The impact of floods in hospital and mitigation measures: A literature review

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Abstract. In late December 2014, the flood was most significant and largest recorded specifically in the Kelantan, Malaysia. It was considered to be a “tsunami like disaster” in which 202,000 victims were displaced and causing widespread collapse of public infrastructure. Flooding of hospital results in interruption of business, loss of infrastructure, such as electrical power and water supplies, increased difficulty in providing routine medical and increased patient admissions and nursing care for patients with chronic diseases, such as renal failure, diabetes, cancer, cystic fibrosis and mental illness. The aim of this paper to identify the best of measures for reduce the risk of flood in hospital. Method of this paper uses the previous study result. Several related previous study can be used as measures to mitigation flood risk in Malaysian hospitals. Early stage research of related studies hope to help add more information to assist researchers in reducing the risk of flooding in hospital. The findings with proper pre-event preparation framework for mitigation flood risk of hospitals, the continuing medical services can be provided to patient especially during emergency.

1. Introduction

Floods are natural disaster resulting from rainfall in certain seasons because water levels of rivers and lakes overflowed and went into the surroundings [1][2]. Floods can create various of damage to property and loss of life is significant. Scenario flooding and destruction from flooding not only recorded in Malaysia but also throughout the world. According to the World Meteorological Organisation (WMO), the flooding is three worst natural disasters in the world and has claimed thousands of lives and destruction of property valuation hundred thousand million [3]. A record number of floods in Malaysia, such as in year 1926, 1931, 1947, 1954, 1957, 1963, 1965, 1967, 1969, 1971, 1973, 1983, 1988, 1993, 1998, 2001, 2006, 2007 and 2010. Reports from Department of Irrigation and Drainage stated that about 29,000 square kilometers, or 9% of the total area and more than 4.82 million people (22%) of the population affected by floods every year [4].

Floods are an annual occurrence of varying in state on the east coast of Peninsular Malaysia such as Pahang, Terengganu and Kelantan. In late December 2014, the flood was most significant and largest recorded specifically in the Kelantan. It was considered to be a “tsunami like disaster” in which 202,000 victims were displaced and causing widespread collapse of public infrastructure [5][6]. Kelantan faces Northeast monsoon from November to March each year and compounded by unplanned urbanization, geographical characteristic and land use planning, triggered the severe flood [7]. Healthcare facilities were severely affected by the flood and patients had difficulties receiving medical treatment in a timely and effective manner as most of the healthcare facilities and public amenities were located on the flood plain [5].
Hospital is among most important in which it gives a medical facility and treatment of the highest quality to in and out of patients[8]. In addition to being a major referral centre that provides diagnostic and treatment services. Hospital building equipped with modern facilities and building of sophisticated medical equipment as well as involving professional staff to provide medical services and care to patients [9][10]. Therefore, this study was to review the issue of the impact of floods in the hospital and measures to reduce its impact.

2. Impact of floods on health services
Flooding can either damage hospital facilities directly or disrupt access to them [11][12]. Damage may be direct costs such as losses in infrastructure, expensive medical equipment, hospital furniture, lifeline installations and medical supplies. Indirect costs are unforeseen expenses after emergencies such as increased risk of outbreaks due to loss of laboratory and diagnostic support, temporary solutions like field hospitals and the loss income normally generated by health care services [8][13].

2.1. In Malaysia
On December 2014, a massive flood happened in the state of Kelantan, Malaysia. It was recorded as the most significant and disastrous flood in Kelantan. The governments estimated around 200,000 people were affected [14]. Hospital are also affected by the floods 2014 in Kelantan, such as Hospital Raja Perempuan Zainab II (HRPZ II), Kuala Krai, Tumpat, Pasir Mas, Gua Musang and Tanah Merah [15]. Hospital Raja Perempuan Zainab II (HPRZ II) is the worst hospital affected due to water entered and had to stop 80 percent of their services due to flooding and left more 200 patients had to be transferred to the Hospital Universiti Sains Malaysia (HUSM) [16]. The situation became chaotic in Hospital Universiti Sains Malaysia (HUSM) in Kubang Kerian due to increasing the number of patients because of the closure Raja Perempuan Zainab II (HPRZ II) hospital.

Another challenge that was encountered during flood was a shortage of staff. Almost 50% of the staff was affected by the floods, including the head of the Emergency Department. Furthermore, there was no disaster declaration from the top-down at HUSM on day 1 of the disaster, meaning that Emergency Department staff had to handle the situation themselves. With the increasing number of patients, this became a disaster for them [6]. About five of patients were evacuated to Hospital Besut, Terengganu to receive more critical treatment due to insufficient number of care beds. There are many cases referred from HPRZ II involving victims who suffer from chronic diseases such as acute respiratory syndrome, chronic respiratory disease and heart disease jammed [17]. While the average amount of losses incurred by the Kuala Krai hospital due to floods in 2014 is estimated at RM1 millions of which including damage to non-drug items such as medical equipment, non-medical and other facilities is estimated at RM600 million. While items involving drugs is estimated at RM500 thousand [18]. In addition, the fuel shortage is causing disruption to the electricity supply in Kuala Krai hospital. This is because there is no storage fuel for use in emergencies. Increasing the number of flood victims in Kuala Krai hospital has caused shortages of food, drugs, oxygen gas and clean water. Because of that, the critical patients should be transferred for getting further treatment [19].

2.2. In Overseas
During the past 10 years, in the European Region, 1000 persons are reported to have been killed by floods and more than 3.4 million affected. Flooding of health facilities results in interruption of business, loss of infrastructure, such as electrical power and water supplies, increased difficulty in providing routine medical and increased patient admissions and nursing care for patients with chronic diseases, such as renal failure, diabetes, cancer, cystic fibrosis and mental illness. Ukraine reported damage to 122 hospital due to flooding [13]. Typhoon Nari hit the coastal region of northern Taiwan on the night of September 16, 2001. The health care system in Taipei was seriously damaged. There were 11 hospital damaged by storm induced flooding, which left them in vulnerable condition requiring evacuation. Storm water filled the basements and first floor of many hospitals and caused the backup generators to be inoperable. Power was limited to critical care units, operating rooms and to
important laboratory equipment. Therefore, providing medical service at full capacity was nearly impossible in the aftermath of the typhoon. Some emergency services were closed to the public for days [10]. In 2007, floods in the New South Wales Hunter Valley has caused the Morisset Hospital was without power for almost two days [20]. Some hospital were completely destroyed during 2004 Hurricane Katrina in the USA and in Australia many hospital have been damaged and cut-off from surrounding communities during severe cyclones, storms and major flooding events in the recent past [21]. Flooding occurred in the Gloucestershire Hospital UK has caused water contamination and had disruption inoperability of medical services and cease of activities [22].

3. Flood mitigation measurement for hospital

   The paper is written based on an overview of literature from journal, articles, newspaper, book and report. The review focus about local and other country experiences regarding flood effect in hospital issue and identify the best of measures for reduce the risk of flood in hospital. Given growing international concern about the resilience of health facilities in the face of climate change, many countries have strengthened and developed legal frameworks, research and funding schemes for disaster reduction and climate change adaptation [23]. Floods also caused a large damage of property and life threatening population. Therefore, these publications mainly focus on floods[24]. Flooding can either damage health care facilities directly or disrupt access to them [13]. Federal Emergency Management Agency (FEMA) design guide for improving hospital safety provides important insights into variety of hazards mitigation for health facilities [25]. The FloodProBe project aims to provide cost effective solution for flood risk reduction in urban UK areas [26]. The World Health Organization (WHO) Regional Office for Europe and the United Kingdom Health Protection Agency (HPA) collaborated to assess the health effects of floods as well as to identify measures to prevent or minimize their health effects. This Hyogo Framework for Action (2005-2015) adopted by the World Conference on Disaster Reduction highlights the need to integrate planning for disaster risk reduction into the health sector. This framework addresses primary, secondary and tertiary prevention for managing flood risk with a range of interventions and measures to reduce the impact of human health (refer table 1) [13].

   In studies Plate and Chan said, both of structural and non-structural method needs identified for disaster reduction planning. Selection the best of measures to be able solve or reduce the impact of disaster problems. All activities the both management method of structural aimed “controlling” and non-structural is to reduce the floods impact [4, 27]. FEMA recommends to reducing flood effects in critical facilities must relocating the facilities outside of the floodplain [28]. Having listed some study recommended to mitigate the impacts of flood, it is important to point out that multi method mitigation flood is considered the best practice.

   **Table 1. Preventive measures for flood risk reduction in hospital.**

| Primary | Structural (physically engineered interventions) including tree planting, control of water source and reconstruction of the defense to the beach / river. Nonstructural (policy and organization) including land used management, stewardship and government, resource generation, health financing and service delivery. |
|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Secondary | Flood forecasting, warning system, moving belongings and assets, Evacuation shelters and temporary and mobile structures, maintaining health services.                                                                                   |
| Tertiary | Include ensuring clean water and food supplies, close relationship with another agency(military, fire and rescue, police, water organizations, gas organization, human resources)                                           |

4. Result/discussion

   Sudden and unexpected flood often lead to severe damage and dramatic disruptions to the affected area especially in hospital. According to Sam and Pesigan the destructive effects of natural disasters on infrastructure and operations due to inadequate planning and disaster management [8]. Because
prevention is more cost-effective than dealing with problems caused by the calamity, several improvements can be made in the initial preparation for hospitals in a flood. A comprehensive preparation should include a systemic process of planning, which includes structural, nonstructural and administrative issues [10]. The common organisational objectives to across all case studies which emerged in hospital were [23]:

- Continuity of service delivery;
- Preserving the building structure’s integrity along with its building services;
- Having effective communication both externally and internally;
- Maintaining access to and from the site and;
- Ensuring availability and safety of relevant staff on hand to respond to the crises.

Hospital located near riverbeds, storm drains and areas of lower altitudes sustained even more damage. Thus, hospital must be designed and built to prevent potential disruption of function caused by flooding [29]. Structural elements for hospital building such as safe location, design, and structure are important considerations for allowing buildings to withstand the recent events. Tree planting also important, it is because a canopy of tree can slow precipitation, intercept rainfall and slow its flow into natural and engineered drainage system [13].

While floods can also cause damage to the equipment or drugs. Previously, hospital design focused on the optimum use of space to prepare the most effective interaction and action among difference department [8]. Thus, heavy equipment such as the telephone lines, electric generators, heavy medical equipment and medical supply storage are usually placed in basement. Therefore, when occur flooding, emergency response is interrupted immediately. Several measures can prevent this damage, such as regular inspections of the drainage system and sewage system, relocating the important medical equipment to above grade and convenient maintenance of the equipment to keep it in best working order [10]. In hospital located in flood prone areas transformer, emergency generator and electrical room must be relocated above grade or relocating the hospital outside of the floodplain, so that they can safe from flooding [28]. This is non-structural suggestions, if applied this suggestion will prevent costly damage where interferes with the efficiency and functionally of a hospital.

Features Administration also needs to be considered in preparation for the floods. This includes preparation and training is not limited the emergency staff only, but also involves the management of hospital staff [17]. Besides, the effective communication through top-down management is needed. This ensures the flood information flow can be channeled properly. Effective communications from other parties that cooperated with hospitals to help flood victims are also required [6]. The information chain in communication system should be monitored every moment. Effective human resource management is important to ensure that the hospital staff is required during flooding sufficient to ensure continuity of operation. The list of contact numbers of hospital staff should be updated [30].

Increasing the number of patients caused the beds care inadequate [6]. Sufficient number of critical care beds must be available for the transfer of patients from disaster impacted hospitals or mass causalities [10]. Hospitals often rely on electric generators during electric supply disruption. However, inadequate fuel supply and cause an electric generator are not operating. Therefore, adequate the fuel supply should be available during disaster and the fuel storage is needed [19]. Hospital should be ensuring that they can prepare water and food for the first 72 hours of the flood [13]. Due to methods of communication depend on a power supply, communication hospital are interrupted during power outages. Both external and internal communication must have other, prearranged methods of communication. Hospital should be having backup equipment to support their communication such as radios, battery-run speakerphones and walkie-talkie [31].

The main reasons for evacuation are the presence of water in building and loss of power [13]. Critical patients should be transferred to other hospital for further treatment. Because roads were flooded, rafts and boats were use as alternative method for patient evacuation during this time. Same also with supplies such as fuel, food and water were brought to hospital by the same method [10].
Several related previous study can be used as measures to reduce flood risk in Malaysian hospitals affected by floods. For example, location of the hospital is clearly giving potential damage when flooding occurs. Hazard assessment should be started before construction of a hospital. Flood can affect the internal hospital facilities, such as communications, electricity, medical equipment and supplies also transportation to evacuated patients. Therefore, proper preparation is needed before an event occurs.

5. Conclusion
Floods catastrophic can cause severe damage and can affect the national economy. The variety of damage includes structural, non-structural and administrative. Thus, the risk assessment of flood hazards is conducted to assess the weaknesses the exiting to ensure the best elements needed to reduce the effects the flood hazards in hospital. Selection the best measures through structural and non-structural methods to solve or reduce the problems that faced the impact of the floods. Although we cannot prevent natural disasters from occurring, early warning systems and a well-organized disaster management plan can lessen the disruption. The findings with proper pre-event preparation guidelines for mitigation flood risk of hospitals, the continuing medical services can be provided to patient especially during emergency.

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