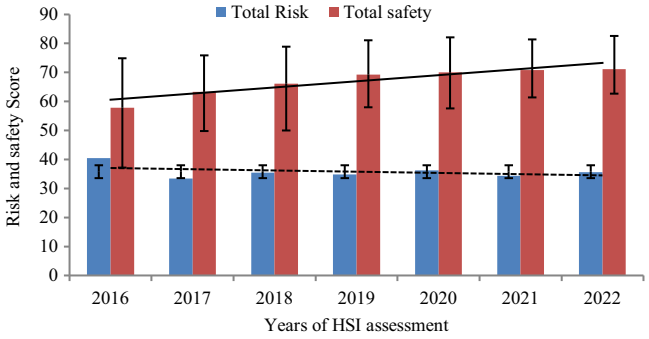

Figure 1. Mean and standard deviation of total risk and safety scores in HSI assessment over the years.

moderate level. Later, their mean scores significantly increased. The mean scores for nonstructural (71.2 ± 12.2) and functional safety (73.9 ± 13.5) at the end of the study period of high rank. Finally, as shown in Table 3, the mean score of the total safety score gradually increased (from 57.8 ± 20.6 to 71.2 ± 8.5), but this was not statistically significant (Figure 1).

Figure 2 presents the number of hospitals whose safety level was ranked low and sharply declined in 2017. Furthermore, the number of hospitals whose safety was ranked at a moderate level increased sharply in 2017. However, their level of safety steadily decreased over the study period. The number of hospitals with a high level of safety that ranked in the category of high-level increased slowly.

Figure 2 indicated that the number of hospitals ranked in the high-level category increased slowly.

The analysis revealed that structural safety for all hospital types remained nearly steady and did not register any significant change ($P < 0.05$) (Table 4). Improving the safety of this department requires the reconstruction or retrofitting of the structural elements of a hospital. In educational and private hospitals, structural safety sharply decreased in 2017, and it did not change in the other years. According to Table 4, there was a gradual increase in non-structural and functional safety dimensions in all hospital types. However, the mean score of non-structural safety increased rapidly in community-based hospitals. More so, the mean functional safety score of educational and community hospitals also increased significantly. Furthermore, Table 4 indicates a gradual increase in the total mean safety score in all types of hospitals. Of interest, military hospitals registered the highest safety scores in all aspects of safety over the study period. On the contrary, community-based hospitals recorded the lowest safety scores over time in all aspects of safety. The safety scores of hospitals that are affiliated with social security organizations increased slightly in all aspects. In summary, there were no important differences in the structural safety of different types of hospitals.

Discussion

The safety of hospitals, initially underlined in the HFA and subsequently in the Sendai Framework as 1 of the important issues, was integrated into the road map of DRR for Iran's health system.[11,13]

Our finding indicated that the risk of geological, societal, and human-made hazards did not significantly change over the study period. This study revealed a significant decline in the risk of hydro-meteorological and biological hazards. Surprisingly, the total risk of hazards also declines gradually. This contrasts with the findings in the 2022 global assessment report on DRR, which reported the risk of hydrometrological and biological disasters as increasing.[17] The increase in the risk of biological and hydro-meteorological hazards can be attributed to climate change.[17] This is in contrast with what happened in the Kermanshah province during the 2017 earthquake, the 2018 flood, and coronavirus disease 2019 (COVID-19). Another possible explanation for the significant decline in the risk of biological and hydro-meteorological hazards is that they were overestimated at the beginning of the study period. However, it is recommended that the hospital committee for DRR be educated about hazard identification and profiling to effectively assess the risk of hazards to hospital safety.

The study's result indicated that the mean structural safety score was 67.8 ± 22.2 at the beginning of the study (2016) and later did not rise significantly. This structural mean score is higher than what Ardalan et al. reported in the 2 national studies in Iran.[9,13] Rajaei Ghafouri et al. (2018) also showed that the mean score of structural safety at Tabriz Hospital was 52.73 ± 17.34.[7] The safety

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Table 4. Comparison of Hospital Safety Index from 2014 to 2022 in respect type of hospitals

Parameter	Type	2016	2017	2018	2019	2020	2021	2022	*P*-Value
Structural safety	Educational	76.5 ± 20.6	63.09 ± 17.6	57.6 ± 18.3	58.9 ± 13.4	65.2 ± 20.8	68.8 ± 11.9	66.2 ± 15.4	**0.323**
	Community	60.7 ± 27.3	76.6 ± 20.6	70.6 ± 22.9	74.8 ± 19.6	73.8 ± 19.8	76.1 ± 19.4	76.3 ± 15.4	**0.392**
	Private	69.2 ± 22.4	48.3 ± 25.9	48.3 ± 25.9	48.3 ± 25.9	48.3 ± 25.9	48.3 ± 25.9	48.3 ± 25.9	**0.171**
	Military	71.6 ± 3.5	73.2 ± 14.3	76.6 ± 9.4	77.5 ± 8.2	78.3 ± 7.07	71.6 ± 16.5	72.5 ± 15.3	**0.553**
	Social Security Organization	67.5 ± 2.4	65.7 ± 3.7	80.8 ± 3.5	80.8 ± 1.2	78.3 ± 2.3	80.8 ± 1.2	72.5 ± 1.2	**0.076**
	P-value	0.743	0.349	0.347	0.142	0.436	0.302	0.253	
Non-structural safety	Educational	63.3 ± 19.2	52.4 ± 18.4	56.7 ± 18.4	60.6 ± 13.04	62.8 ± 13.3	64.3 ± 11.4	65.7 ± 11.5	**0.208**
	Community	38.4 ± 27.09	59.02 ± 16.7	64.4 ± 18.1	70.1 ± 10.06	69.5 ± 13.4	66.1 ± 15.1	71.6 ± 12.5	**0.001**
	Private	55.1 ± 13.08	70.8 ± 0.8	75.6 ± 6.7	78.3 ± 10.5	78.4 ± 10.8	85.3 ± 8.4	85.9 ± 10.8	**0.120**
	Military	63.4 ± 17.9	57.1 ± 6.7	76.03 ± 20.04	74.6 ± 23	84.3 ± 14.3	83.3 ± 13.3	66.2 ± 10.8	**0.540**
	Social Security Organization	61 ± 9.85	70.8 ± 0.8	76.09 ± 3.2	74.4 ± 0.59	74.9 ± 7.7	77.5 ± 5.4	78.6 ± 6.3	**0.169**
	P-Value	0.239	0.553	0.438	0.274	0.236	0.154	0.257	
Functional safety	Educational	42.4 ± 18	55.8 ± 19.9	68.04 ± 12.7	71.9 ± 13.8	72.8 ± 13.4	78.6 ± 7.1	78.9 ± 7.1	**0.001**
	Community	33.9 ± 28.6	55.5 ± 19.8	61.2 ± 21.3	64.9 ± 17.5	61.6 ± 16.06	57.3 ± 17.7	63.3 ± 12.8	**0.012**
	Private	59.5 ± 39.5	78.4 ± 12.5	78.6 ± 14.2	75.9 ± 10.2	80.9 ± 10.8	83.8 ± 8.8	84.9 ± .8.1	**0.278**
	Military	89.7 ± 3.5	71.8 ± 22.7	91.5 ± 5.05	90.5 ± 8.4	93.4 ± 6.7	91.8 ± 4.5	87.8 ± 1.2	**0.509**
	Social Security Organization	74.4 ± 5.5	61.9 ± 8.65	71.9 ± 3.1	76.07 ± 4.6	77.9 ± 0.68	81.8 ± 0.15	84.4 ± 3.5	**0.422**
	P-value	0.555	0.502	0.231	0.289	0.058	0.006	0.006	
Total safety	Educational	61.9 ± 16.6	58.4 ± 13.9	59.4 ± 13.7	62.6 ± 8	65.8 ± 12.3	69.4 ± 5.3	68.6 ± 6.8	**0.232**
	Community	48.6 ± 25.2	67.1 ± 15.4	66.9 ± 16.3	71.4 ± 13.1	70.1 ± 13.8	69.4 ± 12.4	72.3 ± 10.3	**0.065**
	Private	60.9 ± 3.5	61.08 ± 10.2	62.6 ± 8.1	62.8 ± 7.7	63.8 ± 7.5	66.5 ± 8.6	66.9 ± 8.08	**0.095**
	Military	76.5 ± 9.6	68.1 ± 13.7	79.4 ± 2.3	79.2 ± 4.4	83.1 ± 2.1	79.2 ± 3.4	73.6 ± 11.1	**0.520**
	Social Security Organization	66.9 ± 2.88	59.08 ± 0.93	77.6 ± 3.4	77.9 ± 0.5	77.2 ± 3.3	80 ± 0.98	76.7 ± 2.02	**0.763**
	P-value	0.384	0.731	0.345	0.183	0.400	0.411	0.711	

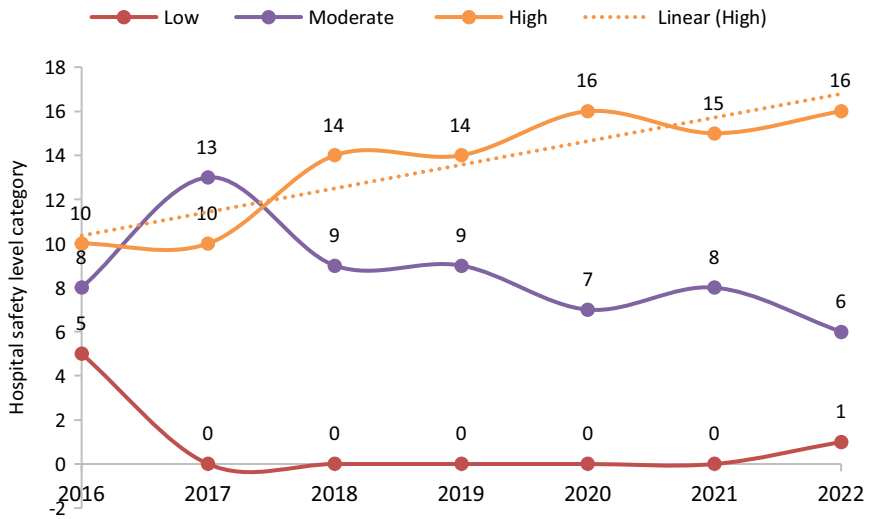

Figure 2. Hospital safety category over study time period.

assessment of of Georgian hospitals indicated that 63.1% of hospitals were at average risk.[2] This is in contrast with the findings in the structural safety assessment project that was undertaken by the Iran Ministry of Health (MOH), which indicated that approximately 70% of hospitals could not safely respond to earthquakes.[9] Thus, the project recommended that a structural safety assessment be conducted by an expert team of building engineers. The most obvious finding that emerged from this study is about the mean scores of structural safety, which remained nearly constant from 2016 to 2022. Although this is in line with what was revealed in the study by Ardalan et al., that indicated the structural safety score to have remained constant during the study time.[13] A possible explanation for this result is that improving the safety of this section necessitates the reconstruction or retrofitting

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of the hospital's structural elements. However, implementing these measures needs significant financial of financial resources. So this issue hindered hospitals from taking steps to improve the safety of the structural section.

This study found the mean score of nonstructural safety of hospitals not only to be moderate but also to have gradually increased over the years. This finding is also confirmed by the safety of Georgian hospital, which indicated that more than 80% of the hospital's nonstructural safety was between good and moderate level.[2] Ardalan et al. also found that the nonstructural safety of hospitals in Iran remarkably increased from 2012 to 2015.[13] The safety of this section included electrical and telecommunications systems and safety, water supply and safety, medical fuel and gases, heating, ventilation and air conditioning (HVAC) systems, and safety and medical/laboratory equipment and supplies. Most hospitals already have these items, so improving safety of this items could be achievable with limited financial resources.

Another important finding in the present study is that the functional safety of hospitals was enhanced. This may have been a result of some factors as explained below. First, the design and communication of the programs related to hospital safety and disaster planning. Second, the functional safety of hospitals in Keremashah province would have been enhanced by the different training courses that were held to promote hospital safety in disasters. Third, performing periodical evaluations in line with the hospital accreditation by the KUMS and MOH. Furthermore, a finding about the functional safety of hospitals is supported by results in a study by Ardalan et al., which indicated that the nonstructural and functional safety of hospitals countrywide in Iran improved significantly.[13] Ingrassia et al. showed that most of the hospitals in Italy were prepared to efficiently manage and respond to their safety in case of disasters.[18]

This study also depicted that the total safety score slightly increased during the study period. This could have resulted from the improvement in HSI data for enhancing Iran's hospital safety to respond to disasters (Ardalan et al., 2016). However, the impacts of recent earthquakes in 2012 East Azarbaijan, 2013 Bushehr, and 2017 Kermanshah revealed the critical need for closer supervision in the implementation of the safety building code, especially for hospitals.[6,10]

In terms of the differences in safety levels among hospital types, the analysis herein indicated that the safety of military hospitals was higher in all components of HSI. On the other hand, community hospitals had the lowest safety level. There were no important differences in the safety components among different types of hospitals. Educational hospitals also had significant improvements in functional safety over the study period. Ardalan et al. findings indicated that hospital safety levels among different types of hospitals had significant differences, and in particular, hospitals affiliated with military organizations had higher safety levels.[13]

Nonetheless, the major limitation of this study is related to its self-assessment of HSI, which could have been susceptible to a risk of bias. As a result, further research is needed to ensure the accuracy of the data for HSI self-assessment.

Conclusions

In summary, this study aimed to investigate hospital safety over 6 y using FHSI. Its findings suggest that hospital hazard assessments, which are designed to identify the potential hazards and risks to hospitals during disasters, may not accurately reflect their actual impact. The study's findings indicate that, while progress has been made in improving the non-structural and functional safety of hospitals in response to disasters, there is still a lack of attention to their structural safety. This highlights the need for policy-makers and hospital administrators to focus on addressing structural vulnerabilities in hospitals located in disaster-prone areas. By doing so, hospitals no doubt can become more resilient and better equipped to respond to disasters, ultimately helping to mitigate their impact on communities and save lives. The findings herein can be used to inform policies and initiatives aimed at improving the safety and resilience of health-care facilities in disaster-prone areas like Iran and elsewhere.

Data availability of statement. The datasets generated and/or analyzed during the current study are not publicly available due to participant confidentiality but are available from the corresponding author on reasonable request.

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Author contributions. Vahid Ghanbari: conceived and designed the study. He wrote the first draft of manuscript and approved the final version of the manuscript. Ehsan Rahimi: conceived the study and data management Nader Salari: analyzed the data, read and approved the manuscript. Joseph Kimuli Balikuddembe: conceived the study, prepared and approved the final version of manuscript. Yaghob Hidari: Data gathering and management, approved the final version of manuscript. Leili Rostamniya: conceived and designed the study. He wrote the first draft of manuscript and approved the final version of the manuscript.

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