Disaster Preparedness and Hospital Safety in State Hospitals in Lima (Peru)

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Abbreviations:
COVID-19: coronavirus disease 2019
HEDM: Hospital Emergency and Disaster Management
HSI: Hospital Safety Index
ICU: intensive care unit
IHCD: internal hospital crises and disasters
MAGDM: Multiple Attribute Group Decision Making Principle
PAHO: Pan American Health Organization
TOPSIS: Technique of Order of Preference by Similarity to Ideal Solution

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Abstract

Introduction: Peru's health infrastructures, particularly hospitals, are exposed to disaster threats of different natures. Traditionally, earthquakes have been the main disaster in terms of physical and structural vulnerability, but the coronavirus disease 2019 (COVID-19) pandemic has also shown their functional vulnerability. Public hospitals in Lima are very different in terms of year constructed, type of construction, and number of floors, making them highly vulnerable to earthquakes. In addition, they are subject to a high demand for care daily. Therefore, if a major earthquake were to occur in Lima, the hospitals would not have the capacity to respond to the high demand.

Objective: The aim of this study was to analyze the Hospital Safety Index (HSI) in hospitals in Lima (Peru).

Materials and Methods: This was a cross-sectional observational study of 18 state-run hospitals that met the inclusion criteria; open access data were collected for the indicators proposed by the Pan American Health Organization (PAHO) Version 1. Associations between variables were calculated using the chi-square test, considering a confidence level of 95%. A P value less than .05 was considered to determine statistical significance.

Results: The average bed occupancy rate was 90%, the average age was 70 years, on average had one bed per 25,126 inhabitants, and HSI average score was 0.36 with a vulnerability of 0.63. No association was found between HSI and hospital characteristics.

Conclusion: Most of the hospitals were considered Category C in earthquake and disaster safety, and only one hospital was Category A. The hospital situation needs to be clarified, and the specific deficiencies of each institution need to be identified and addressed according to their own characteristics and context.

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Introduction

Hospital safety is a condition that ensures that workers, patients, visitors, infrastructure, and equipment within a health care facility are free from risk or danger of accidents.[1] For its part, the Pan American Health Organization (PAHO; Washington, DC USA) defined a "hospital safe in the face of a disaster" as one whose services remain accessible and functioning at their maximum capacity and in the same infrastructure immediately after a disaster.[2]

In this context, the Republic of Peru, following the Hyogo Framework for Action (2005-2015)[3] and the Sendai Framework for Disaster Risk Reduction (2015-2030),[4] has adopted the Thirty-Second State Policy of the National Agreement as a starting point for Disaster Risk Management, with the aim of protecting the life, health, and integrity of people, as well as promoting a culture of prevention.[5]

Peru's health infrastructures, particularly hospitals, are exposed to disaster threats of different natures. Traditionally, earthquakes have been the main disaster in terms of physical and structural vulnerability,[6–11] but the coronavirus disease 2019 (COVID-19) pandemic has also shown their functional vulnerability.[12]

Public hospitals in Lima are very different in terms of year constructed, type of construction, and number of floors, making them highly vulnerable to earthquakes. In addition, they are subject to a high demand for care daily. Therefore, if a major earthquake were to occur in Lima, the hospitals would not have the capacity to respond to the high demand.[11] In Peru, a country located in the Pacific Ring of Fire, 81% of the world's earthquakes occur and an average of 150 to 200 earthquakes with minimum intensities and magnitudes of 4.0 or more are reported. Earthquakes in 1940, 1966, 1970, 1974, and 2007 had magnitudes equal to or less than 8.0. Meanwhile, Lima, the capital of Peru, registered 14 earthquakes in the years 1582, 1586, 1609, 1630, 1655, 1687, 1694, 1699, 1716, 1725, 1735, 1734, and 1743; the one in 1746 was the most destructive, accompanied by a tsunami which claimed the lives of 5,100 inhabitants of Lima and Callao.[13,14] As an example of what could happen in Lima, the 2007 earthquake in Pisco, very close to the capital, affected the infrastructure of seven health facilities, one of which was the Pisco Hospital, the most complex, more than 70 years old,[15,16] and which ended up inoperative.

The construction of hospitals in Peru is regulated by the technical standard E.030 on earthquake-resistant design of the national building regulations. In parallel, the Peruvian Ministry of Health (Lima, Peru) has incorporated the technical standard for infrastructure and equipment of health facilities for the second and third level of care[17,18] so that new hospitals are built under the seismic-resistant approach and have incorporated the safe hospital policy considered by the State as a commitment within the Sendai actions.

Considering that there are no published studies that analyze the safety of hospitals in Lima, as well as the high risk of earthquakes in that city, the objective of this study was to analyze the safety of hospitals in Lima, considering parameters of structural and functional vulnerability, which is useful for decision making in terms of prevention and improvement of hospital safety at the managerial and governmental level.

Methodology

The Department of Lima constitutes a very important part of the Peruvian territory and is in the central-western region of Peru, at 1,350 meters above sea level, covering inter-Andean and coastal areas. Its geographical coordinates are between 10º16'18" and 13º19'16" south latitude and 75º30'18" and 77º53'02" west longitude of the Greenwich meridian. The population is 11,369,314 inhabitants, and this area has a population density of 4033.10 inhabitants/km^2. A total of 66.1% of its population is between 15 and 60 years old, with a slight predominance of males. Life expectancy averages 80 years for women and 74 years for men. This geographical area has a mixed form, combining at the same time the form of cities, whose expansion is strongly conditioned by an irregular geography. The area has food, textile, agricultural, livestock, and fishing industries, among others. One of Lima's major current problems is related to public transport. This situation has led the municipal authorities to build viaducts, bridges, interchanges, expressways, and flyovers as a way of solving the constant congestion. The average age of the vehicle fleet in the Lima metropolitan area in 2021 was 13 years old. Throughout the area, there are more than 400 urban transport routes managed by 308 transport companies, which are provided by buses and minibuses, and the area also has an international airport located in the city of Callao. The mentioned traffic problems in this area can be a major limitation for evacuation in case of disaster. In Lima District, there are 38 hospitals (public and private) of very different size and care capacity. Only the 18 state-run hospitals are accessible to the entire population of this District.[19]

A cross-sectional observational study was conducted of 18 national public hospitals out of the 38 in the metropolitan area of Lima, selected under the criteria of being state-run hospitals, having complete information on open access safety indicators, and belonging to Category II (hospitals with out-patient, emergency, in-patient, and intensive care capacity) and Category III (specialized and sub-specialized care, out-patient, in-patient, and emergency hospitals in the specialties, as well as proposing standards to the national authority and developing technological innovation and research and teaching) of the Peruvian Ministry of Health classification.[20]

The open data sources used are the evaluation reports of the hospitals carried out by the official auditing bodies of the Peruvian Ministry of Health and of the hospitals themselves. The evaluation reports of the hospitals have been validated by the official auditing bodies of the Peruvian Ministry of Health.

The parameters of the Hospital Safety Index (HSI) proposed by PAHO Version 1,[2] which includes structural, non-structural, and functional vulnerability, were evaluated. The parameters assessed were: (1) degree of specialization of the hospital according to the Peruvian Ministry of Health classification; (2) date of elaboration of the last hospital safety plan; (3) total reported beds of the most current date (all of them were reported at a date after the 2020 pandemic where there was expansion of hospital beds); (4) most updated reported occupancy percentage; (5) year of construction (the first year of hospital operation was considered); (6) population assigned to each hospital by the Ministry of Health according to the latest available report; (7) HSI, expressed as a numerical value and as hospital safety Category A, B, or C, calculated according to PAHO methodology (Category A: high, with index of 0.0 - 0.35; Category B: index of 0.36 - 0.65; and Category C: index of 0.66 - 1.0, with Category A showing that hospitals can continue to function in emergency and disaster situations); (8) vulnerability index and vulnerability category (high, medium, or low) obtained with PAHO's mathematical model of the HSI; (9) existence of plans in case of earthquakes, tsunamis, volcanoes, and landslides (three categories were considered: facility does not have plans or they exist only in documents, facility has plans and trained staff, or facility has plans, trained staff, and allocated resources); and (10) existence of plans in case of agents with epidemic potential (three options were considered: facility does not have plans or they exist only in documents, facility has plans and trained staff, or facility has plans, trained staff, and allocated resources).

Open access documentary information was collected from each hospital using a virtual data collection form. From the records, a descriptive statistical analysis was performed. Associations between the characteristics of hospitals and the HSI were calculated using the chi-square test. A P value of less than .05 was considered to determine statistical significance. Statistical software SPSS v.26 (IBM; Armonk, New York USA) and Stata v.15 (Stata Corp; College Station, Texas USA) were used.

Results

The 18 studied public state hospitals in Lima had an average of 294 in-patient beds per hospital, with an average bed occupancy rate of 90%. The oldest hospital was built in 1826, while the most modern hospital was built in 2016. The average age of the hospitals studied was 70 years. The safety plans of these hospitals had been drawn up from 2015 through 2021. The average population assigned to each hospital was 1,331,319 inhabitants (ie, one bed per 25,126 inhabitants). Table 1 shows the average

	Mean	Maximum	Minimum
Plan Date		2021	2015
Total Beds	294	796	7
Occupation Rate	90	100	65
Year of Construction	1953	2016	1826
Age	70	197	7
Covered Population	1,331,319	2,864,000	67,810
Beds per Person	25,126	357,143	351
Hospital Safety Index	0.36	0.80	0.19
Vulnerability	0.63	0.81	0.20

Table 1. Characteristics of Hospitals in Lima (Peru)

		n	%
Degree of Specialization	Category III	12	66.7%
	Category II	6	33.3%
Earthquakes, Tsunamis, Volcanoes, Landslides	Does Not Exist or Only in Document	3	16.7%
	There is a Plan and Staff	6	33.3%
	There is a Plan, Staff, and Resources	9	50.0%
Agents with Epidemic Potential	Does Not Exist or Only in Document	6	35.3%
	There is a Plan and Staff	4	23.5%
	There is a Plan, Staff, and Resources	7	41.2%
Hospital Safety Index Category	Category C	10	55.6%
	Category B	7	38.9%
	Category A	1	5.6%

Table 2. Hospital Safety Indicators and Categorization of Lima's Hospitals

value of the HSI was 0.36, which implied an average vulnerability of 0.63.

Of the 18 hospitals included in the study, 66.7% were categorized as Level III specialized; 50.0% had plans, trained personnel, and resources to deal with disasters in the event of earthquakes, tsunamis, volcanoes, and landslides; 41.2% had plans, trained personnel, and resources to deal with agents with epidemic potential; and 55.6% were classified as Category C in the HSI. Table 2 shows the hospital safety indicators and the categorization of hospitals in Lima. Table 3 shows the association between the HSI category of the Lima hospitals studied and each of the characteristics associated with the HSI category level.

Discussion

One finding of this study, relevant in terms of vulnerability and hospital safety, is the age of the hospitals with an average of 70 years. The 86% of hospital safety publications analyzed in a recent systematic review showed that, in the event of a disaster, the hospital structure is one of the most important elements in hospital safety and risk, identifying the age of the building, the type of building, the construction materials, and the type of flooring as factors that increase the risk of hospital damage in the event of a disaster.[21] In a study conducted in Mexico, it was found that in hospitals older than 40 to 50 years, structural adaptations according to safe hospital guidelines are too costly and unfeasible, so it is recommended to replace them with new hospitals built in different spaces.[22]

Another aspect to consider is the likelihood of occurrence of internal hospital crises and disasters (IHCDs) in institutions with old infrastructure and operating systems. A study conducted in hospitals in the Netherlands on 134 IHCDs over a 20-year period, with an average of 6.7 IHCDs per year, concluded that these IHCDs can lead to hospital closures, patient evacuation, and loss of health care capacity, identifying technical failures, fires, power failures, and hazardous substance warnings as their causes. In addition, 29.1% were cascading events of multiple failures and warned that every hospital should prioritize planning to prevent and control these events with full staff training. In this sense, hospitals in Lima, being so old, should be subjected to evaluations to determine the feasibility, effectiveness, and efficiency of their modernizations.[23]

Regarding the characteristics of the hospitals involved in the study, it was found that their safety plans had been developed from 2015 through 2021. In addition, only 17.6% of the hospitals had plans, resources, and staff trained to deal with threats from agents with epidemic potential and only 22.2% were trained to deal with earthquakes, tsunamis, volcanoes, or landslides. This is consistent with the findings of a study in 28 hospitals in Iran, where 65.5% had moderate disaster preparedness.[24] This result not only leads to an analysis of the importance of having contingency plans, but also that such plans should be contextualized to reality, existing social and environmental changes, as well as being well-planned and feasible to be implemented immediately when required. In this regard, a study carried out in Taiwanese hospitals, in which the modelling of patient flow by routes during an earthquake emergency care, considering demand, crowding index, health throughput, and times, highlighted the importance of implementing adequate, well-planned, and organized response measures.[25]

Peru, considered a country with a high seismic risk, should not only have up-to-date plans, available and scrupulously known by each member of the hospital institutions, but these plans should be addressed in accordance with the current changes in climate, geology, global phenomena, and social changes starting from a national model that branches out to the local level.

Regarding the care capacity and occupancy rate (90%) of hospitals, a five-year follow-up study in Sweden showed an average bed occupancy rate of 93.3% and that a 10.0% increase in occupancy was associated with a 16-minute increase in hospital stay and a 1.9% decrease in admission rates.[26] Another study in the United States showed that lack of bed availability was associated with delayed transfer of patients requiring intensive care, just as delay in obtaining an intensive care unit (ICU) bed was associated with more hospital deaths and ICU re-admissions.[27]

Lack of hospital bed availability also causes user dissatisfaction, as demonstrated by a study of hospitals in England where the bed occupancy rate showed a positive association with mortality and a negative association with health improvements.[28]

The availability and occupancy of hospital beds is very relevant, even more so when catastrophic or pandemic events occur. This is demonstrated by a study conducted in New York (USA) which reports that during the COVID-19 pandemic, the bed occupancy rate reached 118%, and the increase in occupancy rate was

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		HSI Category							
		Category C		Category B		Category A			
		n	%	n	%	n	%	χ^2	P Value
Degree of Specialization	Category III	7	38.9%	4	22.2%	1	5.6%	0.836	.658
	Category II	3	16.7%	3	16.7%	0	0.0%		
Earthquakes, Tsunamis, Volcanoes, Landslides	Does Not Exist or Only in Document	2	11.1%	1	5.6%	0	0.0%	1.543	.819
	There is a Plan and Staff	4	22.2%	2	11.1%	0	0.0%		
	There is a Plan, Staff, and Resources	4	22.2%	4	22.2%	1	5.6%		
Agents with Epidemic Potential	Does Not Exist or Only in Document	5	29.4%	1	5.9%	0	0.0%	4.907	.297
	There is a Plan and Staff	1	5.9%	3	17.6%	0	0.0%		
	There is a Plan, Staff, and Resources	3	17.6%	3	17.6%	1	5.9%		
Occupancy Rate	Less than 85%	2	11.1%	2	11.1%	0	0.0%	4.050	.132
	86 to 95%	5	27.8%	4	22.2%	1	5.6%		
	96% or More	3	16.7%	1	5.6%	0	0.0%		
Age	Less than 50 Years	3	16.7%	2	11.1%	1	5.6%	5.812	.055
	50 to 80 Years	3	16.7%	4	22.2%	0	0.0%		
	81 Years or More	4	22.2%	1	5.6%	0	0.0%		
Beds per Person	1,000 or Less	0	0.0%	1	5.6%	0	0.0%	2.181	.336
	1,001 to 5,000	6	33.3%	4	22.2%	1	5.6%		
	5,001 or More	4	22.2%	2	11.1%	0	0.0%		

Table 3. Characteristics Associated with the HSI Category Level of Lima Hospitals
Abbreviation: HSI, Hospital Safety Index.

associated with hospital mortality, which increased by 0.7% for every 1.0% increase in occupancy.[29]

The ideal occupancy rate is 80% to 85%, as the remaining percentage should be considered free for unexpected situations.[30] This highlights the problem of hospital bed availability in Lima. A study conducted in the United States showed that changes in testing or advanced treatment in the emergency department did not facilitate a decrease in admissions during periods of high hospital occupancy.[31] Another study carried out in Spain indicated that, in six years, the average annual growth in occupancy was four percent.[32] In the face of a seismic event, hospital beds in Lima would be insufficient, a fact that has been amply demonstrated during the last pandemic, in addition to the shortage of health professionals trained to deal with disaster emergencies and the limited resources available to deal with them.[31]

Finally, with respect to the HSI, the average score recorded by Lima's hospitals was 0.36, which implied an average vulnerability of 0.63; in addition, 55.6% belonged to Category C and only 5.6% belonged to Category A. Only a few studies have reported on the HSI of hospitals in different countries; a study analyzing primary care centers in a province of Iran, assessing disaster safety with a maximum of 100 points, found that these facilities had an overall average score of 28.7 (low safety in functional, structural, and non-structural aspects).[33]Another study conducted in 15 hospitals in Indonesia found that their HSI had a value of 0.544 (equivalent to Category B).[34]

In contrast, in a study of six Australian hospitals, their HSIs were found to have high scores. In addition, vulnerabilities and opportunities for improvement were identified.[35] According to a study that evaluated Chinese hospitals, the HSI assessment can provide a basis for the hospital to quickly discover its weaknesses in disaster prevention and emergency response, promote hospital modernization and transformation, and improve its own safety to ensure the normal exercise of hospital functions in emergency situations.[36]

It is not enough just to know the category in which hospitals are located; nowadays, technology offers different possibilities to identify the vulnerabilities of each hospital according to different situations through simulation, projection, and application of dedicated programs for such purposes. A study carried out in 15 hospitals in Indonesia to assess the Hospital Emergency and Disaster Management (HEDM) index, using TOPSIS (Technique of Order of Preference by Similarity to Ideal Solution) and MAGDM (Multiple Attribute Group Decision Making Principle) models, concluded that the hospitals' HMI was 0.408 out of 1.0. However, by applying HEDM and TOPSIS for MAGDM modelling, it was possible to identify changes in the factors studied so that it is possible to make them more proactive in reducing disaster risk by classifying these factors into mitigation, preparedness, response, and/or recovery factors for each emergency and disaster management attribute.[37]A study of six Sri Lankan hospitals using the Papathoma Tsunami Vulnerability Assessment (PTVA)-4 model identified two of the hospitals with the highest tsunami risk and specified the vulnerability score of each hospital, identifying their critical points.[38]

The fact that no association was found between the hospitals' HSI category and the characteristics studied, such as degree of specialization of the hospital; availability of plans in case of earthquakes, tsunamis, volcanoes, and landslides; plans in case of agents with epidemic potential; occupancy rate; years of age; and beds per person of the assigned population, demonstrates that

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hospitals in Lima are deficient regardless of these characteristics. In other words, this is not a particular problem but a generalized situation, which implies greater risk.

Limitations

The limitations of this study were: (1) the evaluations that public auditing bodies have made of hospitals have not all been carried out in the same year; and (2) access to the evaluations of privately owned hospitals was not possible.

Conclusions

Hospitals in Lima show a high level of vulnerability and are characterized by old buildings, a large population and low availability of hospital beds, as well as deficiencies in the availability of plans, resources, and trained personnel to deal with catastrophes or epidemic threats.

Most of the hospitals have a Category C for earthquake and disaster safety, and only one hospital had a Category A. There are no characteristics associated with this finding. It is necessary to identify and address the specific deficiencies of each institution according to its own characteristics and context. This leads to the need to reflect and take serious actions so that Peru as a country, through its health system, is better prepared for undesired events that generate emergency and disaster situations, based on a complete and timely diagnosis with the help of modern technological tools.

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