

**THE EFFECTIVENESS OF FIRE SAFETY
MEASURES OF GOVERNMENT HOSPITAL
BUILDINGS IN JOHOR,
MALAYSIA**

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MEASURES OF GOVERNMENT HOSPITAL
BUILDINGS IN JOHOR,
MALAYSIA**

by

JAMIL BIN HJ. ABDULLAH @ OTHMAN

**Thesis submitted in fulfilment of the requirements
for the degree of
Master of Science**

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DEDICATION

Dedicated especially to my beloved father, Haji Abdullah @ Othman bin Awang (1948-2021), who taught me a lot about the challenges of life and about being a great person in everything I did, and to my beloved teacher, Haji Nordin bin Said (1943-2011), who taught me to be self-reliant, always believe in God's will and never give up. Their faith in me has encouraged and moved me to become a valuable person, for which I am very grateful.

Al-Fatihah.

DECLARATION

I hereby declare that "The Effectiveness of Fire Safety Measures of Government Hospital Buildings in Johor, Malaysia" is my own work, that it has not been submitted for a degree or examination at any other university, and that all sources used or cited by me have been indicated and acknowledged by full references.

(Jamil bin Haji Abdullah @ Othman)
Signature of Student

Date

Approved for final submission.

Dr. Gunasunderi Raju

Date

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LIST OF ABBREVIATIONS

CRC	Clinical Research Centre
DOSH	Department of Health and Safety
FRDM	Fire and Rescue Department of Malaysia (BOMBA)
FRAs	Fire Risk Analysis
FSA	Fire Safety Audit
HREC	Human Research Ethics Committee of USM
MREC	Medical Research and Ethics Committee
MSQH	Malaysian Society for Quality in Health
MOH	Ministry of Health
NFPA	National Fire Protection Association
NIH	National Institute of Health
NMRR	National Medical Research Register
PAS 79	Publicly Available Specification
PBT	Pihak Berkuasa Tempatan (Local Authorities)
PHCFSA	Private Healthcare Facilities and Services Act
PAHO	Pan American Health Organization
WHO	World Health Organization
USM	Universiti Sains Malaysia

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**KEBERKESANAN LANGKAH-LANGKAH KESELAMATAN KEBAKARAN
DI BANGUNAN-BANGUNAN HOSPITAL KERAJAAN DI JOHOR,
MALAYSIA**

ABSTRAK

Hospital telah direka bentuk untuk berfungsi sepenuhnya dalam menyediakan perkhidmatan kecemasan dan rawatan secara berterusan kepada pesakit. Walau bagaimanapun, terdapat aktiviti-aktiviti yang dilaksanakan di dalam bangunan hospital yang boleh mendedahkan hospital serta penghuninya, termasuk kakitangan dan pesakit kepada risiko bahaya kebakaran yang tidak dijangka. Seperti hospital diseluruh dunia, bangunannya yang kompleks mempunyai masalah terhadap pengungsian bangunan sewaktu kebakaran. Kebakaran Hospital Sultanah Aminah, Johor Bahru, Johor, Malaysia pada tahun 2016 membuktikan bahawa kebakaran bukan sahaja boleh memusnahkan bangunan serta harta benda bahkan juga boleh menyebabkan kecederaan dan kematian. Oleh itu, adalah sangat penting untuk melihat sejauhmanakah persepsi kakitangan yang bekerja di hospital tentang keberkesanan langkah-langkah keselamatan kebakaran di bangunan-bangunan hospital kerajaan di Johor, Malaysia. Dalam kajian ini terdapat dua kumpulan utama perkhidmatan hospital (klinikal dan bukan klinikal) yang telah dibahagikan secara strata berdasarkan norma-norma perkhidmatan kepada tiga kumpulan: kakitangan pengurusan, kakitangan perubatan, dan kakitangan kejuruteraan/ teknikal termasuklah kakitangan syarikat Medivest Sdn. Bhd. selaku Perkhidmatan Sokongan Hospital. Tujuan penyelidikan ini adalah untuk mengkaji hubungan keberkesanan langkah-langkah keselamatan kebakaran dengan ciri-ciri kependudukan bangunan, susun atur bangunan dan kepenggunaan bangunan di 12 buah hospital yang ada di negeri Johor, Malaysia. Satu

tinjauan keratan rentas dengan persampelan rawak berstrata bersama soal selidik tadbir sendiri telah dilaksanakan bagi pendekatan kajian kuantitatif. Sejumlah 1,306 orang responden telah memberikan maklumbalas dari 12 buah hospital terlibat. Manakala bagi kajian kualitatif, satu pendekatan secara pemerhatian ke atas 12 buah bangunan-bangunan hospital turut dijalankan dengan menggunakan senarai semak PAS 79 bagi menilai risiko kemerbahayaan kebakaran. Hasil kajian ini menunjukkan terdapat hubungan antara kependudukan bangunan, susun atur bangunan, penggunaan bangunan, dengan keberkesanan langkah-langkah keselamatan di bangunan-bangunan hospital kerajaan di Johor, Malaysia. Kajian ini juga menunjukkan terdapat beberapa kelemahan yang perlu ditangani oleh pihak Kementerian Kesihatan Malaysia, Jabatan Kesihatan Negeri Johor, dan Pengarah-pengarah Hospital selaku penggubal dasar dan pihak yang berkepentingan bagi memastikan tahap keselamatan kebakaran di bangunan-bangunan hospital adalah mencukupi dan berfungsi dengan baik.

**THE EFFECTIVENESS OF FIRE SAFETY MEASURES
OF GOVERNMENT HOSPITAL BUILDINGS
IN JOHOR, MALAYSIA**

ABSTRACT

Hospital has been designed to function in emergency services and ongoing patient treatment. However, some operations in hospital facilities can expose the hospital and its residents, including personnel and patients, to the plausibility of unexpected fire threats. Like most hospitals worldwide, building complexity has been an issue for safe evacuation during a fire. A fire at Sultanah Aminah Hospital in Johor Bahru, Johor, Malaysia, in 2016 demonstrated that fire could destroy buildings and property and cause injury and death. Therefore, it is imperative to see the extent of the perception of staff working in hospitals about the effectiveness of fire safety measures in government hospital buildings in Johor, Malaysia. In this study, two main groups of hospital services (clinical and non-clinical) are stratified based on service norms into three groups: management staff, medical staff, and engineering/technical staff, including Medivest Sdn. Bhd. as a Hospital Support Service. The study aims to expose the connection between the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia, regarding building occupancy, layout, and building usage in 12 hospital buildings in Johor, Malaysia. A cross-sectional survey with stratified random sampling, along with self-administered questionnaires, was carried out for a quantitative research approach. A total of 1,306 respondents have provided feedback from 12 hospitals involved. While for the qualitative study, an observational approach on 12 hospital buildings was also carried out using the PAS 79 checklist to assess the risk of fire hazard. The result demonstrated a relationship

between building occupancy, building layout, and building usage with the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia. This study also shows that several weaknesses need to be addressed by the Malaysian Ministry of Health, Johor State Health Department, and Hospital Directors as policymakers and stakeholders to ensure that the level of fire safety in hospital buildings is adequate and functioning well.

CHAPTER 1

INTRODUCTION

1.1 Research Background

Hospital buildings are among the most well-known and significant institutional buildings in Malaysia. All public (government) or private hospitals, administrative buildings, or owners of commercial premises must comply with specific fire safety laws and regulations (Jahangiri et al., 2016; NFPA 101, 2006; NFPA 101, 2009). Thermal and smoke protection for fire safety in buildings is measured solely by the presence of passive and active fire protection systems (Hamzah, 2006). Hospital buildings are classified as essential national assets; therefore, fire safety must always be maintained (Shastri et al., 2018). *Fire safety* is a serious matter that cannot be taken lightly, as it affects the institution's reputation (Ong, 2015).

Fire safety measures are critical for all hospital staff to prevent building fire incidents (Spinardi et al., 2017). The actions of everyone can have a significant impact on the overall fire safety environment (Malaysia Society Quality Health, 2022; Setyawan et al., 2021; Loria et al., 2012). The negligence of hospital staff or management leaves a negative impression on the public, and their credibility is questioned and compared to private hospitals (Ong, 2015; Park et al., 2013). However, it was noted that the Private HealthCare Facilities and Services Act 1998 (PHCFSA) only required all private healthcare facilities to meet the fire safety requirements assessed by FRDM, while public hospitals were exempt (Lum, 2016a).

There are methods of approving building occupation. Local Authorities (PBT) were previously responsible for approving any Certificate of Fitness for Occupation (CFO) under the Uniform Building By-Laws of the Street, Drainage and Building Act 1974 (Act 133). To meet the requirements of buildings safety, FRDM was one of the

committees to ensure its compliance, and building physical inspection was a compulsory process. A Certificate of Completion and Compliance (CCC) was introduced in 2007 to smoothen and accelerate the whole building process and avoid red tapes, where the Principal Submitting Person (PSP), such as Professional Architects, Professional Engineers, or Registered Building Draughts men, is responsible for self-regulation.

According to Ong's (2015) report, there needed to be suitable mechanisms for fire safety measures in the affected facilities instead of a new building occupation process. Under the Fire Services Act 1988, FRDM is the competent authority for special enforcement of fire safety requirements (Act A1568, 2018). Fire Services Act 1988 stated that six "fire dangers" constitute an offence. Consequently, FRDM's primary responsibilities include enforcing fire protection in structures, prohibiting unwanted alterations to facilities, and interrupting safety equipment. Therefore, structures that do not comply with fire safety inspection criteria are categorized as high-risk for fire (Anonymous, 2019; Mohamed, 2019). Datuk Wira Wan Mohd Nor Ibrahim, former Director-General of FRDM, assessed that 99 hospital facilities in Malaysia were at risk of fire owing to outmoded building conditions from the British colonial era (Ali, 2016).

In 2016, 19 hospital fires were recorded in Malaysia (BH Online, 2016). However, according to an internet search, 32 cases were identified between 1993 and 2020 (see Table 1.1). It is believed that many similarities in Malaysia were not reported because they were classified as minor fire incidents. Only those reported or attended to were counted in all statistical reports on fires, but most were not reported (Alhadjri, 2016; Babraukas, 2003; Tatum, 2004).

Table 1.1 Hospital fires in Malaysia from 1993 to 2020

No	Year	Hospital Building
1	1993	Admin 2 nd Floor, Faculty of Medicine UKM, Kuala Lumpur
2	1993	Neurology Institute, Faculty of Medicine, Kuala Lumpur
3	1993	Specialist Clinic, Hospital Tuanku Ja'afar, Seremban
4	1995	3 rd Floor, University Malaya Medical Centre, Kuala Lumpur
5	1996	2 nd Floor, Melaka Hospital, Melaka
6	1996	Operation Theatre, HSNZ, Kuala Terengganu
7	2007	Neurology Ward, 1 st Floor, HKL, Kuala Lumpur
8	2009	Doctor Messroom, Hospital Tuanku Ja'afar, Seremban
9	2010	UPS Room, Hospital Tengku Ampuan Rahimah, Klang
10	2011	Mental Patient Isolation Room, HKL, Kuala Lumpur
11	2012	Storeroom, Columbia Specialist Centre, Miri
12	2013	Tunnel area, Sarawak General Hospital, Kuching
13	2013	Nuclear Medical unit, Sarawak General Hospital, Kuching
14	2013	Boiler, Sarawak General Hospital, Kuching
15	2014	Clinical Research Division, Sarawak General Hospital, Kuching
16	2015	Specialist Medical Centre, Sibul
17	2015	1 st Floor, Timberland Specialist Medical Centre, Kuching
18	2015	Hospital Tuanku Ja'afar, Seremban
19	2015	Level 7 Ward, Hospital Tengku Ampuan Rahimah, Klang
20	2016	Electrical Equipment Room, MUIP Specialist Hospital, Kuantan
21	2016	MDB Switch Room, Damai KPJ Specialist Center, Kota Kinabalu
22	2016	Lundu Hospital, Lundu
23	2016	Storeroom, Sri Kota Specialist Medical Centre, Klang
24	2016	South ICU ward, HSA, Johor Bahru
25	2016	5B Ward, Hospital Raja Permaisuri Bainun, Ipoh
26	2017	Hospital Bahagia Ulu Kinta, Ipoh
27	2017	Neonatal Intensive Care Unit, Hospital Shah Alam, Shah Alam
28	2017	Third Ward, Hospital Segamat, Segamat
29	2017	Men Isolation Ward, Hospital Sibul, Sibul
30	2018	National Forensic Medical Institute, HKL, Kuala Lumpur
31	2018	Convenience Store, Hospital Selayang, Kuala Lumpur
32	2020	Women Ward 1, HSA, Johor Bahru

(Source: Researcher Survey, 2020)

Hospital buildings should withstand fire risk and be safe from potential hazards that can cause deaths and business disruption (Janius et al., 2017; Zamanian et al., 2015). The buildings contain high-dependency patients, some of whom are immobile or bedridden, and young children under medical observation (Chaeibakhsh et al., 2021; Ulrich et al., 2005; Ulrich, 2001). Unchecked fires in hospital buildings leave staff and patients vulnerable, as the staff cannot protect themselves, let alone rescue others, and are not well prepared for such a disaster (Manyele et al., 2008; Preeti, 2018; Zamanian et al., 2015). To find safe escape routes during fires, building occupants must learn to resist fire without fear (Alahmadi, 2010; Kobes et al., 2010a).

People tend to behave differently when in danger because they become mentally unstable and thus have the possibility of starting an uprising (Wagner et al., 2017; Alqassim, 2014). These spontaneous actions and behaviors are unexpected, whereby they become aggressive and uncontrollable (Haghani & Sarvi, 2016; Smelser, 2011). Understanding behavior and emotional responses are crucial for hospital staff during fires (Jiang et al., 2014). They need to be physically and mentally prepared to improve their knowledge and awareness of fire safety (Fernández & Iglesias, 2018; Samur & Intepeler, 2016; Abdullah et al., 2009). Improving knowledge and awareness of causes, effects, and complexities reduced fire losses (Ju, 2016; North, 1999). Therefore, the essential aspects of fire safety management are understanding fire risks, risk prevention, and preparedness (A. Razak & Jaafar, 2012; Yung, 2008; Almand, 2006). Risks exist because fire safety procedures are not correctly applied (Agyekum et al., 2016a; Agyekum et al., 2016b; Saad, 2014).

Eight elements of fire safety management should be implemented: investigations, training and exercise, fire prevention, emergency services, fire hazard assessment, fire deterrence, reports, records, and communication (Nadzim & Taib, 2014). When these elements are implemented, fire risks can be effectively identified and eliminated (Lyn, 2020; Ahrens, 2019). The most effective way, therefore, is to increase fire safety awareness by involving all hospital staff (Beard, 1986). Hospital management or building staff need to understand how the system works in case of fire (Shafiei et al., 2019). Fire protection is considered fragmentary, and buildings with fire protection equipment are meaningless if the escape routes and exits, firefighting equipment, fire alarm, emergency lighting, fire safety equipment such as fire service intercom, fire lift, or other fire protection measures do not function appropriately (Rahardjo & Prihanton, 2020; Lum, 2016b). The best approach to protecting people

and property combines active and passive protection (Johansson & Hees, 2016; Tatum, 2004). Fire prevention will be successful if the firefighting system is well maintained and training is adequate (Agyekum et al., 2016a). A building fire signifies fire safety management failure (Bongiovanni et al., 2017; HM Government, 2006).

Human errors such as carelessness, negligence, and lack of fire safety awareness are important factors that can lead to fire recurrence (Kulkarni et al., 2016). According to findings from forensic fire investigation reports, every building fire has a cause (Black, 2009; Bouquard, 2004). The causes of fire can be classified into four categories: a) natural fire, b) accidental fire, c) arson, and d) undetermined fire. Table 1.2 shows a statistical fire investigation report (FRDM, 2018), which indicated that accidental fires were the leading cause of building fires in Malaysia, followed by fires involving arson.

Table 1.2 Cause of fire in Malaysia from 2014 to 2017

No	Cause of Fire	2014	2015	2016	2017
1	Natural	54	61	41	34
2	Accidental	6,666	6,471	5,787	5,238
3	Incendiary	385	341	265	265
4	Undetermined	29	17	0	15
	Total	7,134	6,890	6,093	5,552

(Source: FRDM, 2018)

As shown in Table 1.3, accidental fires have been divided into four categories (Yereance & Kerkhoff, 2010). According to the statistic, electrical fires play an important role as an ignition source in building fires (see Table 1.3).

Table 1.3 Source of Ignition (Electrical) in Malaysia from 2014 to 2017

No	Source of Ignition	2014	2015	2016	2017
1	Arcs	1,281	988	683	722
2	Sparks/Short Circuit	1,876	2,123	1,826	1,518
3	Overcurrent/Overload	419	405	366	319
4	Resistance Heating	361	288	465	632
	Total	3,937	3,804	3,340	3,191

(Source: FRDM, 2018)

Past fire incidents resulted in the knowledge that most fire causes can be determined through the reenactment of fire scenarios (McEwen & Miller, 2013, Lilley, 1997; John & Patrick, 1985;). This incident has contributed to the current fire safety guidelines (Gorbett & Pharr, 2011). According to FRDM’s fire loss statistics from 2013 to 2017, estimated fire losses increased from RM1.90 billion in 2013 to RM4.40 billion in 2015 and significantly decreased in 2016 to only RM1.70 billion before increasing dramatically again to RM3.10 billion in 2017 (see Table 1.4).

The high number of fire losses led us to investigate this issue. Do we hope this research will address the following questions: (1) Are these fires caused by a lack of fire safety equipment? (2) Does occupancy, layout, and usage affect the fire safety equipment? (3) Is there a relationship between occupancy, layout, and use of buildings?

Table 1.4 Estimated Fire Losses in 2013 to 2017

No	Year	Total of Loses in Fire
1	2013	RM1.90 billion
2	2014	RM2.80 billion
3	2015	RM4.40 billion
4	2016	RM1.70 billion
5	2017	RM3.10 billion

(Source: FRDM, 2018)

Fire safety is the responsibility of the building occupants (Pan American Health Organization, 2018; Runefors et al., 2017). Kulkarni et al. (2016) believed that occupants could respond to a fire much more efficiently if they were adequately trained in fire safety and understood the correct actions to take in case of fire. Occupants must be familiar with fire safety to avoid future chaos (Shafiei et al., 2019). Unfamiliar building structures (escape routes), faulty fire extinguishers, improper room layouts, and confusing floor plans cause people to panic in an emergency (Rahmani & Salem, 2018; Li & Chow, 2003). They assumed that danger was imminent and inevitable (Mawson, 2012; Leslie, 2001). Therefore, to prevent future tragedies, such problems

should be managed appropriately and resolved immediately (Habib Mohamed & Jaishree., 2017; Wabo Nero et al., 2012; Lakoff, 2007).

In Perak, for example, a fire in ward 5B of Raja Permaisuri Bainun Hospital was caused by the electric wall panel near the male patients' beds (Balqis Jazimah, 2016; Shamsul, 2016; Zahari, 2016). Fortunately, there were no fatalities or injuries, even though the incident occurred at night. Perak State Health Department Director Datuk Dr. Juita Ghazalie stated that the repairs cost RM25,000.00 and 44 electrical panels and switches had to be replaced. Since the incident, 15 hospitals in Perak immediately ordered inspections of the buildings' electrical systems (Amarudin, 2016). Ong (2015) claimed compliance with fire safety regulations was required for adequate fire safety in hospital buildings. In addition, cost allocation for building maintenance was necessary (Lavey & Shohet, 2004).

The real reasons for these electrical problems in hospital buildings are inadequate building maintenance budgets that could compromise fire safety. As a solution, former Health Minister Datuk Seri S. Subramaniam called for RM600 million to replace electrical wiring in hospital buildings in Malaysia that were between 30 and 50 years old (Ismail, 2017; Anonymous, 2017; Amarudin, 2016). News reports indicate that fire safety problems in hospital buildings are widespread in several Malaysian states, namely Kuala Lumpur, Negeri Sembilan, Melaka, Terengganu, Selangor, Sarawak, Pahang, Sabah, Perak, and Johor (BH Online, 2016).

The fire disaster in Hospital Sultanah Aminah (HSA) Johor Bahru was an example of hospital fire safety inadequacy (Ahmad Fikri, 2020). The first tragedy on 25 October 2016 claimed six lives, leaving two others seriously burnt and another two seriously injured (Mohd Farhaan & Nabila, 2016; Rizalman, 2016; Shah & Ahmad, 2016). While the tragedy reoccurred on 28 June 2020, there were no deaths or injuries

due to the quick response in evacuating the building. Hospitals harbor biological, chemical, physical, and fire hazards (Shastri et al., 2018). It was noted that hospitals lacked risk assessment (Boo, 2020; Yaacob, 2018; Fire Forensic Division, 2016a, 2016b). The fire safety audit report indicated that most hospitals had significant financial maintenance problems to address problems related to fire safety that occurred in the buildings (Kamarulzaman & Mohd Hazwan, 2016; Kamarulzaman & Mohd Sahrul Ridzuan, 2016a, 2016b, 2016c, 2016d; Kamarulzaman & Noorul Husna, 2016a, 2016b, 2016c). These findings, therefore, require attention and an immediate solution (Jaafar et al., 2021; Lum, 2016a).

1.2 Problem Statements

The Malaysian Society for Quality in Health (MSQH) developed many methods to produce specific guidelines and standards. These standards are evaluated annually in the form of guidelines, manuals, and procedures, while the review of operational requirements focuses on work instructions and calculation sheets for checklists. In principle, these inspections prioritized hospital services and performance in all aspects, including fire safety (Jandali & Sweis, 2018; Tsui & Chow, 2004). However, NFPA 551 (2007) states that persons performing fire risk assessments must be legally documented. They must be authorized for this task, have appropriate training, and be experienced and professional (Wener et al., 2015). It was observed that these requirements still needed to be met, leaving activities in the building that affect the occupancy, layout, and usage of the building unaccounted for, while services and performance were well established, suggesting that adequate fire safety monitoring was not carried out. As Beard & Carvel (2005) noted, the word 'hazard' was often used, but the word 'risk' was omitted. There are countless hazards and risks

associated with fires that make the building vulnerable or create a sense of insecurity, such as untrained staff in fire situations, inadequate escape routes according to the capacity of people, and obstruction of evacuation routes due to the design of floor plans, which affected occupancy risk (Gul et al., 2017; Barnett, 2002). These changes occurred upon change of building, usage for example, by converting wards into offices. These changes were not only related to the change of the original building layout but also affected the buildings' original use and their designated parts (Yacob et al., 2019). Therefore, this study showed that it was essential to understand these issues from the perspective of building occupancy, building layout, and building usage.

1.2.1 Building Occupancy Problems

Fire safety measures can be challenging because of the need to protect innocent lives and preserve the building's value and contents (Ab Aziz et al., 2019). Hospital buildings are important government properties and must be protected. Fire safety implementation in the building must be prioritized as they are essential to maintain the hospital's reputation. Compared to other types of buildings, hospital buildings pose a higher fire risk (Setyawan et al., 2021). Previous research found that potential fire hazards in hospital buildings were related to the storage of flammable chemicals, improper electrical wiring and cladding, faulty electrical circuits, and placement of medical equipment and materials (Ong, 2015; Pal & Ghosh, 2014).

Occupants' numbers and building size were related to the psychological and psychosocial approaches (Tancogne-Dejean & Laclémence, 2016). It, therefore, depended on the activity carried out in the building. Inappropriate activities could jeopardize building safety and lead to fires (Olanrewaju et al., 2021). Humans are the leading cause of fires due to carelessness, negligence, and lack of fire safety awareness.

It can be concluded that fire risks and hazards existed in buildings because fire safety was not well implemented (Agyekum et al., 2016a).

Understanding fire behavior can eliminate building destruction (Abdul Rahim et al., 2014). The most significant threats to people and building contents are the danger to occupants' lives and losses during fires. Fire can easily ignite and start anywhere; without proper observation, it can become uncontrollable. Therefore, to prevent fires, management needs to improve their knowledge and skills in fire safety (Kobes et al., 2010b). Buildings that catch fire lose their authenticity, and it is the responsibility of building management to take the first fire safety steps to prevent risks and hazards. This first step is called the foundation of fire safety management (Othuman et al., 2014).

Essential aspects to consider in a building fire are the occupants' behavior, the cause of panic, and the impediment to a quick escape (Bahaudin & Arshad, 2018; Pal & Ghosh, 2014; Rahmani & Salem, 2018). If there is a fire in a hospital, all patients must leave the building and go to the designated assembly point. However, the crucial part is to include bedridden patients (Jiang et al., 2014; Patharla et al., 2020;). They are the most vulnerable as they cannot evacuate unless someone assists them. In buildings, evacuating residents under fire conditions is challenging (Jiang et al., 2014; Nadzim & Taib, 2014).

1.2.2 Building Layout Problems

Well-protected buildings demonstrate the effectiveness of active and passive fire protection (Parsia & Tamyaz, 2018). Complete fire protection refers to the building itself, depending on how it was designed and its purpose. According to the Uniform Building By-Law 1984 (2012), building construction must comply with the minimum requirements set by the competent authority, for example, in terms of materials used

and the prescribed building design and layout. This requirement prevents the spread of heat and smoke from one room to another within the building (Konecki & Galaj, 2017; Hull et al., 2016). The primary purpose of fire protection in a building involves two unified fire protection systems, passive fire protection systems (that contain the spread of fire) and active fire protection (that keeps the fire under control or extinguishes it) (Rahardjo & Prihanton, 2020). A lack of fire prevention could compromise the safety integrity of the building, and if the layout of the building was changed for a specific purpose without proper safety advice, it could lead to safety problems (Parsia & Tamyez, 2018; Hu, 2016; Hamzah, 2006).

Buildings constructed with a unique fire safety design and a suitable floor plan increase building safety and durability (Suhaili et al., 2020). When designing a building floor plan, it is vital to know how a fire will start and behave in a building, as this is critical to saving the lives and property of occupants (Nelson & Mowrer, 2002). Changes to the building layout explicitly affected fire safety conditions when the layout was frequently restructured during renovations, conversions, alterations, extensions, and adaptations to the occupants' needs (Frank et al., 2013; Hui et al., 2012; Pellitteri & Belvedere, 2010). Some of these requirements were to improve safety, while others were to optimize the building. However, without proper building design, such as sectioning, the fire could quickly spread through open doorways, wall openings, ceilings, or other sections, destroying the building and its equipment and causing extensive damage (Enright, 2014; Stout, 2000).

In 1994, there was a fire in a budget hotel in Sandakan, Sabah, which claimed eleven lives caused by a fixed window grille and three locked fire escapes/doors (Sharif et al., 1995). This tragedy could be a typical example of fire safety being compromised for safety reasons. The compromise of fire safety in buildings can lead

to injuries, deaths, and massive destruction of valuable assets/property, including buildings (Novin et al., 2020; Amirall & Furton, 2016). Finally, altering building floor plans without proper advice from experts or the relevant authorities can become a vicious trap in the event of a fire (Schweitzer et al., 2004). Indeed, land or buildings are valuable, but life is priceless and cannot be replaced. Buildings are intentionally designed for the safety of occupants and contents (Novin et al., 2020). With a fire safety review, buildings are safe to be occupied (Littlewood et al., 2017; Siddiqui et al., 2014).

When renovating, remodeling, extending, or changing the layout of a building, elements of compositional design such as cultural, geographical, architectural, individual, and legal aspects should be considered (North, 1999). Most retrofitted buildings compromised existing emergency exits, such as fire doors and protected staircases, for a safe evacuation, initially designed for the earlier layout (Gorbett et al., 2016; Hölscher et al., 2006). Consequently, various structural designs increased the intensity of a rapidly spreading fire (Izydorczyk et al., 2017; NFPA 921, 2016; Phillips & McFadden, 1996; Zhang & Usmani, 2015).

In summary, building designs were influenced by numerous redesign measures (Haq & Zimmering, 2001). Unnoticed alterations affected the integrity of the building layout and the function and placement of existing fire suppression equipment, such as sprinkler heads, smoke and heat detectors, hose reels, and broken glass (Kurniawan et al., 2014; Nystedt, 2010; Tatum, 2004). The failure of these devices was related to the revision of the floor plan, as the features and operating specifications of the devices were different. Ceiling smoke detectors, for example, were meant to detect smoke as it rises to the ceiling; however, changes in location or layout may affect the smoke's direction, failing or delaying smoke detection. Therefore, proper building layout is

necessary to ensure that the installation devices are well maintained and appropriately operated in terms of fire safety (Agyekum et al., 2016a).

1.2.3 Building Usage Problems

The fire safety characteristics of hospital buildings are related to building construction (Nigam et al., 2016). In general, the usage characteristics of a building are determined by the design layout required by the users (Shahi et al., 2020). Regarding this structural design, hospital buildings become assembly places with the possibility of overcrowding. However, in the event of a fire, the building must be easy to evacuate. Most hospital buildings can only provide an adequate safe escape route for occupants if assisted by hospital security staff, which is contrary to self-evacuation principles in case of fire (Habib Mohamed & Jaishree, 2017). Hospital management can invoke the right to protect the "privacy and confidentiality" of their patients, which is why "restriction areas" were set up everywhere (Okeke & Mabuza, 2017). These are unavoidable hazards and risks that pose an immediate threat. The fire safety risk assessment differs for building usage (Gestal, 1987). The risks and hazards to be considered in building usage are defined by the content of combustible and flammable materials in the premises or the structure itself as a fire load (Isnin et al., 2012; Phillips & McFadden, 1996).

Building content is influenced by its usage (Anonymous, 2017; John & Patrick, 1985). Gorbett & Pharr (2011) demonstrated the relationship between building usage and fire load contents using the example of a fire that occurred in 1942 at the Coconut Grove Supper Club in Boston, Massachusetts, that killed 492 patrons. The investigation determined that this was caused by the alteration of inward swinging doors on the exits that prevented self-rescue. The 2003 incident at the

Station Nightclub in West Warwick, Rhode Island, which killed 100 patrons and seriously injured 230, was caused by flammable and combustible materials that coated the walls and contributed to a rapid fire that caused helpless victims to besiege rather than evacuate (Gorbett et al., 2016).

Unknowingly, changes in building use also affected the internal environment, such as occupancy and layout. To comply with the requirement, Ong (2015) opined that hospital management should hire competent persons such as architects, building designers, or fire protection engineers to prepare proper construction drawings and obtain approval from the relevant authority before making changes to building usage (Wang, 2012). Changing usage by restricting occupancy and proper design may result in adequate fire protection. Many problems were found in the improper use of buildings, such as large quantities of flammable materials stored in confined spaces or located in areas with limited access, such as the laboratory, operating room, boiler room, laundry room, kitchen, and intensive care unit, where fires could unknowingly occur (Liu & Chow, 2014).

1.3 Background and Needs

In this study, three research topics were explored based on the issue. First, hospital occupancy issues were shown by prior studies (Lin et al., 2020; Boyd et al., 2014). Fire safety measures in inhabited buildings were lacking, which required to be assessed from a critical perspective (Lee et al., 2018). Second, fire safety difficulties in building layout were shown in previous articles (Littlewood et al., 2017). Expanding patient therapy and medical techniques were needed to address these issues (Yi & Seo, 2012). Thus, the structure was redesigned to improve service (Mahmood et al., 2017; Chow, 2002). Finally, a past study has shown that building design and use are equally

essential (Patharla et al., 2020). The Background and Needs section employed five articles each to offer an overview of the answer to the three categories connected to the issue in the research synthesis in Chapter 2, Literature Review.

1.3.1 Problem Solving and Limitations in Hospital Building Occupancy

Kurd et al. (2021) investigated occupied hospital buildings in terms of fire load, fire suppression systems and occupant exposure. The study aimed to assess the fire risk of a hospital using the Fire Risk Assessment Method for Engineering (FRAME) and to quantify the impact of each risk element to take corrective action based on fire safety principles. A descriptive cross-sectional survey was conducted in Velayat Hospital, Qazvin, Iran. FRAME is the Persian method that was reviewed by previous researchers (Yarahmadi et al., 2009). It is reliable to assess the fire risk of buildings, including their contents, people, and activities. However, this method was only suitable for the assessment of certain indoor spaces.

Omidvari et al. (2020) investigated building occupancy and associated risks in relation to hospital staff, visitors, and patients with disabilities. The study aimed to investigate the causes of fire and to evaluate fire safety measures (Jahangiri et al., 2018; Omidvari et al., 2015). The researcher conducted the study in healthcare facilities using existing risk assessment methods, Analytic Hierarchy Process (AHP), checklists, NFPA101, Fire Risk Method for Engineering (FRAME) and Failure Mode and Effects Analysis (FMEA). Compared to Kurd et al. (2021), this study added the FMEA method, which was widely used in the 1960s in the US aerospace industry to investigate system failures and the associated reasons. In addition, this method used the risk priority number (RPN) in its analysis to define the detectability, probability, and severity characteristics for failure assessment. However, this method required

complex mathematical calculations and was difficult to learn, at least in technical subjects (Benitez et al., 2019).

Zamanian et al. (2015) investigated fire safety issues in occupied hospital buildings, focusing on fire hazards that could lead to death and injury, especially for patients with disabilities as well as elderly residents of the building for whom special assistance was required during an emergency evacuation. The study examined residents' attitudes towards fire safety measures in hospitals affiliated with Shiraz University of Medical Sciences (SUMS). This study was conducted with 520 people from 13 hospitals with mixed occupancy departments. The study assessed two factors using 54 questions from a checklist, 12 of which related to fire safety knowledge/awareness. It was found that occupants' knowledge about fire safety in the buildings was inadequate and incorrect.

Kulkarni et al. (2016) studied fire safety problems in hospital buildings, focusing on hospital occupants without considering their impression of fire safety. The study aimed to assess the fire safety knowledge and practices of health workers in a tertiary care hospital in Maharashtra, India. Two hundred and two health workers including housekeeping staff, male and female ward staff, nurses, ward managers, supervisors, OPD nurses and dieticians were interviewed based on their socio-demographic data. In addition, face-to-face interviews were conducted. This study was a good example of assessing fire safety perceptions, but fire safety issues are global issues that should involve more participants at all levels to incorporate their current knowledge (Lee et al., 2018).

Ong & Suleiman (2015b) believed fire safety management in hospitals was inadequate in terms of the number and severity of fires. Various problems were found in relation to fire safety management in occupied hospitals. The study aimed to

investigate problems related to the application of fire safety management in hospital buildings as well as to sensitize managers to the problems. The study was conducted in four unnamed Malaysian hospitals through observation, document review and interviews. The selected participants were the authorities, hospital staff, management, and maintenance concessionaires. While study investigated building fire safety in Malaysia, the mechanisms as well as the exact location of the buildings were not mentioned. Replicating purpose is one thing but repeating studies in the same place is ineffective (Zamanian et al., 2015).

1.3.2 Problem Solving and Limitations in Hospital Building Layout

Helber et al. (2016) stated that the layout of hospitals was designed, expanded, restructured, renovated, and modified to meet the needs of the facility without taking adequate fire safety measures. The research aimed to suggest locations for departments and wards for a given building system to reduce resource consumption by these mobility devices. The study was conducted in Medizinische Hochschule Hannover (MHH), Germany with available dataset of hospital design layout. The information obtained was used to evaluate and combine with hypothetical systems applied by computer programs. However, despite the success, there were some drawbacks, as this method could not be replicable for a typical researcher, due to the different system calculations of specific datasets, which may lead to errors in the study (Vaidogas & Šakėnaitė, 2015).

El Kady et al. (2017) studied hospitals building layouts and found inadequacies and patient flow problems. The research aimed to provide user-friendly two-stage methods with heuristic replacement approaches to find better solutions to the current challenges of multi-stage design. The study was conducted in Egyptian

hospitals, namely a five-story secondary hospital with 17 departments in Cairo and a seven-story tertiary referral facility in Monofeya. Two problem phases were conducted, the Hungarian allocation method and the Computerized Relative Allocation of Facilities Technique (CRAFT). This study was like Helber et al. (2016), whereby no data was provided on the travel or transport activities discussed. Therefore, without complete research data on the building under study, it is impossible to obtain accurate computerized results on the actual layout.

Li et al. (2020) discussed the complexity of hospital buildings with enormous structures and dynamic habitats that affect healthcare performance in terms of medical contingencies, patient transport, equipment transport and treatment process, which is related to facility design. The study aimed to develop a new way of selecting health care systems and to improve the efficiency of layout planning. The study was conducted using interviews and observational studies in an orthopedic clinic in the Sixth People's Hospital of Shanghai, China. Data collection was analyzed using discrete event simulation (DES) and agent-based simulation (ABS). However, due to the complexity of the data analysis, the study only focused on specific points of the buildings and is an insufficient method for investigating overall layout issues.

Lin & Wang (2019) noted that simulation studies required significant changes in healthcare with greater relevance and complexity associated with many types of existing hospital building infrastructure, systems, and procedures. Therefore, the requirements for positioning of services, machinery, and accessibility of departments as well as layout design were considered to minimize errors and costs. The study aimed to optimize the room layout plan by integrating Systematic Layout Planning (SLP) with Human Reliability Analytics (HRA) and Fuzzy Analytic Hierarchy Process (AHP). This layout study included the staff toilets, pre-operative waiting unit, post-

anesthesia care unit, nursing room, equipment room, operating theatre, sterile supply storage room and central sterile supply department in an operating theatre in a hospital in Shanghai, China. Based on the logical and non-logical efficiency of layout utilization, human errors, and the safety of the system in the facilities need to be investigated.

Garip (2011) investigated the needs of building users, which included medical staff, patients, and hospital visitors. Even when existing structures meet all practical criteria, they were often unable to meet the psychological needs of patients and their caregivers, including doctors and staff (Mahmood et al., 2017). The study aimed to describe the visual features that help people 'know' the building and influence the legibility of the environments. The study was conducted using a symmetrical building layout in the clinical faculty CAPA in Istanbul. In this study, 41 participants from different departments with similar layouts but different colors, uses, signage features, floor coverings, lighting design and indicators were interviewed. It was found that people who spent more time in the buildings are more likely to give correct numbers and information than people who spent less time there. According to the perception study, hospital staff were more reliable than patients when it came to their opinions of buildings.

1.3.3 Problem Solving and Limitations in Hospital Building Usage

Patharla et al. (2020) studied the concept of 'safe hospital' introduced by the Pan American Health Organization (PAHO) and the World Health Organization (WHO). The study aimed to identify the causes of major fire incidents in Indian hospitals reported from January 2010 to December 2019. The study examined 33 major fire incidents in government, private and trust hospitals. Data was collected

from news reports available on the internet that focused on India, and only hospitals with high occupancy rates of 100 beds or more were assessed in this study. Based on this question, the researchers established a relationship between building usage factors and hospital fires in India.

Chowdhury (2014) found that every room or department usage in hospital buildings was associated with fire risks. The risks found in the buildings were due to three causes: a) liquid-based chemicals that were flammable or combustible when exposed to fire or heat, b) heat or sparks generated near the oxygen supply source, c) improper handling of oxygen-containing equipment components due to careless behavior. The study aimed to investigate the probable causes of fire in the ICUs and NICUs of Indian hospitals. The researcher used an internet search (Google search engine) to collect readily available information on all reports of fires in hospitals in terms of time, place, and source of each fire. Based on the issues discussed, the study focused on the risks of building usage and factors associated with fires, including major causes such as electrical equipment (e.g., air conditioning).

Choudhary et al. (2020) emphasized that the utilization factors of hospitals are vulnerable to fires when these disasters result in loss of life and property due to improper behavior of the occupants, lack of knowledge on fire prevention, inadequate housekeeping, and obstructions at the exits. The aim of the study was to identify these problems and provide recommendations for existing hospitals. In this study, some terms such as fire safety, hospital fire, fire risk and fire safety problems were used to identify specific issues related to risks and hazards in hospitals using online research databases. A total of 684 articles were found, but only 27 papers were examined in depth. Compared to the earlier studies by Patharla et al. (2020) and Chowdhury

(2014), this study was qualitatively more convincing. Based on this study, previous fire events in hospitals were related to various activities in occupied buildings.

Huang et al. (2019) stated that hospital buildings had complicated space layouts, high energy usage and sophisticated medical equipment that need to be always operational, which undoubtedly leads to a high impact on building usage. The study aimed to look at hospital evacuation from two perspectives: a) risk identification and b) discussion and outlook on general evacuation procedures. The study was conducted for disabled patients who were dependent on wheelchairs or hospital beds and needed special assistance or attention in case of fire. Based on recent fires in hospitals, the researchers therefore collected data on two specific areas. According to the study, hospitals that were constantly occupied and in operation were at varying risk of fire. Additionally, emergency planning for fires were pertinent for all residents as hospitals are regularly used by large numbers of people and medical staff may not be able help these people simultaneously.

Phuspa et al. (2019) found that fire incidents in hospitals were associated with excessive building usage, such as the use of electrical components, high-voltage medical equipment, high-voltage power supply, and air conditioning systems that ran continuously. In addition, fires in these activities easily occurred due to human error (Thirunavu et al., 2021). The study aimed to investigate the fire safety systems of Ponorogo Regional Hospital, Indonesia. The study was conducted in 27 rooms of the hospital, using a total sampling method for the study population. Data was collected through observations, interviews and document reviews using the HVCRA (Hazard, Vulnerability, Capacity, Risk Assessment Model). Based on this study, overuse of various activities in the hospitals were identified. Future research needs to understand these problems from the perspective of hospital staff who occupy the buildings.

1.4 Purpose of the Study

The purpose of this study was to investigate the perceptions of hospital staff from clinical and non-clinical areas working as medical staff, management staff and technical staff in government hospitals in Johor regarding fire safety characteristics. This study also measured the relationship between participants' socio-demographic factors and their perceptions of building occupancy, building layout, and building usage. Fire safety procedures are critical factors that need to be addressed to prevent fires in buildings, so it is the responsibility of occupants to create a comprehensive fire safety environment. It is necessary to assess their preparedness and understanding of the building environment in the event of a fire.

1.5 Research Aim

The study aimed to investigate the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia.

1.5.1 Research Question(s)

A few studies were conducted on fire safety in Malaysian hospitals in Malaysia (Abdullah, 1998; Jaafar & Talib, 2017; Ong, 2015; Ong & Suleiman, 2015a; Ong & Suleiman, 2015b; Salleh et al., 2020; Shah et al., 2017; Thim, 2000). However, there was insufficient data on basic fire safety issues relating to the fire safety features of government hospitals in Johor. Therefore, the study aims to address these are research questions.

1. What is the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia?

2. What are the staff perceptions of the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia with regards to building occupancy, building layout, and building usage?
3. What is the association between staff sociodemographic factors and their perception of the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia with regards to building occupancy, building layout, and building usage?
4. Is there a relationship between building occupancy, building layout, and building usage in terms of the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia?

1.5.2 Research Objective(s)

1. To identify the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia.
2. To investigate the staff perceptions of the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia with regards to building occupancy, building layout, and building usage.
3. To analyse the association between staff sociodemographic factors and their perception of the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia with regards to building occupancy, building layout, and building usage.
4. To examine the relationship between building occupancy, building layout, and building usage in terms of the effectiveness of fire safety measures of government hospital buildings in Johor, Malaysia.

1.6 Study Significance

This study aims to provide valuable insights and essential information for designing fire safety policies and programs for Malaysian government hospital buildings. The results of this study can serve as a primary reference and guide for those responsible for implementing practical approaches following the relevant fire safety requirements for hospital buildings. This study can also indicate the impact of significant changes in building occupancy, building layout, and building usage on fire safety characteristics and that the changes made are justified. In addition, this study can help policymakers such as the Ministry of Health Malaysia (MOH) and Johor State Health Department understand the importance of fire safety implementation in Malaysian government hospitals. Furthermore, the knowledge gained from this study can contribute to the scientific training of future researchers. Finally, the results of this study will also show the relationship between contributing factors and fire safety characteristics.

1.7 Limitations

In the study, some problems arose and were deemed research limitations. These limitations were classified into five issues:

- a) Time Consuming Research/ Limited Resource
- b) Ethical Approval Process/ Site Research Procedure
- c) Limited Accessibility Area/ Restrictions Area
- d) Sample Population Approach/ Sampling Methodology
- e) Covid-19 Pandemic/ Movement Control Order (MCO)