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# Hospital evacuation; planning, assessment, performance and evaluation

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## ABSTRACT

**Objective:** Malfunction in hospitals' complex internal systems, or external threats, may result in a hospital evacuation. Factors contributing to such evacuation must be identified, analyzed and action plans should be prepared. Our aims in this study were 1) to evaluate the use of risk and vulnerability analysis as a basis for hospital evacuation plan, 2) to identify risks/hazards triggering an evacuation and evaluate the response needed and 3) to propose a template with main key points for planning, performance and evaluation of such evacuation. **Methods:** A risk and vulnerability analysis at two county hospitals along with a systematic online literature search based on the following keywords; "evacuation/closure", "hospitals/medical facilities" and "disaster/hazards" alone or with "planning", was conducted. **Results:** We found that although all hospitals have a disaster plan, there is a lack of knowledge and appropriate instruments to plan, perform and evaluate a hospital evacuation. Risk and vulnerability analysis can be used to reveal threats leading to an evacuation (e.g. on-going climate changes and terror actions). These key points can later be used to plan, perform and evaluate such evacuation. **Conclusion:** There is a need for an elaborated evacuation planning for hospitals. An evacuation plan should continuously be drilled based on a risk and vulnerability analysis. A general guide can be used as foundation to plan, perform and evaluate such plan.

## 1. Introduction

Hospitals are key factors to provide emergency preparedness in most communities and are expected to be fully functional at the time of major incidents or disasters[1]. Hospital's medical disaster plans focus on how hospitals surge their capacity to receive a large number of victims. However, the increasing complexity in technical infrastructure as well as a more constrained healthcare economy, leads to an increasing vulnerability of hospitals and risk for failure in crisis management[2]. The threats and hazards in today's society are also more complex than previously and often require cross-border cooperation between involved organizations and consequently, changes the basic requirements for the management of a major disaster[1–3].

Today, stockpiles of equipments and materials in the hospitals have been reduced in favor of "same day

delivery" re-supplying. Bed occupancy, especially in intensive care units, has increased. The emergency medical plan is often written for management of external events, i.e. events that will bring casualties to the intact hospital. However, what if the threat is pointed against the hospital and the patients must be evacuated?[1,4–7]. Is such evacuation necessary and is there any routine for such action? One way to approach all of these questions is to perform risk and vulnerability analysis[8–12].

Hospital vulnerability varies among different countries both in terms of locations and events. In some countries (e.g. in South America) over 50% of healthcare facilities (hospitals and primary healthcare clinics) are located in high risk areas, while the figure is much lower (8%–9%) for other countries such as United Kingdom[6].

Under Swedish law, all county councils ("Health Boards") are required to maintain "emergency medical preparedness" in their geographical area of responsibility[11]. Every hospital should have a disaster plan, including an evacuation plan. Although no large-scale evacuation of Swedish hospitals has been reported, there is no available data if the hospitals have any functional evacuation plan and if this plan has been drilled or actually used[13].

The purpose of this study was therefore, to evaluate if

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there is a need for an evacuation plan in hospitals and how it should be designed by raising a number of issues;

- Can an appropriate Risk and vulnerability analysis (RVA) be used as a foundation for evacuation planning in hospitals in general?
- What hazards can trigger a hospital evacuation?
- How can rescue resources (internal and external) respond to the needs that arise in an evacuation situation?
- How such plan should be performed and evaluated?

## 2. Materials and methods

A risk and vulnerability analysis was performed at two county hospitals in Region Västra Götaland in Sweden. Lidköping hospital (2008) has 132 beds and around 1 000 employees and serves 85 000 inhabitants. Kungälv hospital (2010) has 200 beds and over 1 400 employees and serves 118 000 inhabitants. A risk management group consisting of an emergency nurse, hospital director, chief physician and the heads of the departments of surgery, emergency medicine and anesthesiology, a medical utility technician and an IT coordinator was used for analyzing process. Group discussions were used as a tool to reason about various possible risk scenarios in each hospital, respectively. Three types of risk and vulnerability analyses forming the ground for analyses were<sup>[12]</sup>

–MVA (Municipal Vulnerability Analysis): an IT-based method to analyze vulnerabilities in an organization, developed by a team of researchers at Lund University, Sweden.

–ROSA (Risk Och Sårbarhets Analys): based on qualitative risk assessments by a risk management team, developed by a research team from Växjö, Sweden.

–IBERO (Instrument för BERedskapsvärdering av Områdesansvar): developed by the county administrative board of Stockholm County, Sweden as an aid to analyze the ability to withstand and manage events with major consequences for social functions or citizens.

An online literature search was conducted, using the Pub Med, Scholar, ELIN, LOVISA, LIBRIS and CRED (the Centre for Research on Disaster Epidemiology database) and medical libraries (e.g. Gothenburg University) based on the keywords; “evacuation/closure”, “hospitals/medical facilities” and “disaster/hazards” alone or with “planning”.

## 3. Results

### 3.1 Risk and vulnerability analysis

Although all three analyzing methods (MVA, IBERO, ROSA), give an overview on how to work with risk and vulnerability analysis and highlight the importance of the analyzing process as a crucial part of the result, initially it was desirable to use one method that illustrates what is worth

preserving in order to create a common value (MVA, IBERO). However, since various methods have a somewhat similar target, instead of using one method, a combination of all three could be used in the different phases of the analysis.

The goal of this type of analysis was to find “corresponding type of incidents” which may need “analogous inquiries” for triggering the evacuation, i.e. similar risks and thus similar requirements for evacuation such as time to evacuation, coverage and restoration of function. By classifying various events with the same keywords, their number could then be reduced. The keywords used in our analysis are shown in Table 1. The result of risk and vulnerability analysis is presented in Table 2 (a–c).

Current resource analysis at these hospitals showed that the average occupancy rate for 2008 at Lidköping hospital and 2010 for Kungälv hospital varied between 85 and 98 percent. All patients admitted to the hospital were in need of continuous care and could not easily be moved in an emergency situation. Key factors regarding hospital evacuation are presented in Table 2 c. Both hospitals could present a solid and sufficient disaster plan, but no evacuation plan. The same result was also obtained from four other regions in Sweden through telephone interview with their disaster planning officers. None of the hospital had repeated drills/exercises.

### 3.2 Literature study

All documents found in our search were reviewed (2 450 hits). All documents dealing with instructions, guidelines or other than hospital evacuations were excluded. Of the remaining one hundred scientific documents those dealing with our aims i.e. risk and vulnerability analysis, hazards triggering a hospital evacuation, response to an evacuation situation, and design of an evacuation plan was studied in detail. Table 3 shows the results of our search. Many papers were reviews and lesson learned. There were also KAMEDO reports, which are reports with a main task of sending observers to disaster areas all over the world to study recent disasters, collect useful information and increase the familiarity with the problems of disaster medicine<sup>[13]</sup>. The main results of these reviews are as follow;

- 1–There are both internal and external threats leading to evacuation
- 2–There is no accepted, validated tools to assess the hospital evacuation process
- 3–There is a need for distinct coordination and leadership and central command
- 4–There is a need for cross–border communication and collaboration with other authorities
- 5–There is a need for relocating vital functions from the lowest floor to safer area
- 6–There is a need for adequate estimation of resources and staff
- 7–There is a need for repeated and validated training of staff
- 8–There is a need for careful assessment of relocating area

for evacuee

9–There is a need for careful assessment of transportation vehicles and routes

10– There is need for careful assessment of hospitals infrastructure with respect to type of building and utilities and supporting functions

#### 4. Discussion

Our findings show that there are potential risks and hazards, which may lead to hospital evacuation. The evolution of hospital care with increasing technical interdependencies, as well as variation in threat levels, makes a continuous planning process necessary[7]. We could

also show that the current hospital disaster plans have no or insufficient evacuation plans[10]. A hospital evacuation may be necessary regardless of the event causing the hospital malfunction. Our study together with our literature search suggests that some common factors should be taken into consideration when preparing a hospital evacuation plan.

There is a need for distinct command and control structure and an organization to control the event and take proper decisions. A decision to evacuate a hospital is not easily taken, but it should be taken without any hesitation, if anything endangers patients' safety and includes their evacuation routes, transportation and priorities[6]. Such decisions demand good communications within and outside of the hospital. Different geographical areas are facing various threats. The specific location of a hospital

**Table 1.**

The keywords used in our risk and vulnerability analysis.

Key words	Definitions
Critical/Triggering event	How quick critical events reach the patients and personnel?
Duration of an event	Static or dynamic event process?
Time to evacuation	Minutes, hours, days
Total or partial evacuation	Influencing parts of or whole hospital?
Magnitude level	Locally, regionally, national or internationally.
Staff resources within the hospital	Can the event be managed with existing staff or there is a need for extra staff from other units?
Influence on other activities than healthcare	Other involving organizations? How many?
Functional recovery	How long does it take for the hospital to get back to its normal level of function and capacity? (quick or slow recovery)

**Table 2.**

The results of risk and vulnerability analysis at two county hospitals.

a)Potential hazards	<ul style="list-style-type: none"> <li>–Fire</li> <li>–Flooding</li> <li>–Landslides</li> <li>–Pandemic</li> <li>–Electricity/heat/water failure</li> <li>–Threat/bomb threat/terror threat</li> <li>–Accident involving dangerous goods</li> <li>–Infection with multi-resistant bacteria</li> </ul>
b)These risks could be grouped into two various types of events	<ul style="list-style-type: none"> <li>– An unpredictable event with a very rapid progress, requiring swift action e.g. a threat/bomb threat/act of terrorism. This incident is intentional and can never or rarely be predicted.</li> <li>–An event evolving over a longer period of time, but with major impact and long time to restore function e.g. flooding. The sequence is considerably slower and more time is available to prepare for a possible evacuation. The problem in such an event may be that hospital infrastructure (power, heat and/or water) is also affected as well as other parts of society.</li> </ul>
c)Key factors for hospital evacuation based on our case study	<ul style="list-style-type: none"> <li>–Need for a distinct command structure and organization</li> <li>–Identification of transport possibilities</li> <li>–External space and rooms</li> <li>–Triage</li> <li>–Location of sensitive infra-structure equipment such as servers and power generator with regard to potential hazards and threats</li> <li>–How to ensure patient safety during the evacuation? Transfer or ongoing maintenance of patient medical records?</li> <li>–How are staff/patients/relatives warned and informed of the situation?</li> <li>–What are the responsibilities of external contractors?</li> <li>–How to carry on the evacuation of seriously ill patients in an intensive care unit?</li> <li>–Who is responsible for guarding the buildings when they are empty?</li> <li>–To where will patients in need of care and treatment be evacuated? Another hospital, another town?</li> </ul>

**Table 3.**

Shows the results of the literature study.

Author	Study type	Year	Outcome	
Bagaria et al (6)	Review	1980–2008	2009	<ul style="list-style-type: none"> <li>–45 hospital evacuations</li> <li>–Triggers for evacuations were earthquakes, hurricanes, flooding, power failure, water damage, bomb threat</li> <li>–Minority were complete (flooding and natural disasters) and the majority partial (chemicals, internal fires, nuclear events)</li> <li>–85% were immediate and 15% delayed (mainly natural hazards)</li> <li>–Over 90% of hospital managed their own evacuation, but only 6% had a specific evacuation plan</li> <li>–The most two common challenges were communication (external and internal) and logistic particularly moving the patients (in and out); elevators, transport vehicles</li> <li>–The positive outcome of some of the event was probably, among the others, due to education, and training of the personnel</li> </ul>
Kader (9)	Thesis		2008	<ul style="list-style-type: none"> <li>–Evacuation procedure should be smooth and easy, to reduce travel time and extensive efforts for patients' transfer, especially the critical ones</li> <li>–Evacuation systems need to be designed based on nature of threats and hazards</li> <li>–Multiple evacuation exits should provide to a building, and should distribute the exits horizontally and vertically</li> <li>–The zoning of important functions should consider the threats and vulnerability, e.g. switch gear or generators.</li> <li>–Critical functions of a hospital should have the options and flexibility to accommodate extensive services</li> <li>–In hospital complex design, it is wise to connect one building with others in different levels, specifically, where the critically ill patients are located to avoid the vertical evacuation</li> <li>–Multiple accesses to the site with adequate space for transportation required for mass evacuation</li> <li>–Location of helipad should threat specific</li> <li>–A hospital should have both external and internal assembly areas</li> <li>–Specific attention should be paid to the elevator as the practical way to transfer patients vertically</li> <li>–Stairwell design should consider the turning radius of various specialized devices, such as Backboard</li> <li>–Emergency power supply should be protected from any kind of hazards to provide continuous support for evacuation</li> <li>–Facilities, such as, communication system, lighting, signage, or clock should be designed with two types of operating system; electricity and battery</li> <li>–Flash lights should be located in all units and stairwells with proper hanging system</li> </ul>
Social–styrelsen (15)	KAMEDO report		2007	<ul style="list-style-type: none"> <li>–A sudden and widespread power failure at the Karolinska University Hospital in Huddinge, Sweden.</li> <li>–Although lasting about one and a half hour, it endangers the patient safety, and incoming ambulances were diverted to other hospitals, resulting in an overloading of these hospitals.</li> <li>–The conclusion was that the emergency plan for a hospital must include internal events such as disruption of hospital supplies, infrastructure disturbances, disruption of water and gas supply and fires</li> </ul>
Ayugustine et al	Case Study		2005	<ul style="list-style-type: none"> <li>–All staff need incident command system training</li> <li>–Size of evacuation zone will vary with event</li> <li>–Identify alternate patient care areas and transport needs based on evacuation zone</li> <li>–Financial consideration</li> <li>–Importance of good community relations</li> <li>–Re-evaluating existing (bomb) threat and evacuations plan</li> </ul>
Taffee et al	Review		2005	<ul style="list-style-type: none"> <li>–here are issues and complexities</li> <li>–Issues; Nature of threat, risk to patients and staff, evacuation mode, continuing care, resource demand</li> <li>–Complexities; Threat probabilities and timing, change of risk over time, resource contention, scale and scope, facility–dependent activity time</li> <li>–Modeling approaches; Project model, Mathematical programming, Simulation, hybrid model, Models in plan evaluation</li> </ul>
Schultz et al (4)	Case Study	1994	2005	<ul style="list-style-type: none"> <li>–No accepted, validated survey tools to assess the hospital evacuation process exists</li> <li>–Following principal subjects are important in a hospital evacuation process; hospital demographics, description of existing disaster response plans, an event ' s impact o the hospital operations, decision–making and incident command, movement of patients within the facility and off–site institutions and hospital recovery</li> </ul>

**Table 3.**

Shows the results of the literature study (Continued).

Author	Study type	Year	Outcome
Sternberg et al (12)	Review	1971–1999	2004 –275 hospital evacuations –> 50% due to internal hazards –Increasing number per decades –Most evacuations were due to incidents with less than 49 evacuees –Most common cause internal fire (23%) followed by HazMat, hurricane, human threat, earthquakes, flooding –In 11% of evacuations at least one casualty were listed
Schultzet al (25)	Review	1995–1996	2003 –Eight centers were studied –74–334 inpatients at evacuation –75% immediate evacuation –75% complete evacuations –70% nonstructural damages –2–320 patients transferred –70% to other hospitals –Evacuation time 1–19 h –Evacuations can be accomplished quickly and safely with the use of available personnel and resources
Socialstyrelsen(15)	KAMEDO report	2002	–Severe flooding in parts of the Czech Republic and southern Germany because of heavy rain –Several hospitals had to be evacuated due to loss of electric power, heat, water and sanitation. –Lessons learned from this incident were that a distinct coordination and leadership are key issues. –A central command organization with clear-cut responsibilities and authority is crucial. –A hospital at risk of flooding should not have electric power, water, heat, sanitation and computer servers installed in the basements
Burgess et al (13)	Review	1999	–101 hospitals –13% (12) due to HazMat –11 incidents at ED, inhalation common hazard exposure

and its infrastructure, including back-up systems and external space and rooms influences the risk profile of that specific hospital and thus the need for an evacuation. Experiences from reported incidents (see Table 3) singles out electric power supply as one of crucial factors in hospital evacuations. The black-out at Huddinge Hospital clearly demonstrates how various functions in a hospital such as access to medical files and drugs depend on electric power<sup>[4–6,14–17]</sup>. During the fire at Royal Marsden Hospital electricity functioned throughout the evacuation phase, which was one of the reasons why the evacuation proceeded smoothly<sup>[6]</sup>.

Another important part of evacuation planning is to identify the resources suitable for transportation of patients both within the affected area and to other facilities. External space and rooms for temporary evacuation, and internal facilities to ease the evacuation such as elevators for vertical evacuation and adjusted stairwells with adequate turning radius are some of the points to consider in an evacuation plan<sup>[10]</sup>. The planning for transportation of patients to other facilities must be done at the regional or national level, since it requires an overview of transportation resources and routes at the regional level and might incorporate military assets<sup>[18]</sup>. Transferring medical records and distributing drugs during the transport must moreover, be pre-planned. An increasing use of computer-based medical records (without any national standardization) raises the vulnerability of information transfer and exchange. Contingency planning

must be based on a good and dynamic understanding of the threats that exist and the human response needed<sup>[4,10]</sup>. Thus, in order to reduce the number of events enforcing an evacuation, a more proactive approach with qualitative assessments is needed. This can partly be obtained by using RVA to clarify what, where and how it has to be planned<sup>[19]</sup>. As an evacuation situation involves the entire hospital's activities and several actors in and out of the hospitals, seminar-based approach of the analysis can be used as an aid to involve people with various skills and different backgrounds.

Although it is possible that certain events occur as a consequence of others, a case study focuses on one event at the time. As an example a fire in a main electric cable drum may result in an immediate power failure causing other major difficulties. To identify all dependencies is difficult, but knowing that an event can generate another event is important because the consequences can be far more extensive if multiple technical systems are shut down. All of these events, irrespective of the cause, will generate a burden on other hospitals that are to receive the evacuated patients. During the last decades, the number of hospital beds in Sweden, as well as other countries, has been reduced. Hospital occupancy rates are high with few beds immediately available if a sudden influx of patients occurs. Crowded hospitals and ambulance diversions, on a regular basis, can decrease the quality of medical care as well as ambulance availability and surge capacity<sup>[2]</sup>. These are

**Table 4.**

Template one: Check points for hospital evacuation plan.

Key points	Yes	No	Comment
Pre–evacuation			
Evacuation plan?			<ul style="list-style-type: none"> <li>–HVA?</li> <li>–Other organizations involved?</li> <li>–Roles identified?</li> <li>–Annual training?</li> <li>–Plan for ongoing activities?</li> <li>–All risk plan, Infra structural support?</li> <li>–Preplanned area for evacuee?</li> <li>–Transportation routes inside and outside?</li> <li>–Vita functions secured?</li> <li>–Medical files and medications?</li> </ul>
Resource and security			<ul style="list-style-type: none"> <li>–Staff and resources</li> <li>–Remote hospitals</li> <li>–Prehospital institutions</li> </ul>
Evacuation (refer to your evacuation plan)			
Decision on evacuation based on evacuation plan			<ul style="list-style-type: none"> <li>–Command and control</li> <li>–Communication</li> <li>–Situation assessment</li> </ul>
Secure all critical functions			<ul style="list-style-type: none"> <li>–sensitive equipments e.g. IT, generators</li> <li>–Sensitive localizations e.g. assembly areas</li> </ul>
Secure patients safety			<ul style="list-style-type: none"> <li>–Medical files, triage, transport</li> <li>–Drugs and instruments</li> </ul>
Establish information routs; external and internal			Contact with external contractors
Post–evacuation			<ul style="list-style-type: none"> <li>–Decision on ending the evacuation phase</li> <li>–Starting the Recovery and plan to return to normal status</li> <li>–Psychological follow–up of patients and staff</li> </ul>
Transport issues			<ul style="list-style-type: none"> <li>–Coordination</li> <li>–Staff</li> <li>–Training</li> <li>–Referral policy</li> <li>–Resources</li> <li>–Triage and patient safety</li> </ul>

important factors to consider in contingency planning and such aspects must be incorporated in the decision–making process of the healthcare system. It is therefore, desirable to plan based on the risks' nature rather than specific events. In order to reduce the complexity of all factors influencing an incident causing an evacuation, they could be categorized according to the following keywords[9]

- Speed; the time the critical event reaches people, property and the environment?
- External factors such as temperature, wind, rain, smoke or landslide
- The intensity of the incident, how great is the power of the threat?
- Geographical coverage of the event, which area is involved?
- The duration of the event, how long is the imminent danger?
- The probability of the event, are we sure that the event will occur?

Depending on the nature of the threat/incident, different demands arise in an organization leading to various responses[6]. Landslides, pandemics and infection by multiresistant bacteria may be risks that do not initialize a complete, but a partial and gradual evacuation or reallocation of an internal resource, e.g. closing down the

elective surgery. For instance, a fire within the hospital might necessitate an immediate evacuation of patients and staff at risk to a temporary shelter for further transportation to other healthcare facilities. Busses (and other vehicles) might be considered as transporting means instead of ambulances[20].

Swedish Legislation demands that every hospital should have a medical disaster plan, including an evacuation plan. However, planning for internal incidents that might lead to a hospital evacuation is rudimentary or non–existent and regardless of cause, most plans are never drilled as shown in our telephone interview[6,14]. Moving a patient may require the mobilization of different staff categories in various levels. It is therefore, imperative that these actions are carefully prepared before an evacuation is carried out (Template 1). An evacuation plan must also be repeatedly exercised to ensure that all staff know their roles and feel confident in an evacuation situation[5,20–27]. The plan should be generic with a simple design and cover most of the incidents that may occur. Template 1 shows one simple protocol to be used before, during and after an evacuation. Although such a protocol can be more detailed, our proposal consists of major points shown by our study and literature review and can be taken as a first step for establishing an evacuation plan.

## 5. Conclusion

Hospitals are becoming increasingly dependent on sophisticated technological support systems as well as same day delivery of supplies, often supplied by external sub-contractors. "New events" such as terrorist actions introduce new vulnerabilities to the healthcare system. Current evacuation planning at most hospitals in Sweden (and elsewhere) is inadequate and rarely exercised. Planning must be based on a continuous risk and vulnerability analysis and consists of good communication, functional logistic and training opportunities.

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