Hospital Evacuation; Learning from the Past? Flooding of Bangkok 2011

A. Khorram-Manesh[1,2*], C. Angthong[3], A. Pangma[4], S. Sulannakarn[5], R. Burivong[6], R. Jarayabhand[7] and P. Örtenwall[1,2]

[1]*Prehospital and Disaster Medicine Centre, Gothenburg, Sweden.*
[2]*Sahlgrenska Academy, Gothenburg University, Gothenburg, Sweden.*
[3]*Department of Orthopedic Surgery, Thammasat University, PathumThani, Thailand.*
[4]*Emergency Medical Institute of Thailand (EMIT), Bangkok, Thailand.*
[5]*Department of Internal Medicine, Cardiology, Rajvithi Hospital, Bangkok, Thailand.*
[6]*Department of Emergency Medicine, Ayutthaya Hospital, Ayutthaya, Thailand.*
[7]*Department of Orthopedic Surgery, BhumibolAdulyadei Hospital, Bangkok, Thailand.*

Authors' contributions

This work was carried out in collaboration between all authors. Author AK designed the study, performed the interviews and analysis, managed the literature search, wrote the protocol, and wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Research Article

ABSTRACT

Aims: To evaluate hospital evacuation in light of recent hospital evacuations in Bangkok and surrounding areas. This information was compared with results reported in the literature.
Study Design: Retrospective and qualitative.
Place and Duration of Study: Bangkok, Thailand, December 1 to December 11, 2011.
Methodology: Four facilities were included in this study, three hospitals and one "prehospital" facility, each of which had either experienced evacuation or had been receiving facilities during disaster response operations. Data were obtained using questionnaires and interviews to characterize facility backgrounds and capacities. Responses were obtained from one representative of each of the four Thai facilities. The questionnaire was designed for this study following recommendations by an earlier Swedish study that employed "risk and vulnerability analysis" (RVA), and was further

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Corresponding author: Email:amir.khorram-manesh@surgery.gu.se;

adapted according to results of a literature review.

Results: Overall, consistent results in the literature, as well as in the recent Thai disaster experience, about hospital evacuation indicate shortcomings in planning (including training), command and control, communication, support, resources and transportation. Patient safety, transfer of medical data, care and treatment of patients during transportations showed positive outcomes in recent Thai evacuations.

Conclusion: Despite numerous previous findings and recommendations found in the literature, the need exists for continuous improvement in evacuating a hospital, especially in improving planning (coordinated emergency plans and synchronized exercises), leadership, communications and collaboration and implementation of best medical facility response to disasters.

1. INTRODUCTION

The hospital is a principal asset for successful management of disaster/major incident response; however, hospital's medical disaster response plans often focus on receiving large numbers of victims, not being victim to disaster and therefore in need of evacuation management [1-3]. Such evacuation management often requires cross-border cooperation involving many organizations, which consequently vastly changes what is required to manage the disaster. Such vulnerability of hospitals varies among different countries both in terms of locations and the types of events [3-6].

From natural disasters - volcano eruption, flooding and earth quakes, to the man-made disasters - industrial events, transportations incidents and terrorist attacks, many occasions may occur when hospitals find themselves engaged rescue missions to be evacuated. In addition, new and unpredictable events such as technical failure at the hospital also present major threats to the hospital and its patients [3,7]. Disasters may not be preventable, but their effects can be mitigated by learning from evidence about their etiology and potential outcomes [5,7-22].

Many disasters have struck Thailand, including the Tsunami that hit its western shores in 2004 [1,7,20-23]. The effects of that disaster prompted improvements in emergency preparedness, the Thai Emergency Medical System (EMS) and hospitals organizations, as well as improvements in the levels of preparedness and education among different professional groups. We have recently reviewed Thailand's preparedness, and its disaster and emergency medical organization, and concluded this constituted a functional disaster management organization in Thailand. However, we also identified some areas in need of improvement, such as provision of the action roles in the national disaster response model and increased knowledge about disaster planning and management, along with continuous evaluation of the systems using exercises as well as simulation training [7].

Flooding is not infrequent in Thailand [20]. However, due to exceptionally heavy rain in September, 2011, 53 of 77 Thailand's provinces with around 2 million inhabitants were affected by flooding. The Ayutthaya province in the central region of Thailand was declared an emergency zone due to the flooding. A number of reservoirs reached maximum capacity, further increasing the risk of water overflow and of the spread of water-borne diseases. The flooding began in Bangkok and its surrounding provinces on the September 30, 2011. Recent flooding in Thailand provided a good opportunity to evaluate the success or failure of

current organizational response in managing after natural disaster. This study investigates whether disaster plans alone are enough to manage hospital evacuation and evaluates what lessons learned from the past should be integrated into future disaster planning.

The purpose of this study was to evaluate recent hospital evacuations in Bangkok using a mixed, qualitative and quantitative, methodology to learn about the hospital and EMS experiences and to use these findings to compare recent emergency response with past ones.

2. MATERIALS AND METHODS

2.1 Healthcare Units

Our prehospital and hospital evaluations in Bangkok were performed between December 1-11, 2011. Three hospitals, Ayutthaya Hospital, Bhumibol Adulyadei Hospital and Rajvithee Hospital were available to be included in this study. All three hospitals were "receiving hospitals" during disaster response operations, though Ayutthaya Hospital was later itself evacuated. Information was obtained on hospital background, capacity and status (data from December 2011).

2.1.1 Ayutthaya Hospital

Ayutthaya Hospital is is a 600-bed; public hospital located 70 km from central Bangkok. It employs over 1000 personnel and provides services for all major specialties except cardiovascular surgery and interventional radiology. The hospital campus occupies a large area, including staff accommodation, a couple of restaurants and a parking area, and is easily flooded due to its closeness to the Chao Phraya River. Many core facilities such as power generators are located in the basement.

2.1.2 BhumibolAdulyadei Hospital

Bhumibol Adulyadei Hospital is a 770-bed military hospital located in Bangkok that employs over 1000 staff and serves all major specialties. Many facilities, departments and utilities that serve the hospital, such as central laboratory, power generator, supply units, sewage and water system, are located on the first floor, ground or in the basement. Its campus is also large and includes staff accommodation, restaurants and a parking area.

2.1.3 Rajvithee Hospital

Rajvithee Hospital is located in the centre of Bangkok and lists 910 beds, 1000 personnel and has all major medical specialities. Its power generator is located in the basement of a separate building. Its campus includes staff accommodation and restaurants. In front of the hospital entrance a market place partially obstructs the flow of traffic in and out of the hospital.

2.1.4 EMIT

EMIT(Emergency Medical Institute of Thailand) was recruited for evaluation of the prehospital activities. A flexible public organization with long-term sustainability, EMIT aims to achieve high quality and demonstrates an international standard of EMS in Thailand. It

has developed provincial "Command and Control Centers" (CCC) with a single, uniform contact number to supervise the whole chain of prehospital actions and services under the guidance of trained EMS personnel (24).The EMIT collaborates with the ministries of public health, defence, police and the Department of Disaster Prevention and Mitigation. It supports EMS operations by establishing EMS standards relating to training and certification, and conducting research and developmental activity, including information and communication technology (ICT). An emergency medical committee coordinates the work between EMIT and other organizations.

2.2 Questionnaire and Interviews

Information obtained from an earlier Swedish study of Risk and Vulnerability Analysis (RVA) in two different county hospitals was used as the basis upon which a questionnaire was designed [25]. Important topics and categorical variables for a potential hospital evacuation were identified in the first hospital and guided the evaluation of the second hospital. The results from both hospitals were then matched, and this information was used to create the questionnaire to be used in our Bangkok study. The questionnaire consisted of two parts (Appendix 1), Part 1, the hospital part, included 4 categories: *i)* General, *ii)* Pre-planning, *iii)* Evacuation Process (including transportation), and *iv)* Post-Evacuation/Recovery. The prehospital, Part 2, of the questionnaire queried about prehospital management, coordination and transportation of patients. The questionnaires were sent to one representative recruited in each hospital or in EMIT two months before interviews were held. Their responses were delivered to the first author (AK), who then interviewed each representative based on their responses on the questionnaire. All information was gathered, analyzed and registered in Gothenburg by the first author (AK) and was later sent back to all authors for approval and additional comments. The result was categorized in the following subgroups: *i)* Evacuation *ii)* Command, Control and Communication, *iii)* Patient safety, *iv)* Support and Maintenance, and *v)* Transportation). They were further listed as either obstacles or facilitators, as previous study had done [26].

2.3 Literature Search

An online literature search for the time period January 1996 to January 2013 was conducted using PubMed, Google Scholar, CRED (the Centre for Research on Disaster Epidemiology database) and university medical library search engines (e.g. Gothenburg University) based on keywords, including: 'evacuation/closure', 'hospitals/medical facilities' and 'disaster/hazards', alone or with 'planning'. Later on, two new keywords were added: 'lessons learned/recommendations' to narrow the results. The purpose of this search was to gather some information about the past hospital evacuations, which were then, compared with results obtained from qualitative investigation of the recent evacuations in Thailand. Only articles reporting on major hospital evacuations were included. Those with clear lessons learned and or recommendations [5,8-19,29-41] were extracted and reviewed by the first author (AK) and the results were summarized. No other parameters were studied. Evacuations reported by newspapers or documents not scientifically evaluated were not included.

3. RESULTS

3.1 Questionnaire

The following are the results of the interviews using the questionnaire (by AK). Raw interview data was collated under 5 themes.

3.1.1 Evacuation

3.1.1.1 Facilitator

All hospitals had an Emergency Plan for evacuation in case of fire, and staff underwent recurrent training annually. The hospital staff performed pre-event evaluations, in which, they received information and then used this to plan for various contingencies, depending on time, space and available resources. Guided by the EMIT, coordination was good between evacuated and receiving hospitals according to our data. Meanwhile, EMIT, due to its importance in the national CCC, appeared to be a contact point between hospitals and facilitated engagement with other organizations. Data showed that evacuations were synchronized between EMIT and all hospitals referring units. A referring unit consisted of administrators and nurses who were in direct contact with the hospitals and the CCC. From this vantage point they supervised evacuations, coordinating vehicles, identifying alternate transport sites, and establishing transportation protocols. As observed in existing disaster plans, all hospitals had written plans to stop on-going activities, close operating theatres, and postpone planned operations and outpatients' visits. Only emergency cases were treated.

3.1.1.2 Obstacle

Traditionally, RVA was not performed, thus, fire was considered the main risk for which most hospital disaster plans targeted. The recurrent training programs were solely focused on fire and staff was not trained to cope with flooding or other threats. Although two hospitals had identified flooding as a risk, only one had a plan, and that was designed only for flooding levels up to 80 cm. Action cards were not employed. Existing disaster plans were not written in conjunction with other organizations, whether local or national. Moreover, insight from other organizations was lacking. Possibilities and limitations, and clarification of roles and responsibilities of other organizations (police, rescue teams, healthcare etc.) were not explicit, with the exception of the military hospital, in which the hierarchy was already in place and orders were obeyed without question. The lack of evacuation planning in other organizations as well as synchronization of efforts was mentioned by interviewed personnel as the main reasons for diminished collaboration.

3.1.2 Command, control, and communication

3.1.2.1 Facilitator

The most important facilitator for an evacuation was the preparedness of the command, control and communication capability. The EmergencyOperationCenter initiated by EMIT was activated early. This was done at the ordinary location since the planned headquarter located at Bangkok's Don Muang airport (the backup airport to the primary) was already flooded. By initiating this center EMIT effectively established its network, was clearly and directly represented in the city's CCC. This enabled EMIT to follow up and obtain relevant

information. In addition to district CCCs, a chain of command and control was established within each hospital. These were based on existing disaster plans and placed the chief of the hospital in charge. This command structure was even more organized and clear at the military hospital. The CEO of the hospital had the authority to initiate and terminate evacuation in mutual understanding with other authorities. The EMIT initiated communication with involved hospitals and partners using mobile radio communication. A central dispatch center was set up and enabled commands to be verbally delivered to all prehospital staff.

3.1.2.2 Obstacle

Variation in quality of received information affected the quality of decision-making. Not all of the hospitals had received reliable information during their pre-event planning. In some hospitals only the nature of the event was taken into consideration, since the access to other information (impact and duration of the floods, weather-related information) varied and was not always reliable. In BhumibolAdulyadeiHospital information was available on a daily basis since the army was represented in the city's CCC. This made decision-making easier for CEO. There was no common evacuation criterion. Only one hospital showed explicit criteria as to when the hospital should be evacuated, namely, when patient safety or the infrastructure or support systems were threatened. Other hospitals relied on their CEO´s experience and knowledge, as well as his individual connections. Internal and external communication was delayed and in some cases not available at all. External information was often unreliable and inconsistent. Consequently, staff would become confused and uncertain. Communication between staff and their families was ineffective. Worry about the condition or location during a disaster of relatives and family members, caused some staff to leave, lowering their number. Plans did not exist for how to incorporate volunteer resources effectively. Each unit was responsible for own recovery. No written recovery plans were presented at interview, except at BhumibolAdulyadei Hospital, which described the following "…path to normalization": "Phase I: Emergency cases and people around flooded area, Phase II: Recall in- and out- patients when the cars start working and can drive, Phase III: Fully open activity."

3.1.3 Patient safety

3.1.3.1 Facilitator

As per their disaster plans, all hospitals had set aside areas for patients who awaited evacuation. Receiving hospitals were identified for services available and patients were sent according to need. In general, the plan was to take critical patients first, followed by special needs or specialized treatments and the elderly. At the beginning, ICU patients were located to the higher floors, which were considered safer. However, that was when there was uncertainty of being evacuated, later on, in most cases, the decision was made together with the patients and their families whether they should stay or move to other hospitals. During evacuation special emergency medical transfer teams moved the patients. These teams varied in skills and abilities depending on patient's condition, e.g. an advanced life support (ALS) team would transport stable or unstable critical-care patients under supervision of a doctor,a nurse and two EMTs (Emergency Medical Technicians). In some cases only 2 nurses and 2 EMTs were used. Each ambulance had the capability of first-response ABC, and was equipped with respirator, ECG monitor, infusion pumps and oxygen and carried an advanced medical bag. Usually a general practitioner accompanied this team, but emergency physicians and few cardiologists were also included. The BLS (Basic Life Support) teams transported non-emergent patients under the supervision of 2 EMTs and

their vehicle was equipped with non-invasive items, such as oxygen and patient transport equipment. All evacuated patients via air or ground ambulances had IV lines. Patients were matched according to their conditions and were triaged before transport using sieve and sort method. Although all patients were sorted as RED, YELLOW or GREEN, triage methods differed by department or by hospital. Collecting areas were set up for each triaged group. In one hospital red, yellow and green lines were pre-drawn on the walls, leading the patients and staff to the appropriate area, and from where the patients were transported to other hospitals. In the other hospitals each color category was directed by a leading triage officer. Medical files were handwritten, with three copies, one each for receiving hospital, transport team and origin. The summary of the patient's history was always available and followed the patient. Recent laboratory results and x-rays were also sent with patients if needed. Most of the patients were also provided with their medications, for a couple of days or up to weeks. In general, however, the receiving hospital was responsible for providing each evacuee's medication. Patients' confidentiality was achieved by sealing envelopes. None of the hospitals had documented guidelines on who to leave behind and triage was to decide on that. All hospital disaster plans included directions and plans for individual follow up of patients if any signs of post-traumatic stress disorder (PTSD) or any other physical injuries were discovered.

3.1.3.2 Obstacle

Lack of internal transport, like boats in flooded areas and adequate number of staff to lead the patients to collecting areas along with the shortage of ambulances were important obstacle to patient safety. Poor documentation of patients was cited. Although EMIT tracked patients and corresponding hospitals, no documentation displayed pooled characteristics, including the severity of disease, number of ventilator-dependent patients, or the number of patients in each triage group. Infusion pumps were used with each patient transported via air, and even a few transported by ground ambulance. Some hospitals experienced certain mortality during evacuation, but these were patients with morbid prognosis who were non-resuscitation cases. The official total number of evacuees from the hospitals and deaths per evacuee has yet to be announced. No patients died while transported to other facilities.

3.1.4 Support and maintenance

3.1.4.1 Facilitator

The EMIT initiative to establish a logistics unit to provide supplies and equipment for the hospitals was a positive measure. In each hospital, equipment and utilities were coded-numbered before the incident. This facilitated relocation of these equipments and enabled treatment of patients, who waited for transportation, outside the hospital. All hospitals had their own security staffs. These security units were responsible not only for the hospital and human protection, but also for sealing certain means of egress, including making sand bag blockades and establishing security posts. These measures mitigated the risk of further damage and helped to secure the hospital infrastructure. Each hospital had thousands of its staff living in houses and accommodations within the hospital campus, which initially made it easy to use a large pool of human resources and helped to overcome difficulties with moving patients to other wards and collecting areas. These resources also helped to build up preventive measures to further stop flooding.

3.1.4.2 Obstacle

The primary weakness in all of the hospitals evaluated was the vulnerability of infrastructure. Vital support functions were located in vulnerable areas, such as power generators in the basement, laboratories and radiology located on the bottom floor. Surprisingly, though all hospitals had their power generators in the basement, only one hospital had reported electrical power failure as a factor for evacuation. All relied on mobile generators and 24-hour technical support. Later on, however, communication problems arose due to electrical system failure. For example, Ayutthaya Hospital was hit hard and eventually would be completely evacuated; yet, EMIT representatives evaluated its situation from the ground and air, and established direct contact with the hospital to prevent further difficulties, while coordinating the evacuation. Although security units were present in all hospitals, some hospitals had difficulty participating immediately in the hospital response due to a lack of boats. Initially, all hospital staffs and resources were sufficient. However, during the course of flooding, the number of available staff decreased. In some hospitals, staffs sent out as transfer teams did not return and instead were occupied searching for personal families. Decreasing numbers of staff and lack of communication increased the anxiety and concern of the staff. None of the hospitals had a plan to address emotional needs of the staff. In one hospital a shortage of drinking water required that staff buy water bottles from the black market outside the hospital. Some deliveries such as surgical and PCI devices, pacemakers and dialysis fluids were delayed or not even delivered despite the fact that these companies had a valid contract to deliver these products even during these times.

3.1.5 Transportation

3.1.5.1 Facilitator

One major task for EMIT was to coordinate transportation demand and vehicle supply, which in Thailand is made complex because each hospital has its own ambulances. They relocated all ongoing calls, activities, task and transportation and started planning working shifts for the staff. The coordination, as well as identifying alternate transport resources, was performed in collaboration with the hospitals referral units. EMIT performed a total number of 883 missions (509 ambulances, 244 boats, 8 airplane, 35 CASA helicopter, 87 helicopters) and evacuated a sum of 1443 patients (660 by ambulances, 372 by boats, 156 by airplane, 145 by CASA helicopter and 110 by helicopter). Another important facilitator for transportation was the good cooperation and the willingness for collaboration between EMIT's network; other organizations (NGO: Non-Governmental Organizations) and military. Military transportation consists of C 130 aircraft, helicopters, and trucks; some of them modified for transportation of group of patients. In Ayutthaya hospital, fifteen ambulances and military trucks were used to transport the first 100 patients to other hospitals. Seventeen seriously ill patients were airlifted by helicopter to other Bangkok and provincial hospitals. At this hospital all 375 patients, including 33 ICU-patients, were evacuated from the hospital successfully. All patients waiting for transport were continuously monitored. They were triaged based on sieve and sort methods and accompanied by medical teams. A special transport protocol was used during transportations to register all changes in vital signs. There was neither any change of priority nor any mortality reported during transportation.

3.1.5.2 Obstacle

Almost all hospitals reported relative shortages of ambulances and other transportation resources, owing to long transportation times to cover considerable distances between

flooded and receiving hospitals. Neither bus nor taxi contracts were arranged. Outside Rajvithee and Ayutthaya hospitals markets created a crowded situation that risked blocking access to the hospitals' entrances and exits.

3.2 Literature Search 1996-2012

The literature search of articles published between 1996 and June, 2012, resulted in 1020 articles. Adding search terms, 'recommendation' and/or 'lessons learned', to the search, the final number of articles was reduced to just over 50 articles. These results are presented, here, according to what caused the evacuation. Many studies examine issues about many topics, such as, evacuation, command and control, communication, patient safety, support and maintenance, and transportation.

3.2.1 Evacuation

Sternberg et al. [8] studied 275 hospital evacuations in the USA between 1971 and 1999 and reported that half of these evacuations were due to internal events or human error. They also concluded that by identifying various risks threatening hospitals, evacuations could be planned and controlled, and mitigated. O'Neill [27] emphasized the need for hospital- and community-wide drills instead of just focusing on disaster preparedness, with a focus predominantly on the pre-hospital services and addressing primarily the rescue phase of the disaster response. He emphasized that "true readiness can only be achieved by testing and modifying disaster plans through integrated simulation drills and table top exercises". As for hospital preparedness, infrastructural difficulties such as inter-hospital transportation of patients were the focus of the study by Fanara et al. [28]. They noted that significant risk exist when moving patients within the hospitals if those critically ill patients are prepared and accompanied by an inexperienced team. To ensure patients safety equipment may need to be adapted and helpful paper mechanisms, such as check-lists, be used. Proper training is important. Another review of hospital evacuations was published by Bagaria et al. [5] who studied 45 USA hospital evacuations between 1980-2008. They identified various triggers for evacuations such as earthquakes, hurricanes, flooding, power failure, and water damage and bomb threats, the scope of which implies that it is necessary to take account of the wide-range of risks when planning for hospital evacuation. In their report they emphasized that internal and external communication, and logistics, were the most common challenges. Only 6% of hospitals had a specific evacuation plan. In another report, Carry [29]explored the impact of weather on available routes of evacuation. In cold weather evacuating to the areas outside the hospital could cause instable patients to become more instable. In such scenarios horizontal and vertical evacuations can be good partial solutions. Gallagher and associates [30]reported that neighbouring hospitals could also be affected by the disaster. By taking this fact into account, they could plan to evacuate patients in a children hospital in Galveston, Texas, to sister hospitals in Cincinnati during Hurricane Katrina. They also reported evacuation of critical patients to "rescue" facilities before the hurricane struck, using private and commercial air transport. Nero et al. [25] described the need for more elaborate evacuation planning for hospitals, combined with recurrent training to address areas of risk and vulnerability. They also presented a general guide for planning, performing and evaluating these plans.

3.2.2 Fire

Gallon et al. [31] described a wild-fire disaster impacting an acute care facility and a nursing center near San Diego. The decision for evacuation came late and the evacuation was made

harder due to sheer volume of residents and the lack of enough ambulances. The authors discussed their idea of the well-functioning organization and recommended involving hospital staff in all planning and organizational changes. They also noted the importance of having a well-designed building structure within the hospital. School buses from a local school were used for transportation of patients. On 2 January 2008, a fire broke out at the Royal Marsden Hospital in Chelsea, in the West of London [17]. Within half an hour, a total of 472 people (79 inpatients, 143 outpatients and 250 staff members) were evacuated. Six ICU patients and two patients who were undergoing surgery were moved with all their equipment to a nearby hospital. Other patients were evacuated to nearby hospitals after triage. The evacuation was successful with no mortality or morbidity. A calm and competent management increased the confidence among staffs, no panic broke out and well-trained personnel were aware of all instructions, equipment and evacuation routes since they had performed drills regularly. Another point of success was the close distance of these hospitals to others, and the optimized performance of the electrical system.

3.2.3 Hurricane

Hurricanes can be devastating; however they can usually be foreseen. Planning can mitigate harm, remedies such as planning for staff shortages, and addressing the competing interests presented when staff are concerned with personal family safety [32]. However, management of Hurricane Katrina [14] revealed that the lack of resources and staff can be devastating. There were many evacuees who presented with special needs for whom special management was indicated. Evacuation also led to separation of many patients from their relatives. Sexton et al. [15] reported on the evacuation ofthe University of Texas Medical Branch at Galveston in September, 2005, due to the threat from Hurricane Rita. The hospital demonstrated that it could rapidly organize and conduct an evacuation. Specific factors were reported as crucial for this success, including: identifying a decision-maker to initiate or terminate various operations involved in the evacuation, making available a set of guidelines, articulating priorities for patient safety, establishing an incident command center for overview of vital institutional functions, identifying strategic partners, selecting highly motivated personnel who carried no undue personal concern during emergencies, and conducting periodic drills. They also emphasized on the need for resilient communication systems, systems for tracking patients and vehicles, and guidelines for communicating with patients' family members. Hurricane Sandy in 2012 led to the evacuation of 825 patients. A report on its disaster response showed that the localization of vital devices, such as fuel pumps, generators etc., should be planned carefully to avoid major dysfunction. It also pointed out that risk analysis and training of staff are vital for a successful evacuation and that health professionals must be trained to maintain their own and the patient's safety and that clearer evacuation criteria are needed [19].Finally Bernard and Mathews [33]identified that by providing hospital-based accommodations to staff and families during a hurricane, personnel's anxiety reduced and they could remain onsite. They observed that the planned receiving hospital was sometimes itself flooded or affected by disaster; thus, a plan must be in place for evacuation of patients to other facilities, even far away.

3.2.4 Earthquake

In a study published by Schultz et al. [8] about an earthquake in Northridge, California, the importance of preserved and maintained infrastructure in a successful evacuation was highlighted. Two main learning points were offered: *i)* establish "emergency operation centers" (EOC) and *ii)* collaborate with other organizations. In another publication the same year [34], the author discussed patient safety and the priority of evacuee disposition. They

recommended the evacuation of stable and ambulatory patients before the most critical patients in order to save more lives. In this report they also emphasized the necessity of ventilating ventilator-dependent patients manually and replacing electronic IV lines with traditional gravity type. Other important points of criticism made in their report were the lack of a sole decision-maker for evacuation and communication system operations.

3.2.5 Flooding

Massive rainfall from Tropical Storm Allison caused extensive flooding and complete power loss leading to evacuation of 575 patients to 29 other facilities by both ambulance and helicopter. Six deaths occurred, none of them related to the flooding [12]. The most important assets learned were early decision-making, support and maintenance of electrical power, in-house communication system, reliable contact system for contacting outside facilities, battery-operated lighting system, triage of patients, proper management of available volunteers, paper record of all patient transfers, coordination of loading of ambulances and helicopters for patient transfer, and coordinated reassignment of staff to care for transferred patients. Focusing on availability of staff, Schultz et al. [9] studied 8 centers that had evacuated up to 334 patients. The most important factor for a successful evacuation that they identified was the availability of staff. Näsman et al. [11] described their understanding of the disaster caused by flooding at the border between Czech Republic and Germany, which led to power failure that impacted all electricity-dependent communication systems and computer-based patient files. Their study also revealed the vulnerability of having vital functions at lower levels and basements of hospitals. Verni [18] explored the lessons learned by evacuation of three hospitals at high risk of flooding from Hurricane Irene in August, 2011. The episode resulted in the evacuation, transport, and placement of 947 patients without any resulting deaths or serious injuries. They learned that group transport of patients is much more effective. They also detected some shortcomings such as need for automated tracking of patients and extra staff, and the benefit of inter-facility evacuations drills to refine procedures for sending and receiving patients.

3.2.6 Bomb threat

Augustine and Schoettmer [35] describe evacuation due to bomb threat and how arranging for extra space can be used to gather patients. In an evacuation at Galion Community hospital in Ohio, a women's center, church and other areas were opened up and made available to house the patients. The hospital noted key elements of their planned procedure, including: Creating manpower pools, arranging transfer of patients, providing care outside the hospital, defining an evacuation zone, identifying alternative patient care areas, and take care to ensure effective communication among staff and community.

3.2.7 Hazardous material

Vasudevan and Wade [36] described an evacuation of Helena Regional MedicalCenter due to a chemical explosion. Challenges to transportation, such as route availability were discussed beforehand and school buses were used in addition to ambulances. In 1999, Burgess [37] introduced hazardous material incidents as a potential cause for an evacuation. He pointed out that these materials often enter the hospital via emergency departments, where staff are usually first affected due to airborne inhalation. Intensive care unit patients are not likely to be evacuated due to their isolation.

3.2.8 Power blackout

In 2005 Klein et al. [38] published a paper dealing with a blackout in the USA in 2003, which affected many hospitals and led to many difficulties in maintenance and support functions of hospitals, such as lighting, elevator operations, water supplies, communication operations, computer failure, lack of adequate food supplies, mobility to obtain X-ray studies, heating, air condition and ventilation, staffing and inadequate supply of paper; and also other organizational and clinical issues, such as lack of medication, problems with registration of patients, establishing a hospital EOC, loss of isolation facilities, impaired ability to provide care for non-emergency patients, sanitation and inadequate emergency power. Besides some new points, most of the shortcomings had previously been noted in the literature. In a Kamedo report [16] the blackout of Karolinska University Hospital in Huddinge was described. A short power failure resulted in many unexpected problems such as dysfunctions in all electricity-dependent devices, coded doors, pharmacy lockers, etc. All medical supplies were in rooms locked with coded entry. There were also disturbances of water and gas supplies. The event led to diversion of ambulances and emergency patients to other hospital and overloading of hospital's emergency departments.

3.2.9 People with special needs

Children, elderly and others with certain diseases present special needs and should be considered accordingly in an evacuation plan due. Fuzak et al. [39]reported results from their combined retrospective analysis and simulation of a relocation of an entire pediatric inpatient population and concluded it had been a successful evacuation due to good planning, drills and parallel transfers; as well as the benefit of preexisting agreements with regional pediatric teams. Kleinpeter et al. [40] reported on a group of dialysis patients during Hurricanes Gustav and Ike. They used a new disaster response plan, established based on the lessons learned from Hurricanes Katrina and Rita. Patients were distributed among different providers very early enabling most to return to their home dialysis units or a nearby units shortly after. Early planning and evacuation were two key factors for a successful outcome in this evacuation. Dosa et al. [41] reported on the evacuation of nine of 20 nursing homes and 11 sheltered in place before and additional 6 nursing homes after the hurricanes Katrina and Rita hit Louisiana. This evacuation resulted in resident morbidities and mortalities, transportation problems, staffing and supply shortages, and facility damage. The feeling of being abandoned by the state and the federal emergency response initiative, substantial physical and technical difficulty in the effort to evacuate elderly, and staff retention were reported a critical problem regardless of the evacuation decision.

4. DISCUSSION

Disasters are inevitable, but they can be mitigated by planning, education and learning from the past [1-4,7-20,27-48]. Peltz et al. evaluated the management of community disasters in Thailand and identified the three most important elements for effective disaster management, including: *i)* the flow of information, *ii)* overall coordination and *iii)* leadership [1]. Our recent evaluation of Thai disaster management revealed improvements in emergency and prehospital care. However, the recent Thai flooding shows that there is still a need for improvement in at least two of 3 elements reported in Peltz' study, the flow of information and the overall coordination [7].

Our literature search compared the results from Thai disaster response with international studies. A criticism could be made that our study date was limited to 18 years, however, it

was already reported that events older than 20 years are not relevant to today's situation as the lessons learned have possibly been already incorporated in healthcare plans [49]. A second criticism could be the keywords chosen. The strategy in this study was to narrow our results to all relevant studies that fitted our purpose. Finally, a criticism could be that a selection bias choosing included articles influenced our findings. However, many lessons learnt were repeated in the literature and our purpose was basically to match the most common lessons learned with our current study in Thailand. Our study and lessons learned from the literature reveals that irrespective of how and where a disaster strikes, common issues emerge in its management.

The outcome of a disaster not only depends on good prehospital performance but also on a hospital's ability to cope with excessive numbers of victims - "surge capability" [2-3,28,30]. In an evacuation, however, all patients must be moved out of the hospital and this must be planned [5-6,8,13,15-16,18-19,27-28,30-31]. As a key principle in an evacuation situation it is mandatory to know when and how all patients, including all disaster victims, should be treated, evacuated and transported. Coordinated emergency plans and synchronized exercises are needed to raise the level of preparedness [15,17-18,27]. A common Emergency Operation Center has an important role to implement in both pre and post-disaster phases, as well as at pre-hospital and hospital levels, and authority should be invested in order to carry out that mandate [11-12,15,17,34].

The lack of an evacuation plan reduces the national ability to handle a large scale disaster which may lead to evacuation of many hospitals at the same time. Since in some countries such as Thailand, different hospitals have their own ambulances, a common emergency command center should be given the regional or national responsibility to synchronize and manage the utilization of these resources, at least at the initial phase of a disaster. In such a situation the leadership should be based on the functional ability and action cards should be used as a helpful communication mechanism at all levels [4]. The regional command center was well established in Bangkok, but then many decisions about transportation and hospital-to-hospital transfers were left to the referral units. Although the work of these units was outstanding, the lack of oversight on their function and access to their information, presented a challenge to achieving best outcome.

From a regional perspective, all hospitals should share objectives and strategies, which enable them to be synchronized; common criteria for evacuation [19,25]. A major finding in Thailand as well as in some of the past studies was the lack of evacuation plans [9,25]. Although each hospital presented a contingency plan, no such plan was written based on RVA. Thus, major risk factors were not being identified, published and managed. Consequently, these shortcomings made the staff confused and helpless how to respond to an unexpected event? It is thus important that all staff are trained for all-hazard major incidents or disasters. The lack of training was other cited reason for the turmoil and chaos among hospitals staff during the recent flooding in Thailand [4-5,17,29,43]. Leadership should communicate, promote, encourage and support such training, and in doing so enhance the staff's understanding of the plan's importance and what its benefits are [4,11,15,17,26,27,43]. Regional oversight, authorized to carry out the mandate to coordinate pre-hospital activities, as well as, continuous education and training are recommended and improves the outcome at the time of crisis [3-4,6-7]. This was perfectly demonstrated during the recent flooding in Bangkok excellent response by EMIT.

Besides a well-written disaster plan, the level of preparedness can be improved by improving leadership, communications and collaboration. These points are addressed in many studies

[5,10-12,15,17,31,34-35,38]. A successful hospital evacuation depends on effective communication, both within and outside the hospital. The communication within the hospitals appeared to have worked reasonably well in the Thai evacuation; however, in at least one case, communication to and from the outside was diminished due to lack of electricity. The information flow in and out of hospitals also varied among the hospitals, impeded by insufficient access to the reliable information sources. Effective and safe communication between various parts of the command chain (prehospital and hospital) is vital to disaster management and provides for the delivery of a sufficient amount of reliable information [4,6,42,44]. Thailand's EMIT could be more proactive in providing reliable information to the different hospitals since it has access to different authorities on a national level. They may also have an impact on the course of disaster management by having representatives in each hospital. Such impact can influence the course of disaster management long before any major incidents occur, by implementing triage, standard transport protocols and evacuation plans [27,42,44,47]. This would serve to integrate prehospital and hospital care, introduce major partners to the hospitals evacuation process and disaster plans. Cooperation with other organizations, whether governmental or non-governmental, should be synchronized by joint planning, exercises and mutual agreement.

Patient safety had not been deeply analyzed in the past. Deeper analysis and identification of issues of concern for patients are needed [11-12,14-15,18,28,34]. Almost all of our hospitals in the West are computerized and are electricity dependent. Computerized patients' files are vulnerable to internal dysfunction (e.g. power failure), but also to external events like disasters. They may become dysfunctional for internal use, but also unavailable for receiving hospitals. The transfer of medical data as well as monitoring and treatment of patients during transport was handled in an excellent way in Bangkok. In contrast to our data-based medical files, medical files in Bangkok were all hand-written and in three copies. There was always a current summary update available. No patient experienced any loss of information. Also, all patients were followed by a medical team during transport. In this way there was neither a need for transport protocols, nor excessive communication with the central dispatch or hospitals concerning the vital medical decisions. This is obviously a resource issue, but when available, enhances patient safety. All evacuated patients had their medication for sometimes up to one week treatment. This strategy maximized the patient safety and ensured their well-being while transported to other hospitals. This was especially important in case of patients with cancer diseases and facilitated a smooth transition from existing system to different health care systems. Other important issue to remember during an evacuation is management of patients with special needs, family separation, patient tracking and a common triage method. None of these issues were prioritized in Thai evacuation as well as in earlier reports [12,14,18,34].

May be the most common topic, related to hospital evacuation; discussed in the literature is support and maintenance during evacuation [5,9-14,16-19,32-33,35,38]. Continuous technical support of the various infrastructural parts of a hospital is an important factor to be considered [3,6,27,45-46]. Safety and security relating to structural weaknesses as well as the function and location of critical equipment (*i.e.* power generators, electrical cables, and water supply) must be considered. In the current report we find numerous shortcomings in all of these issues. A continuous provision of food, water and other needed necessities for staff and patients should also be pre-planned [5-6,27,46]. Substitutions for all electricity dependent units should exist in every disaster/evacuation plan. Nowadays, all hospitals have reduced their stock of materials. Most of the utilities, instruments, drugs and consumables are ordered based on 'same day delivery'. In many cases in Thailand, none of the companies with whom the hospitals had contracts were able to deliver their products as

planned and no reserves were found at hospitals. This may indicate the need for a new strategy to store critical components for at least a few days running of the hospital [3,48]. Staff availability has been pointed out as a major success factor in some evacuations [9,12,14,18]. However, the benefits of having a large amount of staff in the beginning of a crisis management may soon become a disaster itself, if they are not provided with information, instruction and the possibility of resting and contacting their relatives. It is of course a leadership issue to establish good communications and provide the right working condition for all staff engaged in the crisis. There is no doubt that both patients and staff can be affected by psychological disturbances after experiencing major incidents/disasters [47]. All hospital plans should include planned follow up of both groups. The current hospital plans in Thailand take only patients into consideration.

Access and egress routes need to be clear and functional [5,16,19,26,27-28]. Almost all hospitals in Bangkok had large parking areas inside and outside the hospital. Two hospitals were surrounded by markets blocking the routes for the ambulances and other vehicles to move in and out of the hospitals. In general limited transport resources are reported to be one of the main shortcomings in major incidents [5,16,19,26,28,30,31,36]. In Thailand, as well as in other places, the problem was solved by using military vehicles and contributions from various NGOs. However, the cooperation needs to be synchronized by joint planning, exercises and mutual agreement. Local traffic companies can be a good source to use for transportation of patients with no need for medical care [4,30,36]. New buildings with helipads and well-planned infrastructure are some of the future solutions for hospitals in Thailand and elsewhere [31]. Transportation of patients with special needs should be carefully studied and considered. This issue will not only be vital for receiving hospitals, but also for the required resources during transportation [14]. In some cases, single patient transportation should be withdrawn in favor for group transfer if such action is medically motivated [18].

5. CONCLUSION

In summary, the level of preparedness at all hospitals, for a potential evacuation, can be improved. We will recommend the following major points to be considered in all evacuation plans;

1. Hospital evacuation plan

    a. Hospitals' emergency medical plan should include a hospital evacuation plan; written based on risk and vulnerability analysis and in close cooperation with other partners. It must engage all staff and be available for all to review.
    b. There must be a common definition for evacuation followed by a job description for each staff member (actions card) to prevent confusion and panic.
    c. The Evacuation plan should be regularly rehearsed and tested and staff should be aware of the equipment required, evacuation routes, etc.

2. Command Control and Communication

    a. Clear Command and Control policy and good Communications are vital for a successful evacuation. It is vital that it is clear who is the decision-maker and at which level, to reduce the mismanagement and panic among staff and patients.
    b. Collaboration with other organizations e.g. military is necessary. It must be established, maintained, tested, and where appropriate enhanced. Awareness of

each organizations capacity and availability is an important part of evacuation planning.

a. Internal and external communication must be ensured, dependable and tailored to avoid the spread of rumors.

3. Patient safety

a. There must be a back-up system for all electricity-dependent functions. Electrical doors, pharmaceutical lockers are prime examples.
b. Computerized systems such as medical files and laboratory results should be easily replaced by other options. Medical files should be available in paper forms or be able to be accessed from other servers outside the hospitals.
c. Handwritten medical files are less vulnerable than computer-based patient record. Support for the current patient record shall be included in the plan.
d. An Escorting Medical Team to facilitate the handover to the receiving hospital should be considered when staffing allows.
e. Provision of patients 'medication for a limited time increases patient safety and facilitates the continued care of patients in critical condition at different hospitals.
f. External space for the gathering relatives, patients and field hospitals for continuous monitoring of patients should be pre-planned.

4. Support and maintenance

a. Infrastructural problems such as a loss of electricity, or the unsuitable location of generators and power lines as well as critical units such as laboratories and radiology must be reviewed and alternative positions must be identified.
b. Distribution of supplies to hospitals must be ensured. External contactors agreements and obligations should be clarified.
c. There must be a plan for the release and substitution of staff during the crisis, but also follow-up of staff after the event to ensure their physical and mental health.

5. Transport

a. Evacuation routes, receiving units and hospitals should be pre-planned and arranged. The distance between hospitals can be vital for survival of patients and their safety.
b. Persons with special needs should be considered. Specifically with regard to evacuation, transportation and type of receiving hospital.
c. Central pre-hospital Command Centers should be established to coordinate and synchronize the evacuation process between hospitals and prehospital entities. Such Centers are a natural partner for hospitals in the event of an evacuation.

CONSENT

Not applicable.

ETHICAL APPROVAL

Not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX 1

Shows the summary of questionnaire used in all interviews. The hospital part is divided into Pre-evacuation, Evacuation and Post-evacuation phases. Transport refers to the activity in the pre-hospital setting.

	Yes/No	Comments
Pre-evacuation		
Evacuation plan (EP)		
EP based on HVA (Hazard & Vulnerability Analysis)		
Current disaster a known risk		
EP written together/cooperation with partners		
Mitigation performed (structural/non-structural)		
Plan to stop ongoing activities		
Plan to refer patients		
Known command & control chain		
Known decision-maker		
Known activator of EP		
Known gathering area		
Known evacuation area		
Known receiving hospitals		
Plan to coordinate with partners		
Plan for in/out communication/information		
Security plan		
Back-up for major functions		
Back-up for staff/assets/resources		
MOU		
Pre-event evaluation		
Plan to move patients/utilities?		
Contracted external suppliers		
Criteria for evacuation		
EVACUATION		
Functional plan (Any plan)		
Functional evacuation		
Functional receiver		
Functional plan to stopped ongoing activities		
Functional referral unit		
Functional Command & Control		
Functional activation chain		
Functional coordination with partners		
Functional communication		
Functional information		
Functional security		
Functional resources estimation		
Functional staff estimation		
Functional backup systems		
Functional matching of specialty at referral		

Appendix 1 continues ….		
Functional transport protocols		
Secure patient confidentiality		
Functional Triage		
Unified triage system		
Policy on whom/what leaves behind		
Functional infrastructural support		
Functional external suppliers		
POST-EVACUATION		
Recovery plan		
Psycho-social follow up patients		
Psycho-social follow up staffs		
Infrastructural supports		
TRANSPORT		
Known coordinator		
Known referral policy		
Transport protocol		
Triage		
Enough staff		
Enough ambulances		
High competencies		

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=215&id=12&aid=2077