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Hospital Disaster Management – Evacuation of Perinatal Intensive Care Units Based on Emergency Management Plan

The purpose of this study is to illustrate the special cases of a fire in a hospital especially in a perinatal intensive department, that may be encountered by the firefighters. Due to these special circumstances, the evacuation time of the facility can be significantly increased. There are unusual evacuation and rescue methods, which require special devices and more intense human resources. The evacuation requirement of a hospital is more than a usual evacuation plan, the goal is to maintain the health care services during and after the evacuation, so it is necessary to apply the Evacuation Plan of the Hospital Disaster Plan during a fire evacuation. This requires much more accurate and complex training from both the firefighters and the medical staff. Also, its effectiveness depends to a large extent on the architectural and fire protection design of the building, its modernity, the available medical and rescue equipment and the number of medical staff. The study examines the approximation and joint applicability of the plans above, based on the experience of a hospital evacuation exercise.

Keywords: **Hospital Disaster Plan, fire alarm, evacuation, Perinatal Intensive Care Unit, Neonatal Intensive Care Unit, Intensive Care Unit, shelter-in-place, fire compartment**

1. Introduction

The main purpose of this study is to examine how it is possible to bring the Evacuation Plan of the Hospital Disaster Plan to the Fire Evacuation Plan and which circumstances are necessary to the joint application of these plans. All these are important to secure the healthcare activity during a prompt incident.

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The author of this article identified the following main research objectives:

- to introduce the practical application of the Hospital Disaster Plan
- to see in peacetime the opportunities of application of the disaster medicine, what contains the principles of caring for a large number of injured or sick people with limited care capacity
- to elaborate the crisis management strategies and due to the parallel intervention of the firefighters the recognition of each other's abilities and possibilities as well as the practice of parallel task implementation

For the examination of these questions above, in one of the hospitals of the capital in 2017 during a hospital disaster exercise an imitation of fire was implemented. This incident justified the evacuation of the patients and the staff as well, i.e. the practice of the Evacuation Plan of the Hospital Disaster Plan was carried out.

The primary hypothesis of the exercise: On the 4th floor of the building – which has been supplied with a fire alarm system – an electrical fire occurs in the kitchen in the Intensive Care Unit (ICU)/Perinatal Intensive Care Unit (PICU) and later it spreads to the adjacent corridor of the Obstetrics Department/PICU, although it is separated by walls. The smoke/fire threatens the patients in both areas. The fire alarm starts operating as well as the Smoke and Heat Exhaust Ventilation (SHEV) system. The staff starts evacuation and then in a secured space the patients' placement and transport to other hospitals have begun.

2. Literature review of the theoretical foundation of hospital emergency planning activities

The Hungarian legal system determines some relevant tasks around the emergency planning in the healthcare. There are two types of the evacuation plan which have not been coordinated or separated from each other yet.

2.1. Evacuation planning based on the hospital disaster planning

In Hungary the preparation of Hospital Disaster Plan (HDP) for hospitals is regulated by Act CLIV of 1997 on Health and the provisions of the EMMI Decree 43/2014 (VIII.19.) on the content requirements of health contingency plans of hospitals and amendment of certain ministerial provisions on health care. Basically the HDP is a complex plan system consisting of a master plan and fourteen sub-plans. One of these sub-plans is the Evacuation Plan.

The aim of the "Evacuation Plan of the Hospital Disaster Plan": The secure and rapid withdrawal of the patients, staff and all the documents connected to the care of the patients as well as the most essential medical supplies from unexpected hazards. All these take place with assignment of tasks and responsibilities in the absence of

other prepared rescue procedures.[2] The plan does not focus on maintaining operations through relocation, but on safely leaving the facility, which may be caused by more rapid, more intense emergencies, such as a large-scale fire. The Evacuation Plan of the HDP can thus be understood as an extended Fire Evacuation Plan of a hospital, with the difference that the purpose of the HDP is to ensure the maintenance of health care in crisis situations. So the evacuation process does not end at the Fire Assembly Point. During the process, it is necessary to take care of the patients and at the end of the process to continue the care on its own infrastructure or by transporting them to another institution, possibly by ambulance.

2.2. Evacuation planning based on the Fire Evacuation Plan

Facilities must be designed in such a way that:

- persons in the facility can be alerted quickly and in an awareness raising manner in the event of a fire
- persons who are unable to escape on their own must also be able to reach a shelter-in-place within the prescribed normal time
- the rescue of persons with reduced mobility or disabilities should be ensured in such facilities
- the design of the facility must allow the use of evacuation routes without delay[3]

The preparation of a Fire Safety Policy for individuals engaged in economic activities and for legal persons is compulsory as required by law. Those obliged to do so must prepare a Fire Evacuation Plan as an annex to the fire protection regulations for the building they operate.[4]

A part of the Fire Evacuation Plan is how to leave the building and the responsibilities of workers during evacuation. One of the most important tasks of the workers is to escape and to leave the facility endangered by fire. Based on these, the purpose of a fire exercise is to practice how workers leave the facility.[5]

In the current domestic regulations, the evacuation regulations presuppose that persons escape on their own and the conditions of this must be ensured. More precisely, the execution of evacuation as such can only be implemented under the above mentioned assumption. In contrast, there are no specific regulations for evacuating hospitals, so currently, the evaluation of exercises and – costly – computer simulation procedures can provide planning assistance.[6]

[2] 43/2014 (VIII.19.) EMMI Decree on the content requirements of health contingency plans of hospitals and amendment of certain ministerial provisions on health care.
[3] György Veres, 'Tömegtartózkodású épület kiürítésének vizsgálata I', *Hadmérnök* 4, no 1 (2009), 34–45.
[4] 30/1996 (XII.6.) Ministry of the Interior's Decree on the preparation of fire protection regulations.
[5] Gergely Herczeg, 'Kiürítési gyakorlatok szervezése, lebonyolítása', *Védelem Tudomány* 4, no 3 (2019), 40–61.
[6] Judit Veresné Rauscher and Tibor Kovács, 'Kórház kiürítés vizsgálata számítógépes kiürítés szimulációval', *Védelem Tudomány* 4, no 2 (2019), 23–44.

2.3. Separation of the evacuation plan and the fire evacuation plan

According to the law, the application of the HDP in Hungary takes place when, as a result of an extraordinary event, a disproportion develops between the health care needs and the capacity available locally.[7]

An essential element of the HDP is that, especially when additional sub-plans come into effect (alarm, equipment, transport, communication), the ultimate goal is not to evacuate the hospital, but to maintain health care during and after the emergency, as well as during the evacuation.

In addition, unlike a Fire Evacuation Plan, the tasks performed during an HDP evacuation plan can be protracted, such as in the event of a short-term predicted natural disaster or a civilisation disaster. So, with the exception of a fire, evacuation here does not take place according to the standard times specified in fire protection legislation.

In my opinion, in a hospital it is necessary to manage the two plan systems together, since in a fire the goal is not just to evacuate the facility, the goal is to evacuate the facility safely and maintain patient care activities or to carry out final placement of the patients in other hospitals.

2.4. Examination of the types and sequence of evacuation

During the preparation of the plan, special attention should be paid to the technical characteristics of the building, fire compartments, shelter-in-place areas, fire safe elevators and, in parallel, the professions and specifics found in the facility, such as equipment and documentation to be saved with the patient. These together, significantly influence the order, how they build on each other, and partition of the rescue. Depending on the design of the facility, evacuation can be horizontal, vertical and/or complete.[8]

The order of the evacuation is primarily determined by the condition of the patients. To determine the condition of patients, the principles of the so-called "triage" approach are applied by health professionals who carry out and coordinate evacuation. The "triage" approach means classifying patients based on their condition.

Erdal Tekin et al. proposed the following order of priority for the "triage" approach to hospital evacuation:

Priority 1: Children, newborns, patients who are not connected to a medical device and can walk or be carried in hands and have an able person to carry.

Priority 2: Patients who are in a wheelchair or can only move with the help of a walking aid.

Priority 3: Patients who need a stretcher to be moved.

Priority 4: People in need of intensive care.

Priority 5: Patients with the lowest chance of survival.

[7] Act CLIV of 1997 on Health, Section 228 (2).

[8] FEMA, 'Hospital Evacuation: Principles and Practices', AWR-214-W, 2010, 23.

2.5. The interpretation of the evacuation to shelter-in-place

In its recommendation, the United States Federal Emergency Management Agency (FEMA) highlights that the goal is to maintain patient care during a hospital fire, in which escape to shelter-in-place is a good solution. This will ensure the continuation of patient care within the institution.

In this case, it is necessary to restrict the movement of patients and staff for the protection of property and life. The recommendation also emphasises that the establishment of a shelter-in-place requires prior technical interventions,[9] like an adequate number of medical gas connectors, which is important to be equivalent to the original area, electrical network and other medical devices.

Decision factors of evacuation or shelter-in-place[10] are:

- the nature of the incident (expected time of arrival, magnitude, area of impact, time to run)
- expected impacts of the incident on the facility and its environment

"The most common population protection measures included in external protection plans are onsite and offsite sheltering and evacuation, which are mostly affected by the available time frame. […] The choice between population protection measures (evacuation and sheltering in place) used in cases of chemical accidents involving toxic substance release is a vital decision-making action that mainly depends on the time available for decision making and implementation of protection activities."[11]

The key elements of shelter-in-place:

- To strengthen and prepare critical infrastructural elements:
  - fire safety structures
  - energy supply
  - medical gas supply
  - medical equipment
  - air supply, etc.
- If the necessary time is available:
  - to decrease the patient census before the event
  - to perform the ongoing threat assessment[12]
  - if it is necessary based on the above mentioned, to change the rescue strategy

2.6. Special cases of evacuation in a hospital

At first glance, it may seem absurd, but in case of the infrastructure of a 100-year-old hospital building, in a facility without fire compartments, the medical staff may also be forced to use disaster medicine when evacuating ICU/PICU.

[9] Ibid. 22.
[10] Ibid. 24.
[11] Zsolt Cimer, Gyula Vass, Attila Zsitnyányi and Lajos Kátai-Urbán, 'Application of Chemical Monitoring and Public Alarm Systems to Reduce Public Vulnerability to Major Accidents Involving Dangerous Substances', *Symmetry* 13, no 8 (2021), 2.
[12] Emergency Preparedness and Response Exercise Program, 'Emergency Shelter-In-Place Guidance', *MDPH Hospital Evacuation Toolkit, III* (Harvard, School of Public Health, 2014), 51.

Based on the order of rescue set up according to the "triage" at the start of the evacuation, the most critical patients, who only can be evacuated in the most difficult, time- and staff-intensive way, may no longer be able to be evacuated by health professionals due to the escalation of the emergency.

The number and the status of the persons in the disaster area is a very important information for the intervening forces. As is established in another study, the basis of the disaster planning is not the capacity of the building or the number of all employees, rather the number of the persons present in general. The importance of this number during the disaster planning is to get to know the number of the persons of this group that can take a part in the onsite intervening team and who have to be evacuated.[13]

In this case, it is essential that the intervening firefighters are properly informed so that the rescue can be carried out with the least possible damage to health despite the given situation.

Disaster medicine, therefore, in this case means that the medical staff coordinating and initiating the eviction, based on a quasi-risk assessment, starts the evacuation of patients with the best chances of survival, assuming the risk that the evacuation of patients with lower chances of survival will not be successful or their condition will deteriorate significantly during the rescue operation.

Minimising these risks is one of the tasks of business continuity planning in case of critical infrastructures, as required by law. Thus, at this stage of planning, when planning the safety of operation, special attention should be paid to reducing risks, in our case to prevent the occurrence of fires, throughout:

- the professional, trained usage of standard equipment, and planned preventive maintenance
- to ensure the availability of the early warning throughout the constant maintenance of the fire alarm system
- to ensure to extinguish fires in every case in its early stage throughout:
  - the maintenance of the fire sprinkler system
  - the fire extinguishers are matched with the class of the fire and are available in a sufficient number
  - to apply fire blankets
- the adequate capacity planning concerning both technical and human resources
- to ensure and maintain the conditions of the chosen evacuation methodology

2.7. The importance of the organisation of evacuation exercises

In order to be able to leave a facility in a real emergency as quickly as possible – by preparing participants – evacuation exercises can make a major contribution. Accordingly, evacuation exercises are effective means of preparation.[14]

[13] Irina Kátai-Urbán, 'Veszélyes anyaggal foglalkozó telephelyek riasztási és terület kiürítési hatékonyságának vizsgálata', *Műszaki Katonai Közlöny* 28, no 1 (2018), 90.

[14] Herczeg, 'Kiürítési gyakorlatok'.

The feasibility of these disaster management tasks and the availability of all of the forces, equipment and safety infrastructure must be taken into account. The forces must be available in the necessary quantity, level of preparation and applicability. The equipment must be available in the necessary assortment, technical status and operative applicability. It is important to have the infrastructure needed for the management. The necessity of the forces and equipment must be determined on the basis of credible force-equipment assessment. The appropriateness of the forces' volume is acceptable only this way, if the training and the exercising of them was documented and the forces have the adequate equipment.[15]

Furthermore, the organisational tasks of an exercise help to assess the basic abilities of the organisation (see Table 1 below).

Table 1: The SWOT analysis of the exercise
Source: Compiled by the author.

Strengths	**Weaknesses**
• engaged healthcare professionals • the coercion of action arising from the social weight of premature birth care • the designed ideal circumstances	• the circumstances are worse in real life • the number of the healthcare workers in real life is less
Opportunities	**Threats**
• elaboration of new rescuing techniques and tactics • the healthcare workers can try their abilities in a realistic situation • the firefighters can get to know the difficulties of the intensive care units' evacuation	• the conclusions of the exercise go beyond budgetary possibilities • successful exercise reduces managerial commitment to improving real-world conditions

3. Conducting the examined exercise

The preparation of the exercise took about half a year. During the available half-year, we updated the hospital's Disaster Plan and aligned it with the facility's Fire Evacuation Plan, prepared the implementation together with the professional staff, provided training to refresh existing knowledge, and developed ways to record and evaluate the practice.

From the point of view of the exercise, the modernity of the building is manifested in the fact that it has 2–4 fire compartments per level, fully covered with fire sprinkler system, fire safe elevator for firefighters, mechanical SHEV system. The operation of the Urgent Care Center (UCC) is important from a medical point of view. These conditions do not apply to any of the units involved in the exercise in most hundred-year-old facilities.

During the exercise, the conditions were further idealised and a number of health professionals meeting the minimum professional requirements were commanded, and the evacuation sub-plan was completely redesigned from squad level.

[15] Lajos Kátai-Urbán (ed), *Iparbiztonságtan I* (Budapest: Nemzeti Közszolgálati Egyetem, 2013), 146.

There were two basic evacuation strategies modelled:
- leaving the facility
- escape to a shelter-in-place

3.1. Leaving the facility

The most important task was to set priorities, as well as to categorise and allocate the babies who need to be rescued. Infants who were not under ventilation began to be rescued by professional staff or by the parents present. In case of infants under ventilation, it caused difficulties that the transport of incubators[16] is not really available in sufficient numbers or cannot be assembled due to lack of space or due to congestion and their assembly is time-consuming or also not possible due to lack of space.

Therefore, the rescue of infants in need of ventilation can only be manual, implemented by the so-called bag valve mask ventilation. The weight of an incubator is approximately 100 kg, for moving and ventilating 3 people are required in principle (1-push, 1-direct, 1-breathe).

Considering this theoretical possibility, the number of babies that can be saved is very small. During the exercise, a new technique was tested, in which two infants were placed in a transport incubator, and two nurses/doctors were ventilating them by simultaneously ventilating with one hand and pushing/directing the incubator with the other hand. The simulation was implemented with the help of so-called medical mannequin dolls, whose intubation reacted to movement and possible jolting in a similar way to reality.

Picture 1: Practicing the "new" rescue technique
Source: Picture taken by Attila Kovács, Semmelweis University.

[16] Mobile incubators with their own medical gas and power supply.

The evacuation took place via elevators in the independent fire compartments and, after the arrival of the firefighters, through the fire safe elevator for firefighters. On the ground floor, the evacuated babies were taken over by the UCC and accommodated after the triage, handed over to the ambulance service or the Peter Cerny Foundation's ambulance for transport to another institution.

3.2. Escape to a shelter-in-place

Precisely due to the difficulties of the escape described above, it is faster to ensure safe conditions for staying, and to provide practice opportunities for staff to assess and recognise this.

This is conceivable in two cases:

1. There is no fire in the given fire compartment, so staying there for 90 minutes can be ensured if the appropriate redundant networks are in operation.
2. The rescue operation shall last until the nearest fire compartment, where, with the operation of appropriate redundancies, connectors shall be available where the incubators are provided with medical gas and electricity, so it is safe to stay there for 90 minutes and to prepare for further escape if necessary.

During the exercise, a third situation was also modelled when a doctor and a mother could not escape with her baby from the section affected by the fire because the fire blocked the escape route. In this case, the goal was to signal the entrapment and implement rescuing through the window with turntable ladders.

3.3. Main findings of the exercise

The exercise was successful under idealised conditions, although the complete evacuation took 24 minutes, and the fire compartmentation of the building as well as the operating SHEV system made it safe.

In reality, out of the three patient care units involved in the exercise, one PIC department has a fire compartment, but at present neither the redundancy of the medical gas nor the electrical system is ensured, so although the lockdown is architecturally possible, intensive health care is not.

Transportation of evacuated babies with premature infant ambulance service (Peter Cerny Foundation) takes much more time in reality, as the number of special ambulances is limited and the removal of a newer baby can only take place after the previous infant has been transferred to and from the host institution. This extends the placement of babies in a safe place by up to 10–15 minutes, significantly reducing the chances of babies' surviving.

In reality, concerning one of the PICUs, although it has an exit to the street facade, there are stairs where an incubator cannot be removed. If there is a fire in the ward and the lift cannot be used (because it is not a fire safe elevator), infants in distress can only be rescued by hands by providing ongoing support to life functions.

In reality, the building where the other intensive care units are originally located has one single fire compartment so escaping to the other unit within the building does not provide guaranteed protection.

Currently, redundant medical gas pipelines are not established in these areas, spare cylinders are not available in sufficient numbers, or there is no storage space in the area to store them. If the medical gas is shut off at the Clinic (e.g. due to a fire), infants can only be ventilated manually, which cannot be solved with the current number of professional staff.

3.4. Recommended measures required for safe operation

Qualified fire blankets shall be placed in the territory of all organisational units providing intensive (or similar) care, which is suitable for the immediate extinguishing of small fires and for the protection of vulnerable persons for a short period of time.

The necessary conditions of shelter-in-place and safe evacuation of the facility must be established in all clinics and hospitals, with a special focus on the fire compartments, automatic fire alarm system, appropriate redundant networks per fire compartments, installation of safety elevators, ramps, stairways, necessary technical and transport equipment, but in particular, a number of health professionals must be provided in accordance with the minimum professional requirements laid down by law.

4. Summary

Based on the analysis of the relevant literature, it can be concluded that the exercise of fire evacuation plans is not only a legal obligation but is essential for personnel to be able to implement it effectively even in the event of a real fire.

The relevant legislation and directives provide only guidance and general requirements for facilities where persons unable to escape on their own might be taken care of, so general evacuation time calculation cannot be fully applied in such cases.

Considering that the ultimate goal of evacuating a hospital is not only to evacuate the facility, but to maintain or continue the treatment of the treated persons (within the institution or by transfer to another health care facility), tasks of the staff are much more comprehensive (the application of disaster medicine, preparation for shipment, transmission of medical information, etc.) than required by law for the preparation of a general fire safety policy and fire evacuation plan. This is why it is necessary to coordinate, comprehensively apply and continuously practice the output sub-plans of fire evacuation and Hospital Disaster Plans.

It is necessary to assess the architectural and fire protection characteristics of PICU/ICU areas in hospitals, the available technical and human resources and, with adequate funding, to develop a comprehensive strategy based on practical experience (too) in order to develop a uniform level of safety with approaching the existing and current regulations.

The most important consequence of the exercise and the most valuable result of it is that the staff members providing health care and thus in crisis care actively participated – after the initial aversion and distancing (thinking about this kind of activity for the first time) – professional dialogue and discussions have been formed among them in the planning phase, and after the exercise, they shared their experiences with their colleagues in an organised way.

Utilising the experience of this exercise as well, and after further planning and exercises, the staff that had been involved in the previous complex exercise effectively applied the "shelter-in-place" evacuation method during the 2019 fire of an oxygen cylinder ventilator at the PICU. The staff applied the experiences of the former exercise and managed to prevent the further damage of medical equipment using fire blankets in the initial stage of fire.

References

Cimer, Zsolt, Gyula Vass, Attila Zsitnyányi and Lajos Kátai-Urbán, 'Application of Chemical Monitoring and Public Alarm Systems to Reduce Public Vulnerability to Major Accidents Involving Dangerous Substances'. *Symmetry* 13, no 8 (2021). Online: https://doi.org/10.3390/sym13081528

Emergency Preparedness and Response Exercise Program, 'Emergency Shelter-In-Place Guidance', in *MDPH Hospital Evacuation Toolkit, III.* Harvard, School of Public Health, 2014, 45–57.

FEMA, 'Hospital Evacuation: Principles and Practices', AWR-214-W, 2010.

Femino, Meg, Susan Young and Vincent C Smith, 'Hospital-Based Emergency Preparedness Evacuation of the Neonatal Intensive Care Unit – the Smallest and Most Vulnerable Population'. *Pediatric Emergency Care* 29, no 1 (2013), 107–113. Online: https://doi.org/10.1097/PEC.0b013e31827b8bc5

Fire Protection Technical Guideline – Evacuation (TvMI 2.3:2020.01.22.).

Herczeg, Gergely, 'Kiürítési gyakorlatok szervezése, lebonyolítása'. *Védelem Tudomány* 4, no 3 (2019), 40–61.

Kátai-Urbán, Irina, 'Veszélyes anyaggal foglalkozó telephelyek riasztási és terület kiürítési hatékonyságának vizsgálata'. *Műszaki Katonai Közlöny* 28, no 1 (2018), 76–102.

Kátai-Urbán, Lajos (ed.), *Iparbiztonságtan I.* Budapest: Nemzeti Közszolgálati Egyetem, 2013.

Salmon, Liane, 'Fire in the OR – Prevention and preparedness'. *AORN Journal* 80, no 1 (2004), 42–60. Online: https://doi.org/10.1016/S0001-2092(06)60842-9

Sankaran, Koravangattu, Allan Roles and Gordon Kasian, 'Fire in an intensive care unit: causes and strategies for prevention'. *Canadian Medical Association Journal* 145, no 4 (1991), 313–315.

Tekin, Erdal, Atif Bayramoglu, Mustafa Uzkeser and Zeynep Cakir, 'Evacuation of Hospitals during Disaster, Establishment of a Field Hospital, and Communication'. *The Eurasian Journal of Medicine* 49, no 2 (2017). Online: https://doi.org/10.5152/eurasianjmed.2017.16102

Veres, György, 'Tömegtartózkodású épület kiürítésének vizsgálata I'. *Hadmérnök* 4, no 1 (2009), 34–45.
Veresné Rauscher, Judit and Tibor Kovács, 'Kórház kiürítés vizsgálata számítógépes kiürítés szimulációval'. *Védelem Tudomány* 4, no 2 (2019), 23–44.

Legal sources

30/1996 (XII.6.) Ministry of the Interior's Decree on the preparation of fire protection regulations.
43/2014 (VIII.19.) EMMI Decree on the content requirements of health contingency plans of hospitals and amendment of certain ministerial provisions on health care.
54/2014 (XII.5.) Ministry of the Interior's Decree on the National Fire Protection Regulations.
Act XXXI of 1996 on the protection against fire, technical rescue and the Fire Department.
Act CLIV of 1997 on Health.