Fire Risk Assessment in High-Rise Hopitalls in Accordance With NFPA 101

Evaluación de riesgo de incendio en Hopitalls de gran altura de acuerdo con NFPA 101

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Abstract

Protection the high-rise hospitals against fire is very important due to presence of disable patients, hospital's diverse population, multiple floors and having multiple units on floors. The present study was aimed to assess fire risk in a high-rise hospital. Assessment NFPA healthcare worksheets were extracted from NFPA101 standard completed through field observation. In the next stage, gathered information was analyzed using CFSES software. From all studied zones 100% in the aspects of fire containment and extinguishment were unacceptable. In total, the fire risk level was acceptable in 80% and 100% in the aspects of people movement and general safety, respectively. Our findings indicated that to improve the level of fire risk in high rise hospitals, required measures especially in the area of fire extinguishment and containment including buildings design for automatic sprinkler systems and standardization of fire controls.

Keywords: High-rise hospitals, Fire risk assessment, NFPA 101, CFSES software.

Resumen

La protección de los hospitales de gran altura contra el fuego es muy importante debido a la presencia de pacientes discapacitados, la población diversa del hospital, pisos múltiples y tener varias unidades en el piso. El presente estudio tuvo como objetivo evaluar el riesgo de incendio en un hospital de gran altura. Evaluación Las hojas de trabajo de salud de la NFPA se extrajeron del estándar NFPA101 completado a través de la observación de campo. En la siguiente etapa, la información reunida se analizó utilizando el software CFSES. De todas las zonas estudiadas, el 100% en los aspectos de contención y extinción de incendios fueron inaceptables. En total, el nivel de riesgo de incendio fue aceptable en 80% y 100% en los aspectos de movimiento de personas y seguridad general, respectivamente. Nuestros hallazgos indicaron que para mejorar el nivel de riesgo de incendio en hospitales de gran altura, se requieren medidas especialmente en el área de extinción de incendios y contención, incluido el diseño de edificios para sistemas de rociadores automáticos y la estandarización de los controles de incendios.

Palabras clave: Hospitales de gran altura, evaluación de riesgo de incendio, NFPA 101, software CFSES.

Introduction

Hospitals are in the business of preserving and restoring health and comfort. At the same time, they must protect their patients and staff from fire and other hazards. Protection the hospitals against fire is very important due to presence of disable persons, lack of awareness and expensive devices and equipments in the hospitals (Jahangiri et al., 2016). In 2011-2015, National Fire Protection Association (NFPA) responded to an estimated annual average of 5,750 structure fires in health care properties each year. These fires caused annual averages of two civilian deaths, 157 civilian injuries, and $50.4 billion in direct property damage (Richard, 2017).

Fire safety is one of the greatest challenges facing the designers and operators of high-rise hospitals. This is particularly true where patients are highly dependent on members of staff, for example, the elderly, the mentally ill, those in intensive care units, etc (Koohpaie et al., 2011). In an emergency evacuation situation in a high-rise hospital, many patients will be unable to walk independently out of the hospital (Charters, 1996). Because high-rise hospitals

tend to have more patients and a longer distance to the exit discharge, fire prevention and fire risk assessment for building are essential.

The aim of high-rise hospital fire risk analysis is to gain insight into and characterize fire-related risks to better inform the wide range of decisions that must be made as part of hospital design, construction, and operation (Meacham et al., 2016). Therefore, the results from this study can potentially help in furtherance of research in a particular field of knowledge and can be a guidance in administering the workplace health and safety promotion program.

Materials and methods

This cross-sectional descriptive study was conducted in a high-rise hospital (12 floor) in accordance with life safety code of NFPA, also known as NFPA 101. The goal of this code is fire risk assessment to provide an environment for the occupants that is reasonably safe from fire and similar emergencies. Items listed in NFPA 101 healthcare worksheets included occupancy risk parameters (patient mobility, mobility status factor, zone location, ratio of patients to attendants, patient average age) and fire safety (construction, manual fire alarm, smoke detection and alarm, automatic sprinklers, interior finish, door to corridor, zone dimension, emergency movement routes, corridor partitions/ walls and vertical opening) and completed through field observation (NFPA, 2013). In the next stage, gathered information was analyzed using Computerized Fire Safety Evaluation System (CFSES) software. This method was developed based on the NFPA101 standard and evaluates the fire risk from four dimensions of containment, extinguishment, people movement and general safety.

Results

The descriptive information on occupancy risk and fire safety parameter of the studied high-rise hospital was presented in Table 1 and 2.

Table 1: Descriptive information on occupancy risk parameters of the studied hospital

Parameters	Status	Number of Zones	Percent (%)
Patient Mobility	Mobile	11	36.6
	Limited Mobility	12	40
	Not Mobile	3	10
	Not Movable	4	13.4
Mobility Status Factor	1-5	3	10
	6-10	13	43.2
	11-30	10	33.4
	>30	4	13.4
Zone Location	1st	2	6.6
	2nd or 3rd	7	23.4
	4th to 6th	7	23.4
	7th and above	14	46.6
Ratio of Patients to Attendants	1-2⁄1	8	26.7
	3-5⁄1	17	56.6
	6-10⁄1	1	3.3
	>10⁄1	4	13.3
Patient Average Age	<65 Years and > 1 Year	27	90
	≥65 Years or ≤1 Year	3	10

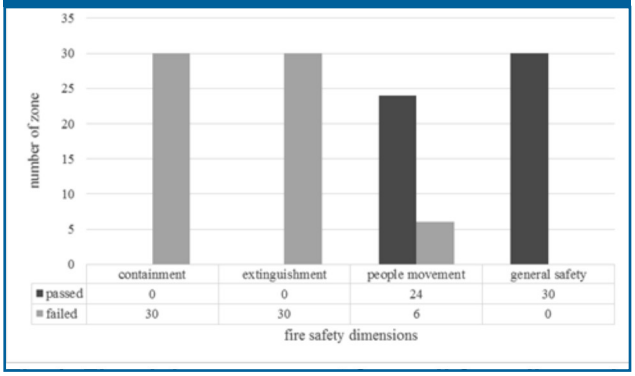
Table 2: Descriptive information on fire safety parameters of the studied hospital

Parameters	Status	Number of Zones	Percent (%)
Construction	First and Non-Combustible	2	6.6
	Second and Non-combustible	4	13.3
	Third and Non-combustible	2	6.6
	4th and Above and Non-combustible	22	73.5
Manual Fire Alarm	Manual Fire Alarm	30	100
	No Manual Fire Alarm	0	0
Smoke Detection and Alarm	None	0	0
	Corridor Only	0	0
	Rooms Only	0	0
	Corridor and Habit Spaces	0	0
	Total Space in Zone	30	100
Automatic Sprinklers	None	27	90
	Corridor and Habit Spaces	0	0
	Entire Building	3	10
Interior Finish (corridors and exits)	Class A	30	100
	Class B	0	0
	Class C	0	0
Interior Finish(rooms)	Class A	30	100
	Class B	0	0
	Class C	0	0
Door to Corridor	No Door	0	0
	< 20 Min FPR	0	0
	≥ 20 Min FPR	0	0
	≥ 20 Min FPR and Auto clos	30	100
Zone Dimension	Dead End	6	20
	No Dead Ends> 30 ft	24	80
Emergency movement routes	< 2 Route	8	26.6
	Multiple Route	22	73.4
Corridor Partitions/ Walls	None or Incomplete	0	0
	< ½ hr	0	0
	≥½ hr to < 1 hr	30	100
	≥1 hr	0	0
Vertical Opening	Open 4 or More Floors	0	0
	Open 2 or 3 Floors	0	0
	Enclosed with Indicated Fire Resist	30	100

Note: The list of abbreviations, FPR: Fire Protection Rating

The final results of fire risk assessment are presented in Fig 1. As can be seen, fire risk from containment and extinguishment dimensions is unacceptable in all of the zones under investigation. Fire risk from the dimension of people movement is unacceptable in 6 (20%) zones. The current study found that fire risk from the general fire safety dimension is acceptable in 30 (100%) of the studied zones and is best in four dimensions.

Fig 1. Fire risk assessment from all four dimension



Discussion: The principal objective of this study was to establish the fire risk assessment in high-rise hospital accordance with NFPA 101 in order to support human health risk assessment. Considering the above assumption, the most finding of the study is that from all studied zones 100% in the aspect of containment, 100% in the aspect of extinguishment and 20% in the aspect of people movement were unacceptable. In total, the fire risk level was acceptable only in general safety aspect (100%) of the studied zones.

A fundamental knowledge of fire containment and extinguishment necessary to make reasonable judgments about action priorities and viable egress routes (NFPA, 2013). In the study reported here, the level of fire extinguishment and containment were lower compared to the prescribed by the life safety code. It was important to identify special considerations for high-rise hospital building to prevent parallel mistakes and problems which may be encountered. These lessons should be used to manage existing hospital buildings and the design of new high-rise hospital. Most researchers, such as Wei-Wen et al.2011 and Taaffe et al. 2005, agreed that there are special considerations for fire safety in high-rise hospital buildings compared to other buildings. Considerations include the long route to exit, patient incapable of self-evacuating, flammable matter and chemicals.

It was discovered that the main cause of high casualties in the hospital fire accidents which happened before 1950 was the lack of installation of automatic fire systems. They provide a longer period for the public to emerge from the high-rise hospitals (Ong and Suleiman, 2015). Very often the structures involved could be saved if an automatic sensoring system, together with a nearby supply of water were available to wet the structure down in sufficient time to prevent the structure from being set afire by small localized fires (Gelaude et al., 1984). Automatic sprinkler systems add several benefits to high-rise hospitals as the system has a high probability of extinguishing or controlling the fire and detect fire at an early stage. In other words, these automated systems alert the public once they detect the fire source (Ong and Suleiman, 2015). Statistics states that the system is able to operate effectively in 90-95 % of all fires large enough to serve a potential threat to the hospital and its occupants (Nystedt, 2010).

Also, evidence-based results show that each opening was protected by an approved self-closing fire door that remains closed or automatically closed in an emergency. Vents, stairways, and elevator channel, allowing smoke to move throughout the high-rise buildings in just minutes. In a high-rise hospital, patients and occupants on upper floors can quickly become trapped by smoke and flames, particularly if the elevators and stairwells are filled with smoke. Smoke often travels a long distance from the fire floor (Black, 2009). Some research on smoke propagation has been developed. Air curtain could be utilized for confinement of fire-induced smoke and carbon monoxide transportation along channels (Hu et al., 2008). Comparison results between louver system and chimney system show that the chimney system provides a more stable smoke and temperature stratification inside the building and a higher hot smoke layer above the floor (Chen and Yung, 2007).

Besides that, researchers also studied the occupant's safe egress and people movement. Based on these results, fire risk from the dimension of people movement is acceptable in 24 (80%) zones. Evacuation is the process in which the occupants in a hospital building notice a fire and whereupon they experience several mental processes and carry out several actions before and/or during the movement to a safe place in or outside the building (SFPE, 2002). Evacuation time of patients and staff often draws major attention because of the hospital's diverse population, mix of patient conditions, multiple floors, and having multiple units on one floor. A hospital is a special facility for providing medical services to its patients. It includes a numerous type of wards, such as general wards, intensive care unit (ICU), psychiatric unit and so on (Huang. 2003). At least two exit routes must be available in a floor of high-rise hospitals to permit prompt evacuation of patients and other hospital occupants. The capacity of an egress route must be adequate and must support the maximum permitted occupant load for each floor served and must lead directly outside or to a street, walkway, refuge area, public way, or open space with access to the outside (NFPA, 2013).

In general, during fire related events or emergencies, high-rise hospitals must remain safe, accessible and functioning at maximum capacity in order to help save lives. Making hospitals safe involves knowledge of the many factors that contribute to their vulnerability during an emergency such as the building's location, design specifications, materials used, fire containment and extinguishment and interior

finish contribute to the ability of the hospital to withstand adverse natural events.

Conclusions

Our findings indicated that to improve the level of fire risk in high rise hospital, required measures especially in the area of fire extinguishment and containment including buildings design for automatic sprinkler systems and standardization of fire controls.

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