Nonstructural Safety of Hospitals for Disasters: A Comparison Between Two Capital Cities

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ABSTRACT

Objective: Hospitals are expected to function as a safe environment during disasters, but many become unusable because of nonstructural damage. This study compares the nonstructural safety of hospitals to disasters in Tehran and Stockholm.

Methods: Hospital safety in Tehran and Stockholm was assessed between September 24, 2012, and April 5, 2013, with use of the nonstructural module of the hospital safety index from the World Health Organization. Hospital safety was categorized as safe, at risk, or inadequate.

Results: All 4 hospitals in Stockholm were classified as safe, while 2 hospitals in Tehran were at risk and 3 were safe. The mean nonstructural safety index was 90% ± 2.4 SD for the hospitals in Stockholm and 64% ± 17.4 SD for those in Tehran ($P = .014$).

Conclusions: The level of hospital safety, with respect to disasters, was not related to local vulnerability. Future studies on hospital safety should assess other factors such as legal and financial issues. (*Disaster Med Public Health Preparedness*. 2014;8:179-184)

Key Words: hospital, disaster, nonstructural, safety

During disasters, a community's disaster management services, including health care facilities, must be able to protect the lives of the affected population.[1] Because hospitals are a community's cornerstone for health care, they are expected to function as a safe environment for personnel and patients and to operate effectively in the face of a disaster.[2,3]

The hospital is a complex facility, with a high level of occupancy (patients, staff, visitors) and expensive medical equipment.[4] This complexity makes them vulnerable to the impact of disasters, with respect to structural, nonstructural, and administrative and organizational elements.[4] Hospital vulnerability is a worldwide challenge, both in developing and developed countries.[5-7] Recent reports indicate that many hospitals are rendered unusable because of extensive nonstructural damage in spite of being intact structurally.[7-14] The nonstructural elements of a hospital include its basic installations and services, equipment and furnishings, and architectural features.[4]

Making hospitals safe in the event of disasters is a major concern. However, measuring a hospital's safety has been difficult. Such an assessment would increase hospital safety by identifying and prioritizing essential safety interventions.[1] To facilitate the evaluation process, the World Health Organization (WHO) has developed the hospital safety index (HSI), which is an international, useful, and validated tool for standardized assessment and comparison of hospital safety, including nonstructural elements.[1] Nonstructural safety is evaluated in the HSI by assessing 71 elements. These elements are grouped into critical systems, air-conditioning systems, furnishings, architectural elements, medical equipment, and supplies.[4] Financially, these elements constitute the greatest expenditure of the budget needed to establish a hospital.[4]

Sweden is a high-income country[15] that has a low vulnerability with respect to disasters.[16,17] To our knowledge, only 1 report from Sweden has described an electrical power failure, which is considered a nonstructural safety problem, at a university hospital in Stockholm in 2007.[10] In contrast, Iran is an upper middle income[15] country and highly vulnerable to disasters.[17,18] In this country, many hospitals have been destroyed or damaged, both structurally and nonstructurally, during recent disasters.[19-22]

In this study, we used the HSI to compare nonstructural safety of hospitals to disaster in Tehran, a highly vulnerable city, and Stockholm, a city with low vulnerability.[1] In accordance with the Hyogo framework, a worldwide strategy to reduce disaster risk within 2005 to 2015,[23] a comparison of hospitals for disaster preparedness and safety at national and international levels can help to identify potential gaps and to build capacity for maximizing risk reduction and hospital safety. Moreover, multinational cooperation and studies can facilitate the transfer of evidence and knowledge of disaster risk reduction among different nations.[23]

METHODS

Setting

This self-assessment study was conducted in 2 capital cities, Tehran, Iran, and Stockholm, Sweden, between September 24, 2012, and April 5, 2013, as a cross-sectional study, using a convenience sampling method. The participating hospitals were selected with permission from the authorities at the Tehran University of Medical Sciences and Locum AB in Stockholm. The inclusion criterion was a general hospital within the capital cities. Excluded were small hospitals (<100 beds) or privately operated hospitals.

Evaluation

This self-assessment study was conducted by a group of evaluators in each hospital. The assessment team consisted of physicians and nurses with an education and expertise in hospital disaster management and engineers who were professionals in nonstructural elements of hospitals. All team members were trained in advance as to the method and content of the HSI evaluation checklist developed by the Pan American Health Organization and the WHO.[1]

Only the nonstructural module of the HSI was used to assess hospital safety. The structural and functional capacity modules were not included in the current study.

The nonstructural module consists of 71 elements grouped into 5 submodules as follows (see Supplement)[1]:

- Critical systems include electrical system, telecommunications system, water supply system, fuel storage, and medical gases;
- Heating, ventilation, and air-conditioning (HVAC) systems in critical areas;
- Office and storeroom furnishings and equipment (fixed and movable) including computers, printers;
- Medical and laboratory equipment and supplies used for diagnosis and treatment; and
- Architectural elements.

Each element has 3 levels; high, average, and low, as defined by the HSI evaluation guideline (Supplement). The level and value for each element was determined by the evaluators through consensus. The value of each level is 1, 0.5 or 0, respectively.

All 5 submodules have equal weighting. The maximum total sum of the submodules is 1 (100%). The hospital safety index is categorized, in accordance with the HSI evaluation guideline,[1] as follows:

- Level A: The range of the safety index is 0.66-1 (66%-100%). It is likely that the hospital will function in a disaster. It is, however, recommended that preventive measures are carried out in the medium and long term to improve the safety level in case of disaster.
- Level B: The range of the safety index is 0.36-0.65 (36%-65%). Interventional measures are needed in the short term. The safety level is such that the ability of the patients, hospital staff, and the hospital to function during and after a disaster is potentially at risk.
- Level C: The range of the safety index is 0-0.35 (0%-35%). Urgent intervention is needed. The hospital's safety level is inadequate to protect the lives of patients and hospital staff during and after a disaster.

Statistical Analysis

To describe the hospital's nonstructural safety score, the mean, median, and standard deviation were calculated. Scores were compared between the hospitals in Stockholm and Teheran, using the Mann-Whitney test. A 2-tailed P value less than 0.05 was considered statistically significant. SPSS 16 (IBM) statistical software was used for data analysis.

Ethical Review

The current study has been reported in accordance with WHO's recommendation that participating hospital names and exact locations are to be confidential.[1]

RESULTS

Nine hospitals were included in this study, 5 from Teheran and 4 from Stockholm.

The most common hazards for hospitals in Tehran were earthquake, infrastructure failure, and epidemics. For the hospitals in Stockholm, the hazards were chemical accidents, epidemics, and infrastructure failure. A total of 8 hospitals were university hospitals, and 6 of those were large (Table 1).

The mean nonstructural safety index was 64% ± 17.4 SD (range, 45%-82%) for the hospitals in Tehran and 90% ± 2.4 SD (range, 87%-93%) for the hospitals in Stockholm ($P = .014$) (Table 2). The lowest safety index for the hospitals in Tehran (Table 2) was found in the medical and laboratory equipment and supplies used for diagnosis and treatment submodule. The hospitals in Stockholm had the lowest safety index in the critical systems submodule, which included electrical system, telecommunications system, water supply system, fuel storage, and medical gases (Table 2).

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TABLE 1

Background of Participating Hospitals in Tehran and Stockholm

Background	All Hospitals	Tehran Hospitals	Stockholm Hospitals
Affiliation, n			
University	8 (89%)	5	3
Non-university	1 (11%)	0	1
Size, n			
Large (400 beds)	6 (67%)	3	3
Medium (100-400 beds)	3 (33%)	2	1

TABLE 2

Nonstructural Safety Score of Participating Hospitals in Tehran and Stockholm

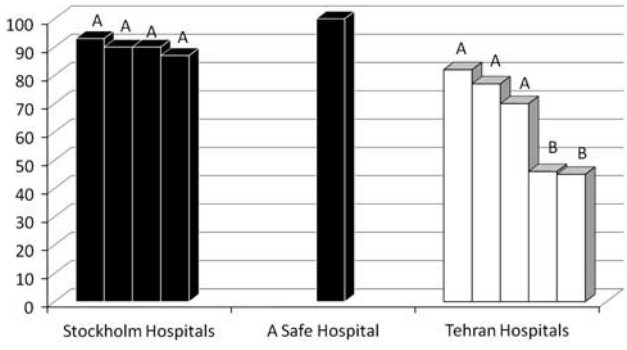
	Hospitals								
	Stockholm				Tehran				
Nonstructural Safety Score[a,b]	1	2	3	4	1	2	3	4	5
Submodule 1	0.167	0.164	0.167	0.164	0.200	0.140	0.099	0.094	0.118
Submodule 2	0.200	0.200	0.200	0.200	0.200	0.157	0.114	0.100	0.086
Submodule 3	0.134	0.167	0.167	0.200	0.100	0.130	0.200	0.134	0.100
Submodule 4	0.200	0.200	0.200	0.200	0.117	0.175	0.134	0.067	0.058
Submodule 5	0.167	0.167	0.167	0.167	0.200	0.167	0.156	0.056	0.100
Total Score	0.868	0.898	0.901	0.931	0.817	0.769	0.703	0.451	0.462

[a] The highest value for each submodule is 0.200.

[b] Submodule 1 is critical systems, ie, electrical system, telecommunications system, water supply system, fuel storage, and medical gases; submodule 2, heating, ventilation, and air-conditioning systems in critical areas; submodule 3, office and storeroom furnishings and equipment (fixed and movable), eg, computers, printers; submodule 4, medical and laboratory equipment and supplies used for diagnosis and treatment; and submodule 5, architectural elements.

FIGURE

Nonstructural Safety of Hospitals Studied in Tehran and Stockholm Compared to a Safe Hospital.



All hospitals in Stockholm were considered safe (level A), while 2 hospitals in Tehran were at risk (level B) and 3 were safe (Figure). The nonstructural safety score of large hospitals was 78% ± 17 SD, as compared to medium-sized hospitals with a safety score of 72% ± 24 SD. No significant difference was found in nonstructural safety with respect to hospital size (P=.34).

DISCUSSION

The current study evaluated the nonstructural safety index of hospitals in Tehran and Stockholm. This study was conducted to be consistent with the Hyogo framework strategies on disaster risk reduction, including international cooperation and hospitals safe from disasters.[23] Our findings showed that the participating hospitals in Stockholm were safe with respect to nonstructural elements, while 2 of the 5 hospitals in Tehran were at risk, as measured by HSI.[1] These results were consistent with previous evaluations, which found nonstructural vulnerability to be one of the main safety failures of these hospitals.[13,24-26] However, further investigation is required, in which the WHO HSI can be used as an inexpensive, standardized and systematic tool with which to measure hospital safety. The application of a standardized tool allows for a comparison of hospital safety between individual hospitals on both national and international levels.

Tehran is located in an area with many active geological faults; therefore, it is vulnerable to seismic hazards, especially

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earthquakes.[27] Hospitals in Tehran are also vulnerable and are at risk of significant damage in an earthquake.[28] The impact on nonstructural elements can lead to a nonfunctioning facility or even the evacuation of a hospital,[5-8,29] and can, as demonstrated by the current study, be a serious threat to Tehran's hospitals. It is recommended that all hospitals in Tehran perform preventive measures in the medium and long term to improve the safety level in case of future disaster.

Maintaining a high standard of structural and nonstructural safety in health facilities, including hospitals, is a national rule and priority for the Iran's health system, in accordance with the country's disaster health management's strategic plan for 2012 to 2025.[30,31] Therefore, other barriers, such as lack of knowledge, absence of standards, and financial shortcoming may be the reason for low safety levels in some of Tehran's hospitals. In general, it is agreed that providing funding for hospital disaster management activities enables hospitals to enhance their disaster management capabilities, eg, nonstructural safety.[32,33] The findings of the current study can be used to develop a realistic risk reduction and medical disaster management plan for vulnerable cities. Also, it helps health system managers and authorities in Tehran to allocate and distribute financial resources in an effective manner, on the basis of disaster risk analysis.

The availability of medical equipment and supplies is a key element of surge capacity during disasters.[34-37] The relationship between the availability of required equipment and response performance is also important.[38] Medical and laboratory equipment and supplies were at the lowest level of safety in the hospitals in Tehran. As previous studies have shown, hospital function will be impaired or inhibited completely because of damage to medical equipment if resilience procedures and codes are not implementd.[14-26] The hospitals in Tehran need to enhance the safety of medical and laboratory equipment and supplies to respond to the medical needs during disasters when a surge of casualties occurs. Also, all hospitals are recommended to evaluate the safety of medical equipment for disaster impact, including those that were determined to be safe in that regard.

Critical systems (eg, electrical systems, telecommunications system, water supply system, fuel storage, and medical gases) were at the lowest safety level in the hospitals in Stockholm. This finding was consistent with a previous study indicating that internal disasters are likely threats to Swedish hospitals.[10]

Infrastructure has had a critical role in hospital functionality during disasters. Reports from previous disasters have shown that failure or damage of critical systems result in evacuation or the functional collapse of the hospitals.[8-12,29] Although hospitals in Stockholm are safe, with respect to nonstructural elements, an actual failure in one of the critical systems may render the hospital nonfunctional. Hospitals in Stockholm thus need to continuously re-evaluate, maintain, and plan for the enhancement of nonstructural safety of critical services.

No difference was found in our study between large and medium-sized hospitals with respect to nonstructural safety. The current findings were consistent with previous studies regarding hospital disaster preparedness and response.[32,39-41] Hospital safety is an effect of disaster risk reduction planning, irrespective of hospital size. All hospitals need to be safe and functional during disasters.[4]

Limitations

One of the limitations of this study was the small number of participating hospitals. However, this study represents the first attempt of both countries to compare hospital nonstructural safety using the internationally standardized method.[1] Another limitation was that the selection of participating hospitals was a convenience sample. Therefore, selection bias must be considered. However, all hospitals were from the capital of each country. All hospitals in Tehran followed the same disaster management strategy and plan with respect to hospital design and construction that was developed by the Ministry of Health and Medical Education. In Stockholm, the hospitals followed a similar strategy, in using a regulated building code that was developed by Locum AB in Stockholm County. In addition, the hospitals were evaluated by different team members, which may have resulted in inconsistency in the way the HSI checklist was applied. Even so, all teams were trained to use the same standardized tool for assessment and data collection.

CONCLUSIONS

Nonstructural safety was higher in the hospitals studied in Stockholm than in those in Tehran. Our findings showed that the level of hospital safety, with respect to disasters, was not related to local vulnerability and risk level.

We recommend that the WHO HSI be used as an evaluation tool of hospital safety to conduct standardized comparisons between individual hospitals, on both national and international levels. Findings from these comparative studies will assist disaster-prone and vulnerable communities and hospitals to identify shortcomings and gaps in disaster management and to gain the knowledge and skills with which to implement the measures of hospital disaster preparedness and safety. Additional factors that affect hospital disaster preparedness and safety such as legal and financial issues and national strategies also should be addressed in future studies.

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Supplementary material

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