Hospitals of the Mexican Institute of Social Security in the face of September 2017 earthquakes. Analysis from the perspective of the Safe Hospital Program

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Abstract

Introduction: The function of hospitals during major emergency or disaster is vital. Their response capacity depends on their geographic location, adequate organization, structural safety and safety of non-structural elements. After September 2017 earthquakes, self-assessment and Safe Hospital Program assessment results were compared in disabled hospitals belonging to the Mexican Institute of Social Security. **Objective:** To compare the Hospital Safety Index (HSI) with self-assessments carried out by the units. **Method:** HSI and the Pan-American Health Organization/World Health Organization checklist were used. The comparison was carried out in 3 hospitals that were disabled after September 2017 earthquakes. **Results:** Variability was observed in HSI, which revealed self-assessment biases: no hospital obtained a HSI score lower than 0.35, although all 3 were disabled in the immediate phase after the seismic events. **Conclusions:** Result variability depends on who applies the instrument. Quick HSI assessment provides an immediate idea of the probability for a hospital to continue functioning in case of disaster and allows determining mitigation actions to increase health facilities' resilience and safety.

KEY WORDS: Resilience. Safe hospital, Earthquake

Introduction

The role of hospitals during an emergency or disaster is vital. Their response for the care of victims and avoidance of life losses will depend not only on their organization, but also on that their facilities are able to withstand such contingency, i.e., of being safe hospitals.¹

Keeping a hospital safe depends on four essential factors: its geographical location, its organization level, safety of the building and safety of non-structural architectural elements (vital lines, furniture and equipment).¹

According to the Pan American Health Organization and World Health Organization (PAHO/WHO) definition, a safe hospital is "a health facility the services of which remain accessible and functioning at its maximum installed capacity and in the same infrastructure, immediately after a destructive phenomenon of natural origin", a concept that was implemented as a national risk-reduction

policy by several countries, including Mexico, and that allows hospitals to have the minimum indispensable measures to protect life, investment and functioning since their planning.¹

To determine that a hospital is safe, a multidisciplinary team applies the PAHO/WHO checklist¹ (CL), which is a reliable and low-cost quick assessment tool that provides an immediate idea of the probability for a health establishment to continue functioning in cases of disaster, without replacing more complex vulnerability studies, by obtaining the hospital safety index (HSI).

In this research, hospitals of the Mexican Institute of Social Security (IMSS – *Instituto Mexicano del Seguro Social*) that were damaged by the earthquakes of September 7 and 19, 2017 in Mexico and their HSI results are analyzed after two self-assessments and an evaluation of the Safe Hospital Program (PHS – *Programa Hospital Seguro*).

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Table 1. Measures and schedule of actions with regard to the Hospital Safety Index results in hospitals of the Mexican Institute of Social Security

Category	Hospital Safety Index	Interpretation of results (necessary measures)
A	0.66 to 1	Urgent measures Although the hospital is likely to continue operating in case of disaster, continuing with measures to improve the response capacity and carrying out medium and long-term preventive measures is recommended, in order to improve the safety level in the eventuality of disasters.
B	0.36 to 0.65	Short-term measures Necessary measures are required in the short term, as current safety levels of the facilities can potentially put patients, staff and functioning at risk during and after a disaster.
C	0 to 0.35	Medium and long-term measures Urgent and immediate measures are required, since the facilities' safety levels are insufficient to protect the lives of patients and staff during and after a disaster.

Background of Mexico's Safe Hospital Program

Mexico's PHS has as its background in the International Conference on Disaster Mitigation in Health Facilities (1996), where recommendations and commitments to promote disaster mitigation strategies in health facilities were issued.² Subsequently, the Safe Hospitals in Disasters strategy was included in the Hyogo Action framework³ (2005) and ratified in the Sendai Framework⁴ (2015), whereby emphasis was made on the importance of damage and service interruption reduction, as well as on health facilities' resilience; resilience is understood as the capability a system, a community or a society exposed to a threat has to resist, absorb, adapt, transform and timely and efficiently recover from its effects, in particular through the preservation and restoration of its structures and basic functions through the management of risks, according to the United Nations Office for Disaster Risk Reduction.

In 2006, Mexico established the National Committee for Evaluation, Diagnosis and Certification of the Safe Hospital Program (CNEDCPHS – *Comité Nacional de Evaluación, Diagnóstico y Certificación del Programa Hospital Seguro*), directed by the Civil Protection National Coordination Agency (CNPC – *Coordinación Nacional de Protección Civil*) of the Ministry of the Interior, a governing entity for civilian protection that has the faculties to act from the legal field. CNEDCPHS is comprised by official representatives of public, private and social organizations, which allows a global and balanced vision, and is responsible for hospital evaluations within the PHS.

Mexican Institute of Social Security and the Safe Hospital Program

The Mexican Institute of Social Security is the largest social security institution in Latin America, which serves more than 75 million people and has more than 6206

Figure 1. Hospital Safety Index graphic example.

medical units throughout the country, out of which 297 are secondary and tertiary care hospitals.⁵

A priority strategy in that institution after the 1985 earthquakes was to have "safe hospitals" available; one of the lessons learned was the need to evacuate 2300 patients from the hospitals that integrated the National Medical Center in Mexico City and that were disabled due to the damages in vital lines. After damage assessment, buildings (10 to 12-floor tall) were demolished and new buildings were built with foundations over 14 meters deep, no more than six-floor tall and with structural technology that incorporated energy dissipators.⁶ Following up on this strategy, in 1997, the Institute signed a technical collaboration agreement with PAHO/WHO to develop a program for hospitals' evaluation and diagnosis and to implement measures to increase their safety and strengthen their infrastructure in situations of disaster.⁷

At the time of this report, CNEDCPHS had evaluated 151 hospitals of the Mexican Institute of Social Security using the PAHO/WHO CL; once the evaluation was made, the PAHO/WHO mathematical model was applied to determine the HSI,⁸ which classifies hospitals in categories A, B and C, which prioritize intervention necessities for increasing hospital safety (Table 1 and Figure 1). Of the

Table 2. Mexican Institute of Social Security hospitals with damages caused by September 2017 earthquakes

Entity	Hospitals per entity (n)	Hospital beds in the entity (n)	Hospitals with damages	Available beds in the hospital (n)	Disabled hospital beds (n)	Time to recover 100% of functionality
Puebla	7	728	415	HGR 36 "San Alejandro"	415	Building of new hospital in 2 to 3 years
			42	HGZ 5 Metepec	0	4 months
Mexico city	15	2674	272	HGR 25 I. Zaragoza	272	8 months
			103	Gineco-pediatría 3 A	0	3 weeks
			205	HGZ 32 Villa Coapa	205	1 year
Morelos	3	394	52	HGZ/UMF 7 Cuautla	52	1 year
State of Mexico	17	1838	149	HGZ/UMF 68 Tlupetlac	0	3 weeks
			185	HGR 196 Fidel Velázquez	0	3 weeks
Total	43	5634	1423	8	944	

HGR (*Hospital General Regional*) = Regional General Hospital, HGZ (*Hospital General de Zona*) = Zone General Hospital, HGZUMF (*Hospital General de Zona con Unidad de Medicina Familiar*) = Zone General Hospital with Family Medicine Unit.

151 hospitals, 4 had been classified in category C, three due to vulnerability in non-structural and functional safety and one due to vulnerability in structural safety, which was shut down and demolished; hospitals with classification A and B showed vulnerability in non-structural safety, which has been mitigated with reinforcement actions, as well as vulnerability in functional organization, and courses for health care operative and managerial personnel were therefore implemented in hospital plans to face emergencies and disasters and undertake actions against different threats.

September 2017 earthquakes

Two earthquakes occurred in September 2017: on the 7th at 23:49:18 hours, with a magnitude of 8.2 and epicenter 133 km southwest of Pijijiapan, Chiapas, which affected the states of Oaxaca and Chiapas;⁹ and on the 19th at 13:14:40 hours, with a magnitude of 7.1, epicenter 12 km southeast of Axochiapan, Morelos, which affected Morelos, Puebla, Mexico City and the State of Mexico.¹⁰

Methods

Information of the Mexican Institute of Social Security about hospitals that suffered damage secondary to the September 2017 earthquakes and the results of the CNEDCPHS evaluation and two self-assessments carried out as part of the internal routine actions of the Institute were analyzed.

Results

Impact of the earthquakes on IMSS hospital infrastructure

The zone affected by both earthquakes included six states of the country, no medical unit of the Institute did collapse, there were no deaths among the personnel, patients or visitors and only the September 19 earthquake caused damages in some hospital units.

As a result of the earthquakes, there were damages in 8 hospitals located in 4 entities of the country: Mexico City, the State of Mexico, Puebla and Morelos (Table 2), 4 with disabling damage (3 were shut down and one had a partial closure), which represented a 944-bed deficit (12 %) out of 5634 hospital beds in these entities.¹¹

The main damages in the 4 units that were not disabled were associated with architectural elements: detachment of ceilings, separation in division walls, plasterwork cracks, broken glasses, detachment of coatings on building joints; patient care was not suspended and functioning to a 100% was achieved in a 3-week to 4-month period, since the units have plans for adapting areas and suspending non-priority services (operation continuity plan); one example was Hospital General de Zona 5 from Metepec, Puebla, where the damage disabled the operating rooms' area and two mobile surgical units were installed.

Hospital General Regional 25, with 272 beds, suffered damage to walls and finishes in the hospitalization area,

Table 3. Results of assessments and self-assessments based on the checklist

Entity	Hospital	Start of operations	Assessment date	Category/HSI		
				CNEDCPHS Assessment	SII-PC 2012 Self-assessment	CIRI 2016 Self-assessment
Mexico City	HGZ 32 Villa Coapa	1976	2007	B (0.64)	A (0.96)	B (0.65)
			2014	B (0.59)		
Morelos	HGZ/UMF 7 Cuautla	1968	2014	A (0.73)	A (0.79)	B (0.47)
Puebla	HGR 36 "San Alejandro"	1972	2007	B (0.62)	A (0.73)	B (0.56)

HGR (Hospital General Regional) = Regional General Hospital, HGZ (Hospital General de Zona) = Zone General Hospital, HGZUMF (Hospital General de Zona con Unidad de Medicina Familiar) = Zone General Hospital with Family Medicine Unit, CNEDCPHS (Comité Nacional de Evaluación, Diagnóstico, Certificación del Programa Hospital Seguro) = National Committee for Assessment, Diagnosis and Certification of the Safe Hospital Program, SII-PC (Sistema de Información Integral de Protección Civil) = Civil Protection Comprehensive Information System, CIRI (Cédula de Identificación de Riesgos Inmobiliarios) = Real Estate Risk Identification Card.

which was deemed to be disabled; rehabilitation was scheduled to take 8 months and it continues operating in the emergency areas, outpatient consultation, imaging, laboratory and pharmacy.

Damages in the 3 hospitals that were fully disabled were the following:

- Hospital General Regional 36 "San Alejandro", Puebla (415 beds): damage to supporting walls and columns in the outpatient services, hospitalization, emergency, operating rooms and obstetric surgery buildings; subsidence and unevenness between the structures.
- The hospital had structural reinforcement at two different moments: first, for damages caused by an earthquake in 1993 and subsequently after the results of a PHS evaluation. The first reinforcement was carried out with steel diagonals with energy dissipators to achieve higher structural safety. The second reinforcement, was also based on a steel structure, but encasing columns with steel plates and diagonal structural beams, also of steel; investment was 244.4 million pesos and the works were still ongoing at the moment of the September earthquake; the reinforcement contributed to the building having a structurally acceptable response and not collapsing.
- Hospital General de Zona 7 Cuautla, Morelos (52 beds): partial damage in the emergency room, operating theaters, obstetric surgery area and major damage in the hospitalization area.
- Hospital General de Zona 32 Villa Coapa, Mexico City (205 beds): damage to load-bearing walls and finishes, and on main and emergency staircases.

The assessment results of the three hospitals that were disabled and shut down were reviewed (Table 3):

1. CNEDCPHS evaluation: it follows a strict protocol, it requires at least three trained evaluators, trained and certified by the Ministry of the Interior; they

must belong to institutions other than that which is to be evaluated, as well as to different disciplines (doctors, engineers, architects, administrators, etc.); if the evaluation protocol is not complied with, the evaluation is canceled.

2. Civil Protection Comprehensive Information System Self-Assessment: in 2012, CNPC requested the different health institutions to have their medical units enter their information in an informatics platform where in an automated form the HSI was generated.
3. Self-assessment with the Real Estate Risk Identification Card (CIRI – *Cédula de Identificación de Riesgos Inmobiliarios*) based on the PAHO/WHO CL: in 2016, the Mexican Institute of Social Security developed a platform as part of the Real Estate Risk Identification Program actions, where medical units entered their information, by means of which the HSI was obtained.

All three hospitals obtained an A HSI on the 2012 self-assessments, with higher scores than those obtained on the CNEDCPHS evaluations carried out by personnel specifically trained for that purpose; the self-assessment was carried out by hospital staff. This allows to consider the presence of bias at the moment the CL was applied; when the results of the CNEDCPHS assessments are compared with the self-assessments carried out in 2016 at the three hospitals, differences in the scores were appreciated again, although not so broad as in 2012.

The factors that can modify these results are diverse: experience of the staff for applying the CL, understanding of the concepts that are assessed, the form in which the CL is applied, since for the CNEDCPHS evaluation, a strict protocol is followed, whereas self-assessments involve the government body and members of the Emergency Operations Committee.

Discussion

The Mexican Institute of Social Security has adopted the PHS and is committed to mitigating the destructive effects of adverse phenomena and increase the safety of facilities, has made investments for reinforcement, has shut down hospitals when it has been necessary, has relocated them or built new buildings following the PHS guidelines; it has demolished a hospital located on a geological fault in Morelia, as well as a hospital in Mexico City with more than 50 years of age and with structural damage by the earthquake of March 20, 2012.¹²

The three hospitals that were disabled and shut down were built prior to 1980 when there were other construction codes, which were modified after the 1985 earthquake; this issue is evaluated in the CL, in the structural safety section that specifies ground characteristics, type of subsoil, how it was built and hospital type, among others. In a systematic review on risk criteria for selection of the location site for a hospital, the main criteria were the cost and demand for services.¹³ Since their planning, new hospitals implement the PHS guidelines, where the importance of geographical location, type of soil, the threats hospitals will be exposed to and the use of technologies that are adequate to the different environmental conditions of the country and that, without detriment of medical services quality, support environmental sustainability, is established. This implies that, when designing a medical unit, factors such as fluid and solid residues reuse, waste minimization and awareness on the advantages of reducing the ecological impact are to be considered.^{11,12}

The damage a hospital can suffer in structural and non-structural aspects due to an earthquake are variable, from problems of finishes and detachment of false ceilings or walls, to total collapse of the building; structural behavior during the earthquake highly influences on non-structural components, especially those that are connected, such as vital lines.

Achour et al.¹⁴ summarize how structural and architectural damage are different and depend specifically on each situation, whereas damage to equipment and furniture is usually similar. These observations are complemented with those of the study by Kirsh et al.¹⁵ on the impact on hospital functionality after the 2010 earthquake in Chile, where none of the 7 studied hospitals collapsed; however, the main damage was the lack of external supplies such as water, energy and communications. None of the Mexican Institute of Social Security

hospitals did collapse; however, there were damages that decreased their installed capacity.

When analyzing the data of the three hospitals' evaluations, the difference in the scores obtained on self-evaluations (carried out by hospital staff) stand out. Different factors can lead to underestimate or overestimate the scores awarded to each variable with regard to the CNEDCPHS assessment, where subjectivity is eliminated by the protocol that is followed and the independent evaluation staff. In the study by Ardalan et al.,¹⁶ 421 Iranian hospitals carried out their self-assessment in 2015, 80 % were rated with medium safety and none with high safety; hospital emergency committees were responsible for entering the information to the platform developed for that purpose. In turn, Asefzadeh et al.,¹⁷ when assessing two Iranian hospitals, observed a high level of safety; however, their results differ from those of other researchers, which is attributed to the data collection methods: oral interviews, written questionnaires, information collector experience, among others, which might coincide with the reasons for the differences in the three assessments of hospitals with damages we refer.

Functional organization vulnerability is a relevant issue because sometimes a hospital can be maintained physically and functionally fit; however, the lack of staff training for addressing an emergency or disaster can be its main weakness. In a study conducted in Tehran, Iran,¹⁸ one of the main vulnerabilities in the functional organization assessed by the CL was observed to be associated with the plans, guidelines, procedures, monitoring and evaluation. Chopin et al.,¹⁹ in an investigation carried out after the 2007 earthquake in Peru, observed that a larger number of medical units that had an emergency response plan in place were able to maintain medical care than those without a plan ($p = 0.043$).

Another relevant aspect about emergency response plans is that they must have a multi-threat approach that considers the care of different types of injuries, as stated by Ushizawa et al.²⁰ with regard to radiation exposure after the March 11, 2011 earthquake in Japan. In that regard, although in this analysis of damaged hospitals functional organization was not assessed separately, in the Mexican Institute of Social Security, protocols²¹ for care in emergencies and disasters are applied, which include evacuation of medical units with an emphasis on critical areas and plans for the care of a massive balance of victims, which allow the staff to immediately adapt the areas for the care of patients, discontinuation of non-priority services, establishment of triage areas and mechanisms for reference and counter-reference.

Conclusions

September 2017 earthquakes of caused damage to 8 hospitals without any of them collapsing; however, three suffered damages that disabled them; in two, reinforcement works are being carried out and the other one will be demolished to build a new one.

Assessment under the PHS stricter protocol, independently of self-assessments, allows knowing the measures that must be taken to strengthen hospital safety. The costs generated by the investment on reinforcement have no comparison with what it means to safeguard life.

After the 2017 earthquakes, in Mexico we have the opportunity to continue developing a safe and resilient health sector.

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