



# Hazard vulnerability analysis for disaster mitigation at Jakarta Medical Center Hospital

Nurul Hikmah<sup>a</sup>, Tatan Sukwika<sup>a,1</sup>

<sup>a</sup>Department of Environmental Engineering, Faculty of Engineering, Universitas Sahid, Jl. Prof. Dr. Soepomo No.84, Jakarta 12870, Indonesia

<sup>1</sup>E-mail: [tatan.swk@gmail.com](mailto:tatan.swk@gmail.com)

## ARTICLE INFO

### Article history:

Submitted 21 January 2021

Reviewed 24 January 2021

Received 01 February 2021

Accepted 11 April 2021

Available online on 01 July 2021

### Keywords:

Disasters, HIRA-HVA, medical center hospital, risk assessment.

### Kata kunci:

Bencana, HIRA-HVA, rumah sakit pusat kesehatan, Penilaian risiko.

## ABSTRACT

As a public health facility, the hospital serves as society's primary goal for health fulfillment. As a public facility, the hospital must be safe from unexpected events that can endanger life and health problems, as well as damage to buildings, loss of assets, and the surrounding environment. As a result, this situation must be anticipated so that it does not have disastrous consequences. The goal of this study was to identify potential hazards and risk-control efforts at the Jakarta Medical Center Hospital (JMCH). This study is a descriptive analysis. The results of the study using a hazard identification risk assessment (HIRA) obtained two levels of risk, namely low and medium risk levels; fire safety risk assessment (FSRA) obtained three levels of risk, namely high (priority 1), medium (priority 2), and low (priority 3); and hazard vulnerability assessment (HVA) it is known that natural disasters are the most dangerous potential hazards. To summarize, the JMCH building poses a risk of danger and the potential for fires in a variety of categories. Furthermore, potential disaster risks can be caused by natural disasters, technological hazards, human hazards, and hazardous materials. One way to reduce these risks is to strengthen the safety program with the help of building managers.

## ABSTRAK

Rumah sakit sebagai fasilitas kesehatan masyarakat umum menjadi tujuan utama masyarakat untuk pemenuhan kesehatan. Sebagai fasilitas publik, rumah Sakit harus aman dari kejadian tidak diharapkan yang dapat membahayakan jiwa dan gangguan kesehatan, serta kerusakan bangunan, kehilangan aset dan lingkungan sekitarnya. Oleh karena itu, keadaan tersebut harus diantisipasi agar tidak berakibat buruk. Tujuan penelitian ini untuk mengidentifikasi potensi bahaya dan upaya pengendalian risikonya di Rumah Sakit Jakarta Medical Center (RS JMC). Penelitian ini bersifat analisis deskriptif. Hasil penelitian menggunakan *hazard identification risk assessment* (HIRA) diperoleh dua tingkat risiko yaitu tingkat risiko rendah dan sedang; *fire safety risk assessment* (FSRA) diperoleh tiga tingkat risiko yaitu tinggi (prioritas 1), sedang (prioritas 2) dan rendah (prioritas 3); dan *hazard vulnerability assessment* (HVA) diketahui bahwa potensi bahaya yang paling berbahaya adalah bencana alam. Kesimpulannya gedung RS JMC memiliki tingkat risiko bahaya dan potensi kebakaran yang tersebar di berbagai kategori, selain itu, potensi risiko akibat bencana bisa ditimbulkan dari faktor bencana alam, bahaya teknologi, bahaya manusia, dan bahan berbahaya. Untuk mengatasi resiko-resiko tersebut diperlukan adanya penguatan program keselamatan melalui kerjasama pengelola gedung.

Available online at <http://dx.doi.org/10.36055/tjst.v17i1.9406>

## 1. Introduction

The Jakarta Medical Center Hospital (JMC Hospital) is a gathering place for many people with various needs as a general health-care facility. As a public area, JMC Hospital is also equipped with standard security facilities for employees, patients, and visitors JMC Hospital. In hospital buildings, there are potential hazards that can be caused by accidents that threaten the lives of patient employees and visitors, such as explosions that cause fires, installation impact accidents, hazardous chemicals, anesthetic gases, ergonomics, at all. There are many possible hazards of disaster risk arising from hospital activities,



such as natural or non-natural factors, technological factors, human error, or even hazardous materials [1]. Factors that cause disasters are due to the interaction between threats (hazard) and vulnerability (vulnerability) [2]. This possibility can certainly be anticipated with organized and systematic planning [3, 4]. Risk factors that may occur in hospital buildings are studied further to find out what hazards/risks are posed to prevent a disaster or emergency from occurring, including rescue and evacuation of victims from the building, and restoration of facilities and infrastructure [5]

Mitigation planning in hospital buildings can be done through an approach to identifying the hazards posed by the building. Readiness indicators from administrative, substitutive strongly influence the assessment of disaster or emergency mitigation in a hospital building, and technical planning to handling before, during, and after, including prevention, mitigation, preparedness, emergency response, and recovery [2, 5]. Hazard vulnerability analysis (HVA) is a risk assessment in a specific environment to support disaster planning. In general, HVA includes hazard elements, including (1) naturally occurring, namely floods, earthquakes, and volcanic eruptions; (2) technology, namely electricity failure, water failure, and fire; and (3) human-related, namely mass accidents, mass poisoning, guests or visitors. Conditionally, at the JMC Hospital, there are potential hazards posed by facilities within the hospital building such as kitchens, treatment rooms, gas and generator installations, B3 waste treatment areas, et al.

HVA was used to identify the following hazards with direct and indirect effects on hospitalization. Materials and technology used by humans have the potential to cause harm. For this reason, approaches to disaster risk identification are needed that require hospitals to determine the type of risk, probability of hazard consequences, threats, and future disaster events such as hazard identification risk assessment (HIRA) and fire safety risk assessment (FSRA). This study is essential and needs to be done to increase knowledge and insight of JMC Hospital management. This study aims to identify the potential hazards and risk control efforts at the JMC Hospital.

## 2. Material and Methods

This study aimed to conduct a descriptive analysis of the dangers and emergencies in the Jakarta Medical Center Hospital area. The selection of JMC Hospital as the object of research is because JMC Hospital is a public place that is often visited by the community, so that safety and comfort are the main things that must be considered by hospital management regarding activities and potential hazards caused. The data used are primary and secondary. Primary data were obtained from interviews with the hospital's occupational safety and health department regarding the work carried out and the potential hazards and health impacts of work activities. The results of the interviews were validated by making direct observations to various units at JMC Hospital. Secondary data is obtained from documents and records related to hazards and emergencies. The secondary data analyzed were in the form of a hazard identification sheet for each unit in the hospital, a fire assessment document for each unit in the hospital, a fire risk identification checklist, and the results of a hazard vulnerability assessment in the hospital.

In this study, the method used is the FRSA and HIRA methods. The use of FSRA aims to identify potential hazards that arise and their impact on buildings and result in loss of life, injury, or material loss/damage. HIRA is to identify hazards in each implementation activity and, based on operational hazard analysis, in the field. The variable vulnerability of the JMC Hospital building is used to determine the amount of vulnerability in the building, namely [3, 6-9]: (1) Natural disasters include floods, earthquakes, landslides, land subsidence, and epidemics; (2) Technological hazards, namely: electrical failure, fire, transportation accidents, information system errors, internal fires, internal flooding, exposure to internal hazardous materials, supply shortages, structural damage; (3) Human hazards, namely: a disease with many victims (medical/infectious), an emergency of VIP, missing residents; and (4) Hazardous materials, namely incidents of hazardous materials with many victims, incidents of hazardous materials with few victims, and exposure to chemicals [3, 6-9].

Determining the priority level of vulnerability in each hazard or disaster can be assessed based on the total risk of the hazard or disaster. The data obtained were then analyzed by Kaiser HVA. Determining the priority of hazard handling and the need for the preparation of an emergency plan based on the potential level of risk, among others: (1) Hazards or disasters whose total risk value is > than 55%; (2) Hazards or disasters which, even though the total risk value is below <55%, must be handled according to the recommendations and provisions of the KARS of the Ministry of Health of the Republic of Indonesia and other agencies; and (3) A hazard or disaster whose total risk value is below <50% but is a hazard or disaster with the first and the second most significant risk values. The analysis method for identifying potential hazards used is HIRA and FSRA. The determination of HIRA and FSRA risk levels can be seen in Table 1, low-risk levels are in the range 1-3, which can be seen in green, moderate risk levels are marked by yellow and fall into the 4-6 range; then the level of significant risk (range 8 – 12) and high risk (range 15 – 25) are shown in orange and red, respectively.

HIRA is used to identify potential hazard risks from an activity being carried out, FSRA assesses the risk of fire posed by the workplace for people doing the work, and HVA is more focused on the hazards that are most likely to occur impact on hospital facilities. and the surrounding community. This article focuses more on providing an assessment to measure a hazard vulnerability whose impact can occur to services, facilities, and the surrounding community so that HVA is more highlighted. The method of analysis of hazard risk control efforts is used a risk matrix to determine the magnitude of the risk, namely [4, 10]:

$$\text{Risk (R)} = \text{Consequence (E)} \times \text{Probability (P)} \quad (1)$$

Where:

Consequence (C) = Hazard severity

Probability (P) = Likelihood of occurrence

**Table 1.** HIRA and FSRA risk levels

K X D	Risk Level	Color Description
1 – 3	Low	
4 – 6	Moderate	
8 – 12	Significant	
15 – 25	High	

### 3. Results and Discussion

Hazard risk control efforts for FSRA, HIRA, and HVA can be carried out using hazard risk control methods based on location, namely: (1) Source: Elimination, substitution, source or process modification, automation, isolation/containment/enclosure of hazard sources; (2) Media: General ventilation/airing with windows, away from sources, and making an orderly work schedule; and (3) Workers: Make safe SOP (standard operation procedure) and use personal protective equipment.

Based on the results of the identification of potential hazards of FSRA at JMC Hospital, namely Table 2, it is known that nine areas have a high level of risk, including the medical gas room, generator set room, wastewater treatment plant (WWTP), radiology room. The risks posed can result in injury and health problems, and even the potential for death. JMC Hospital has six levels of moderate risk, especially in temporary storage place (TPS) of hazardous and toxic waste (B3). The risks that can be caused such as health problems. Meanwhile, the low-risk level is found in three areas: the main lobby of the building, inpatient rooms, and the emergency department (IGD), which can cause minor health problems.

Based on Table 3, the results of the identification of potential HIRA hazards at JMC Hospital, it is known that 12 areas have a low-risk level, including radiology, emergency room, operating room, delivery room, inpatient polyclinic, ICU room, kitchen, and pantry, generator set room, and medical gas chamber. The risk posed is low but can potentially cause work accidents or occupational diseases. The JMC Hospital area has a moderate level of risk, especially in the TPS area, wastewater treatment plants (IPAL), and B3 waste. The necessary action in this area is risk control. The results of the identification of potential HVA hazards at JMC Hospital are still relatively low. Based on Figure 2, it is known that there is a dominant threat to JMC Hospital facilities caused by natural disasters. The human error factor is the second cause of damage to facilities at JMC Hospital. The management of JMC Hospital must not ignore or be aware of hazardous materials and technology factors that can threaten the risk of damage to JMC Hospital facilities in the long term.

**Table 2.** Identification of potential hazards of FSRA at JMC Hospital

No	Risk Level	Area/Unit	Explanation	Color
1	High (Priority 1)	Kitchen, medical gas room, generator set room, IPAL, radiology room, pharmacy unit, laundry installation, operating room, and ICU room.	There is a high possibility of health problems and injuries or even death.	Red
2	Moderate (Priority 2)	Medical record room, outpatient polyclinic, pharmacy, office, delivery room, temporary storage place (TPS) of hazardous and toxic waste.	The severity of injuries and health problems are classified as severe, although the probability is low.	Yellow
3	Low (Priority 3)	The main lobby of the building, inpatient rooms, and the emergency room.	Possible minor to moderate injury	Green

**Table 3.** Identification of potential hazards of HIRA at JMC Hospital

No	Risk Level	Area/Unit	Explanation	Color
1	Low (1-3)	Medical record room, radiology, emergency room, operating room, delivery room, inpatient poly, ICU room, kitchen and pantry, outpatient clinic, generator set room, medical gas room, and medicine warehouse.	Low-risk level. Control measures are needed so that there are no potential hazards that can cause work accidents or occupational diseases.	Green
2	Moderate (4-6)	ER, inpatient polyclinic, laundry, IPAL, pharmacies, and temporary storage place (TPS) of hazardous and toxic waste.	Moderate risk level. Risk control that needs to be monitored is needed as soon as possible to prevent potential hazards in the future.	Yellow

#### 3.1. Hazard Identification Risk Assessment (HIRA)

The results of the identification of potential hazards for all areas/units in JMC Hospital are seen from the level of risk from HIRA obtained two levels of risk, namely as follows:

- The risk level in green means that the risk level is still low (1 - 3). Risk control must continue to be carried out so that there are no potential hazards that can cause work accidents or occupational diseases. Units included in the low-risk category at JMC Hospital are located in the medical record room, radiology, emergency room, operating room, delivery room, inpatient poly, ICU room, kitchen and laundry, outpatient poly, generator set room, medical gas room, and drug store. Occupational diseases (PAK) are often seen in hospitals and may be caused by cold air, heat, noise, chemicals, disinfectants, dust, bacteria, viral infections, and parasite illnesses, among other things. The Minister of Health has also established occupational health and safety requirements in hospitals [11]. One element that might affect workplace safety and health is the predisposing factor [12-14].
- The risk level with this yellow color means that the risk level is moderate (4 – 6). Risk control needs to be carried out and regularly monitored to prevent potential hazards in the future. Units included in the category of moderate risk level at the JMC Hospital are in the ER, inpatient polyclinic, laundry, IPAL, pharmacies, and B3 waste TPS. Based on [15], the low participation of employees in clinical risk management programs, such as reporting and analysis, affects a moderate risk level status.

#### 3.2. Fire Safety Risk Assessment (FSRA)

The results of the potential fire hazard carried out in all areas/units using FSRA at JMC Hospital obtained three levels of risk, namely as follows:

- The high-risk level (priority 1) is marked with a red indicator. This level of risk has the potential for harm to health and injury or even death. Units included in the high-risk category at JMC Hospital are kitchen, medical gas room, generator set room, WWTP, radiology room, medicine room, laundry installation, operating room, and ICU. According to [16-17], the high risk of fire in hospitals is due to poor management of the existing potential hazards and fire protection systems that are not standard. According to [18], the most frequent cause of the fire is the less than optimal inspection and maintenance of the fire protection system.
- The moderate risk level (priority 2) is marked with a yellow indicator. This level of risk has a high probability of causing injury and serious health problems even though the probability is low. Units included in the moderate risk category at JMC Hospital are located in medical records, outpatient polyclinics, pharmacies, offices, delivery rooms, and TPS for B3 waste. Locations of buildings that are categorized as medium usually routinely carry out efforts to control and provide fire detection equipment, installation of signs, and warnings. This is also stated by [9, 16, 20 - 21].
- The low-risk level (priority 3) is marked in green. This risk level indicates a potential hazard with a low probability of causing injury or minor health problems. Units included in the low-risk category at JMC Hospital are located in the main lobby of the building, inpatient rooms, and the emergency room. In several studies, it is known that the primary location or place of the hospital has the availability and readiness of anti-fire hazard supporting and supporting equipment [16, 18 - 19].

### 3.3. Hazard Vulnerability Analysis (HVA)

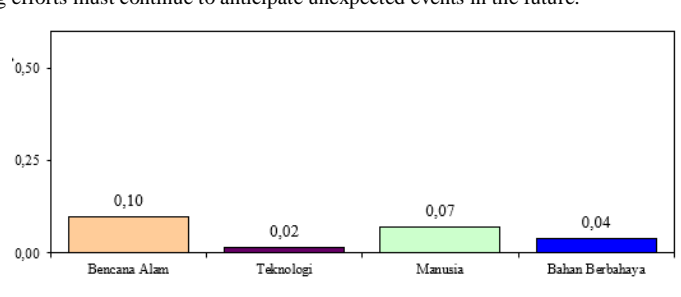
The results of potential hazards or disasters carried out in all areas/units using HVA at JMC Hospital obtained four types of hazards or disasters as follows (Table 4 and Figure 1):

**Tabel 4.** Summary of HVA analysis (percent)

	Natural disaster	Technology	Human	Hazardous material	Total facilities
Probability	35	12	23	19	22
Severity	27	13	30	20	21
Risk relative to specific hazard	10	2	7	4	5

- Natural disasters. The percentage value of HVA for hazards caused by natural disasters obtained from the risk evaluation is 10%. The natural disaster hazard that has the most potential to threaten hospital buildings is earthquakes [8, 22].
- Technological dangers. The percentage value of HVA for the dangers posed by technology obtained from the risk evaluation is 2%. Dangers caused by technology, including radiation from several existing hospital equipment [12, 17].
- Human danger. The percentage value of HVA for hazards posed by humans obtained from the risk evaluation is 7%. According to [14, 23 - 24], one of the most common human hazards is not using personal protective equipment.
- Hazardous material. The percentage value of the HVA for the hazard caused by the presence of hazardous materials, the results of the risk evaluation were 4%. Establishing a hospital affects the implementation of high clinical risk management when generating hazardous medical waste found in research [12].

The total value of each hazard that has been evaluated does not exceed 55%. The highest value indicating a state of danger is 10%. Even though the real risk is still below 55%, handling efforts must continue to anticipate unexpected events in the future.



**Figure 1.** Identification of potential HVA hazards at JMC Hospital

## 4. Conclusions

The research results on the JMC Hospital building can be concluded that the level of risk hazard is spread in the high, medium, and low categories. The level of building fire risk is in the medium and low categories. Furthermore, the potential risk of danger due to the JMC Hospital building disaster is influenced by the threat of natural disaster factors, hazards due to technology, hazards caused by humans, and exposure to hazardous materials. Efforts to control hazard risks are needed in each work area in order to minimize workplace accidents. The risk management that has been carried out needs to be strengthened with a safety program through the cooperation of building managers.

## Acknowledgements

Thanks to Prof. Dr. Kholil and colleagues at the Department of Environmental Engineering, Faculty of Engineering, Universitas Sahid Jakarta, who have helped and supported this research activity.

## REFERENCES

- [1] Republik Indonesia. (2007). *Undang-Undang Republik Indonesia Nomor 24 Tahun 2007 Tentang Penanggulangan Bencana*. Jakarta: Badan Nasional Penanggulangan Bencana.
- [2] Nurjanah, R., Sugiharto, Kuswanda, D., Siswanto, B. P., & Adikoesoemo. (2013). *Manajemen Bencana*. Bandung: Alfabeta
- [3] Manajemen Fasilitas dan Keselamatan RS. JMC. (2019). *Tim Manajemen Fasilitas Keselamatan: Panduan Disaster Plan Rumah Sakit Jakarta Medical Center*. Jakarta: Rumah Sakit Jakarta Medical Center.
- [4] Badan Nasional Penanggulangan Bencana. (2008). *Peraturan Kepala Badan Nasional Penanggulangan Bencana Nomor 4 Tahun 2008 tentang pedoman penyusunan rencana penanggulangan bencana*. Jakarta: Badan Nasional Penanggulangan Bencana.
- [5] Wicaksono, R. D., & Pangestuti, E. (2019). Analisis mitigasi bencana dalam meminimalisir risiko bencana (Studi pada kampung wisata Jodipan kota Malang). *Jurnal Administrasi Bisnis*, vol. 71, no. 1, pp. 8-17.
- [6] Manajemen Fasilitas dan Keselamatan RS. JMC. (2019). *Tim Manajemen Fasilitas Keselamatan: Panduan Hazard Vulnerability Analysis (HVA) Rumah Sakit Jakarta Medical Center*. Jakarta: Rumah Sakit Jakarta Medical Center.
- [7] Medical Center Hazard and Vulnerability Analysis. (2001). *Medical Center Hazard and Vulnerability Analysis: Kaiser HVA Tool and Instruction*. Southern California: Kaiser Foundation Health Plan, Inc.
- [8] Firdaus, R., Kurniawady, A., & Djauhari, Z. (2016). Evaluasi kerentanan bangunan gedung terhadap gempa bumi dengan rapid visual screening (RVS) berdasarkan FEMAP 154. *Jurnal. Jom FTEKNIK*, vol. 3, no. 2, pp. 1-7.
- [9] Sari, M. L., & Sukwika, T. (2020). Sistem proteksi aktif dan sarana penyelamatan jiwa dari kebakaran di RSUD kabupaten Bekasi. *Jurnal Ilmu Kesehatan Bhakti Husada: Health Science Journal*, vol. 11, no. 2, pp. 190-203.
- [10] Badan Nasional Penanggulangan Bencana. (2012). *Peraturan Kepala Badan Nasional Penanggulangan Bencana nomor 02 tahun 2012 tentang pedoman umum pengkajian risiko bencana*. Jakarta: Badan Nasional Penanggulangan Bencana.
- [11] Kementerian Kesehatan. (2016). *Peraturan Menteri Kesehatan Nomor 66 Tahun 2016 Tentang Keselamatan Dan Kesehatan Kerja Rumah Sakit*. Jakarta: Kementerian Kesehatan.
- [12] Oliy, M. W., Rivai, F., & Palutturi, S. (2019). Implementasi manajemen risiko klinis dan faktor-faktor yang mempengaruhi pada rumah sakit di kota Makassar. *JKMM*, vol. 2, no. 1, pp. 106-120.
- [13] Tukatman, Sulistiawati, Purwaningsih, & Nursalam. (2015). Analisis keselamatan dan kesehatan kerja perawat dalam penanganan pasien di Rumah Sakit Benyamin Guluh Kabupaten Kolaka. *Jurnal Ners*, vol. 10, no. 2, pp. 343-347.
- [14] Kartikasari, S. E., & Sukwika, T. (2021). Disiplin K3 melalui pemakaian alat pelindung diri (APD) di Laboratorium Kimia PT Sucofindo. *VISI KES: Jurnal Kesehatan Masyarakat*, vol. 20, no. 1, pp. 1-11.
- [15] Farokhzadian, J., Nayeri, N. D., & Borhani, F. (2015). Assessment of clinical risk management system in hospitals: An approach for quality improvement. *Global Journal Of Health Science*, vol. 7, no. 5, pp. 294-303.
- [16] Karimah, M., Kurniawan, B., & Suroto. (2016). Analisis upaya penanggulangan kebakaran di Gedung Bougenville Rumah Sakit Telogorejo Semarang. *Jurnal Kesehatan Masyarakat*, vol. 4, no. 4, pp. 698-709.
- [17] Phuspa, S. M., Kamal, M., & Rosanti, E. (2019). Hospital fire risk analysis with hazard, vulnerability, capacity, risk assessment model. *Jurnal Kesehatan Masyarakat, Kemas*, vol. 14, no. 3, pp. 353-358.
- [18] Saputra, W. D., Kridawati, A., & Wulandari, P. (2019). Studi analisis manajemen dan sistem proteksi kebakaran di rumah sakit X Jakarta Timur. *JUKMAS: Jurnal Kesehatan Masyarakat*, vol. 3, no. 1, pp. 52-59.
- [20] Kurniawan, P. A., Sugiyarto, & Laksito, B. (2014). Evaluasi penerapan sistem proteksi kebakaran pada bangunan rumah sakit (Studi kasus RS. Ortopedi Prof. Dr. R. Soeharso Surakarta). *Jurnal MATRIKS TEKNIK SIPIL*, vol. 1, no. 1, pp. 824-832.
- [21] Utami, F. M. (2019). Penilaian resiko kebakaran gedung bertingkat pada pusat perbelanjaan golden market Jember. *Undergraduate Theses*. Jember: Universitas Jember.
- [23] Najib, M., Zamad, N., & Setiawan, A. M. (2019). Analisis resiko gempa bumi pada bangunan gedung (Studi kasus: Pembangunan mall maleo town square kabupaten Majene provinsi Sulawesi Barat). *Bandar: Journal of Civil Engineering*, vol. 1, no. 2, pp. 31-45.
- [24] Putri, O. Z., Kasjono, H. S., & Ariff, T. M. (2017). Analisis risiko keselamatan dan kesehatan kerja pada petugas kesehatan instalasi gawat darurat rumah sakit akademik UGM. *Jurnal Kesehatan*, vol. 10, no. 1, pp. 1-12.