



Hospital Fire Risk Analysis with Hazard, Vulnerability, Capacity, Risk Assessment Model

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Abstract

The purpose of this research is to analyze fire risk level on the hospital in Ponorogo. Hospital is a community health service institution should be kept away from fire disaster since many of the patients are vulnerable to become the victim. This research is descriptive – analytic with semi-quantitative approach. The scope involves 27 service units on Ponorogo Regional Hospital. Fire risk is analyzed by proportioning and scoring method of hazard, vulnerability and capacity identification result. The research results indicate 18.5% service unit of Ponorogo Regional Hospital has high fire risk. 59.3% medium risk, and 22.2% low risk. The existence of service unit with high fire risk is caused by hazard potential that does not well managed and fire protection systems that do not comply with the standard. The research result is expected to be used as reference in fire protection system improvement on Ponorogo Regional Hospital so that the fire risk can be minimalized.

Introduction

Fire is one among the threat to a building that should be prevented to reduce the risk of material or non material loss, as instructed by the government in Undang-Undang RI No 28 Tahun 2002 regarding Building. Many building with various purpose, generally has fire potential. Among the building with fire risk is the hospital building.

The fire at the hospital could have a high risk due to the activity in community health service. Hospital uses the materials and medical tools that can be a cause factor. Beside, most of the residents are patient with weak physical ability and require assistance to evacuate themselves (Arrazy et al, 2014).

Fire incidents at the hospital were several times occurred in Indonesia. One was in 2014, as

reported in news.detik.com (Januari 3, 2014). There was a fire incident in the operating room on one of Ponorogo Regional Hospital. Though it was not cost any life, still it cause a material loss to the hospital.

In 2015 the Ponorogo Regional Hospital had been completely accredited by Ministry of Health. The accreditation is purposed to measure how far the hospital comply to the standard settled by the government in the effort to maximalize health service (Maharani, 2009). Definitely the accreditation does not instantly wipe out the fire potential. Beside, Undang-Undang RI No 44 year 2009 regarding hospital obligate protection system to prevent and overcome fire incident for safety of all patient and related residents. Since then this research is importantly conducted.

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Li and Huang (2012), Ding (2013), Li et al (2013), Tofiło et al. (2013), Xin and Huang (2013), Zhang et al. (2016), and Zhang (2018) has same opinion that risk analysis is required to minimize loss in case of fire incident. The analysis result can be used as reference in a better fire protection system plan (Li and Huang, 2012). Fire risk analysis involving responsible employee of the building can improve institution capacity in fire fighting (Ding, 2013). Fire risk analysis result should be communicated to all stake holder in the building to improve their awareness and readiness to fire threat (Zhang et al., 2016).

Fire risk analysis can be done with several methods or approaches. This is relied on the point of view to the factors affecting risk level. The AS/NZS 4360:2004 risk management concept stated the risk level is determined by level of probability/likelihood and scale of impact or severity dan be caused (consequences/severity).

Other concept is HVCRA model (Hazard, Vulnerability, Capacity, Risk Assessment) adopted by Disaster Prevention National Board (Badan Nasional Penanggulangan Bencana/BNPB) in 2012 General Reference of Disaster Risk Study (Pedoman Umum Pengkajian Risiko Bencana tahun 2012). Risk is the result of quantification aligned with hazard and vulnerability factor while it is inversed with capacity factor. This research particularly study the fire hazard factor. Vulnerability factor in a disaster involves object element exposed to hazard risk, in this case is the present of hospital patients. Capability factor is all effort whether the procurement of physical or non physical facility to confront disaster threat (Windraswara, 2009). In this research the focus is on the building fire protection system.

This concept is applied in the research since the risk can be deeply studied and involve increasing and decreasing factor. Disaster risk study can be assessed semi-quantitatively by using proportioning factor and index value, not real value.

Method

The research is a case study with descriptive analitic property to describe an object (Ponorogo Regional Hospital) on present time and the relation with a phenomenon (fire

disaster) sistimatically, factual and accurate. The population in this research is the whole units (27 rooms) in Ponorogo Regional Hospital that is a unity object, thus the sampling used total sampling method. Room or unit in this research ia Polyclinic, Nutrition Instalation, Laundry, CSSD, Power Room, Warehouse, Waste Treatment Instalation, Generator Room, Indoor Cafeteria, Outdoor Cafeteria, Emergency Room, Blood Bank, Office Room, Aster Inpatient Room, Flamboyan Inpatient Room, Mawar Inpatient Room, Radiology, Laboratory, ICU, Operating Room, Teratai Inpatient Room, Delima Inpatient Room, Tulip Inpatient Room, Melati Inpatient Room, Dahlia Inpatient Room, Seruni Inpatient Room, Lobby.

Data collection is conducted by observation, interview and document study. The data is analyzed with disaster risk study based on treat, vulnerability and capacity method by referring to Pedoman Umum Pengkajian Risiko Bencana (General Reference to Disaster Risk Study) in Perka BNPB Number 2 year 2012 yet specify on hospital fire risk. The risk level assessment (low, medium, high) based on treat, vulnerability and capacity variables is done with proportioning and scoring, as described in Table 1.

Those three variables hazards, vulnerability and capacity value from above proportion and scoring process then being inputted in risk index mathematic model below:

$$Risk = (Hazard \times Vulnerability) / Capacity$$

The risk index total calculation will gain a value determining risk level on each unit (room) in Ponorogo regional hospital, with indexation low (score 0 - 0.33), medium (score 0.34 – 0.66) and high (score 0.67 – 1.00).

Result and Discussion

Regional Hospital in Ponorogo researched is the one had been completely accredited in 2015. The hospital has 27 rooms or units divided onto 3 groups which are general service units, inpatient care units and supporting units. Service units consist of patient registration lobby, polyclinics, administration office, nutrition installation and cafeteria. Inpatient groups consist of room class I, II, III, IV and VIP. The last group is supporting units consist of laboratory, waste treatment

Table 1. Index Conversion Parameter and Equation

Variable	Class Parameter	Score Class	Proportion	Total Score Equation
Fire Risk Potential Analysis (H)				
H1 : The presence of flammable goods	Low : No flammable goods	0,333	50 %	Hazards Index = $(0,5 \times H1) + (0,5 \times H2)$
	Medium : There is fire causing substance and arranged as standard	0,667		
	High : There is fire causing substance and not arranged as standard	1,00		
H2 : Electrical Installation is comply to SNI 0225:2011	Low : comply to the standad	0,333	50%	
	Medium : comply to the standard but without technical review	0,667		
	High : not comply to the standard	1,00		
Vulnerability Factor Analysis (V)				
V1 : Population Density	Low : If room space (unit) per-person $\geq 9m^2$	0,00	50%	V Index = $(0,5 \times V1) + (0,5 \times V2)$
	High : If room space (unit) per-person $< 9m^2$	1,00		
V2 : Patient occupation	Low : If room space (unit) is allocated for non medical activity	0,00	50%	
	High : If room space (unit) is allocated for medical activity	1,00		
Capability Factor Analysis (C)				
C1 : Light fire extinguisher compliance to SNI 03-3987-1995	Low : if fire extinguisher compliance percentage $\leq 33\%$	0,333	25%	C Index = $(0,25 \times C1) + (0,25 \times C2) + (0,25 \times C3) + (0,25 \times C4)$
	Medium : if fire extinguisher compliance percentage 34-66%	0,667		
	High : if fire extinguisher compliance percentage $\geq 67\%$	1,00		
C2 : Sprinkler compliance to SNI 03-3989-2000	Low : if sprinkler compliance $\leq 33\%$	0,333	25%	
	Medium : if sprinkler compliance 34-66%	0,667		
	High : if sprinkler compliance $\geq 67\%$	1,00		
C3 : Hydrant compliance to SNI 03-1745-2000	Low : if Hydrant compliance $\leq 33\%$	0,333	25%	
	Medium : if Hydrant compliance 34-66%	0,667		
	High : if Hydrant compliance $\geq 67\%$	1,00		
C4 : Detector and alert system compliance to SNI 03-3985-2000	Low : if system compliance $\leq 33\%$	0,333	25%	
	Medium : if system compliance 34-66%	0,667		
	High : if system compliance $\geq 67\%$	1,00		

installation, emergency room, operation room, blood bank and electrical installation room.

Each room in the researched hospital has fire cause factor. Based on the fire theory, the element of fire consists of heat, oxygen and flammable materials. Heat and oxygen factor is ignored in this research due to hardly controlled and unable to be eliminated. When the hazard factors able to cause a fire incident based on identification result on 27 unit researched on Ponorogo Regional Hospital are : (a) 33% units have physical factor causing fire incident which are flammable materials (stacks of documents) and radiation (medical treatment equipments); (b) 85% of the units have fire-causing chemical factor, which are flammable substance (desinfectant, reagent, etc) and explosive (pressurized gas); (c) 40.7% of the units have electricity installation with low compliance to SNI 0225:2011 (less than 50%); (d) 22% of the units have 3 fire-causing factors, 52% have 2 factors and the rest 26% have 1 factor in the same room.

Xin dan Huang (2013) stated physical factor is the fuel in fire triangle. Physical factor in form of document papers carelessly managed can increase the fire spread potential. 5S socialization on materials that easily transferred the fire to others can reduce the risk of large fire incident (Ding, 2013). Based on observation result can be known that 5S on the rooms has not been well applied. Management will to improve 5S system on Ponorogo regional hospital can reduce the fire risk potential.

Chemical substance is common materials found in the hospital. Nearly all medical activity use chemical substance, like desinfectant, antiseptic, detergent, reagent, cytotoxic medicine and medical gases. 15% units which not have chemical substance in the room is non medical (administration, offices and public facility). Zhang (2018) said the improper chemical management become the cause of many explosion and fire incidents. Clear, accurate, monitoring and comprehensive evaluation of risk assessment in the Material Safety Data Sheet (MSDS) can reduce the potential of fire incident caused by chemical substance (Li dan Huang, 2012). Chemical substance management in the hospital also related with 5S system. This is support the

argumentation that 5S implementation is highly important to be done in the hospital, not only by socialization but also through monitoring and evaluation.

Xin and Huang (2013), Li et. al. (2013) and Rahmawati et. al. (2016) concluded in their research that electrical installation does not comply with the standard is the cause of fire oftenly happen on single building or housing. Monitoring and maintenance complying to SNI 0225:2011 along with wise electrical consumption would avoid the fire potential. The fire incident on Ponorogo Regional Hospital in 2014 also suspected to be caused by electrical short circuit. That incident should be particular evaluation to the management to fix the electrical installation system.

The vulnerability factor according to BNPB guidance in 2012 is grouped onto physical, economical, environmental, and socio cultural vulnerability. In this research it is limited on space physical vulnerability (population density) and patient occupation. The patients are considered as the most risky group threatened by fire incident.

Vulnerability analysis result on Ponorogo Regional Hospital is as follow : (a) 52% units (rooms) are considered vulnerable due to there are inpatients having physical limitation and requires assistance during fire emergency situation; (b) 77% rooms are consider dense with average space 9m²/person; (c) 30% rooms are considered to have high vulnerability to fire risk due to the inpatients occupation and dense population.

The patients are unseparable element of hospital as it's function as health service institution. Thus to reduce the patient is not wise recommendation to decrease fire risk level. The contingency plan and emergency response simulation involving all components under the hospital management is one of the effort to increase the readiness to such condition (Karimah et al., 2016). The arrangement of contingency plan and simulation is one of the effort to increase the capacity to provide the protection to the patient.

The population density always be a challenge in fire fighting management (Rahmawati et al., 2016). The high density will cause difficulty during evacuation when the

object to be evacuated does not well prepared in fire emergency. The communication and coordination of contingency plan to all stakeholder is an effort to minimize the risk (Ding, 2013). Patient density reduction can be done by rearrangement of inpatient room. Along with the reduction then the evacuation during fire incident will be more effective and efficient.

The definition of capacity in BNPB disaster risk concept is the ability of an institution to perform the act to reduce the loss potential due to the disaster. Capacity factors are grouped onto two, which is physically and non-physically. The physical ability is easier to be observed and measured compared to non-physical. While ability from fire disaster point of view generally manifested in active and passive fire protection system. In this research the ability measured only referred to the proper active fire protection system (Light extinguisher, hydrant, sprinkler, alarm and detector) only. This is due to technical improvement recommendation will be easier to be implemented in active fire protection system than the passive one (Lestari dan Amaral, 2008).

The result of Ponorogo Regional Hospital capacity are as follow : (a) Average light extinguisher compliance to SNI 03-3987-1995 in all units (rooms) are 89%. This is caused by irregular maintenance thus several light extinguisher is expired and out of service. (b) average sprinkler compliance to SNI 03-3989-2000 in all units (rooms) is 0%. This is due to the informant can not presents installation and maintenance document for the sprinkler in Ponorogo regional hospital, while the sprinkler network is difficult to be directly observed. (c) Average hydrant compliance to SNI 03-1745-2000 is 20 %. This is due to hydrant maintenance management is not a priority due to economical consideration. Fire fighting still rely to local Integrated Fire Fighter Unit during the emergency situation. (d) Average detector and alarm compliance to SNI 03-3985-2000 is 72%. This is due to the maintenance management is not a priority in Ponorogo Regional Hospital.

Fire protection system without regular and systematic maintenance can increase the loss risk caused by fire incident. There is no other recommendation than the improvement of

active fire protection system maintenance on Ponorogo Regional Hospital. The improvement of the active fire protection system maintenance will undoubtedly give effect to hospital operational cost. Yet it will be worth with the safety level against fire emergency. Budget allocation to maintain the fire protection system is among the management commitment to applicate health and safety work management system on Ponorogo Regional Hospital.

Risk level analysis is done by quantification of index value from analysis result of hazard (H), Vulnerability (V) and Capability (C) factor with mathematical model $R = (H \times V) / C$. The assessment of fire risk level on all researched units is exposed in the table on attachment 1. Based on analysis result, researched object shows 18.5% units have high risk, 59.3% have medium risk, while the rest 22.2% have low risk. The room having high fire risk like CSSD, warehouse, electrical installation room, operating room and TPP. The room having medium fire risk like inpatient room Tulip, Delima, Teratai, ICU, laboratory, radiology, inpatient room Mawar, Flamboyan, Aster, Emergency Room, waste management installation, nutrition room and polyclinic. The last is room having low risk like laundry room, cafeteria, blood bank, Melati Room, Dahlia room; Though the high risk rooms have smaller percentage, yet it is not a reason to ignore research recommendation, since the task to keep patient safety is the obligation of the hospital as instructed in Undang-Undang RI No 44 Tahun 2009 about Rumah Sakit.

Conclusion

This research conclude that though Ponorogo Regional Hospital had obtained complete accreditation, yet there are still units (rooms) having high risk fire risk (18.5%). This can be caused by hazard potential than does not properly managed as well as fire protection system that is not comply to the standard.

The patient is the vulnerable group that should obtain more attention particularly during fire emergency situation.

The flammable materials management with 5S system is recommended to Ponorogo Regional Hospital to reduce the potential of fire. The maintenance of facility and infrastructure of fire protection system also need to be done

as standard along with contingency plan and fire emergency respond involving all stakeholders to increase the readiness of the staffs and patients thus victim can be avoid.

This research has limitation which is it has not describe spacially (mapping) the fire risk on each unit. Risk mapping will assist communication and socialization to the related stakeholders. The mapping result with spacial information can also assist to determine the program to control hazard source effectively and efficiently (Dt.Mangguang, 2015). The recommendation for next research is to develop the analysis result to spacial information assisting in fire fighting program socialization and planning.

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