

The medical perspective on mining incidents

Interviews with emergency medical service (EMS) personnel

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Abstract

Purpose – The purpose of this paper is to examine emergency medical service (EMS) personnel's perceptions and experiences of managing underground mining injury incidents.

Design/methodology/approach – In total, 13 EMS personnel were interviewed according to a semi-structured interview guide. The interviews were transcribed verbatim and analyzed using qualitative content analysis.

Findings – An underground mining environment was described as unfamiliar and unsafe and, with no guidelines for operational actions in an extreme environment, such as underground mines, the EMS personnel were uncertain of their role. They therefore became passive and relied on the rescue service and mining company during a major incident. However, the medical care was not considered to be different from any other prehospital care, although a mining environment would make the situation more difficult and it would take longer for the mine workers to be placed under definitive care.

Originality/value – This study complements earlier studies by examining the EMS personnel's perceptions and experiences of major incidents.

Keywords Preparedness, Emergency medical services, Major incident, Mines

Paper type Research paper

Introduction

Although the overall trend is that incidents are decreasing in the mining industry, incidents with varying degrees of severity still occur (Shooks *et al.*, 2014). Major incidents are uncommon, but when they do occur the consequences can be serious (Bealko *et al.*, 2011). In Sweden, there are about 100 mining incidents per year that result in injuries in which mine workers take sick leave for at least one day. Of these incidents, around 14 are considered serious, resulting in death, invalidity or more than 30 days' sick leave. Furthermore, around six of these serious incidents occur in underground mines (The Mining and Mineral Industry's Health and Safety Committee, 2016). Major incidents in mineral and metalliferous mines tend to be related to traffic incidents, fires and rockfalls (Engström *et al.*, 2018). This will be of consequence to the rescue team, i.e. the rescue service and emergency medical service (EMS). Additionally, potential injuries in a mining environment include: musculoskeletal injuries, burns and head injuries (Enright *et al.*, 2016). Research literature from a medical perspective in major underground mining incidents is scarce (Engström *et al.*, 2018), which can be of consequence to the preparedness of the EMS for mining incidents.

A number of countries have specialized mine medical rescue teams, e.g. Pennsylvania in the USA which has a special medical response team (SMRT) that provides advanced medical care to injured individuals in high-risk or extreme environments, including mines



(Special Medical Response Team). This team operated during the incident at the Quecreek coal mine in 2002 in which, nine mine workers were trapped in the mine following an explosion. The explosion had led to flooding and the SMRT had anticipated a risk of decompression sickness and also hypothermia (Frank, 2002).

Sweden has no specific mine medical rescue teams, which means that all EMS personnel with a mine in their catchment area might be dispatched to a mining incident. Thus, they must possess the knowledge and skills to manage major underground incidents. About one half of EMS personnel did not consider themselves properly prepared to respond to a major incident in an underground mine. Those who had previously entered a mine considered themselves to be more prepared, although there was no association between having worked during a major incident in an underground mine and preparedness (Al  x *et al.*, 2017).

Any rescue operation is complex because of the mining environment, meaning the involved organizations are heavily dependent on each other. In case of a major incident underground the mine workers have to be able to escape but also carry out the first response by, e.g., taking care of injured colleagues (Karlsson *et al.*, 2017). However, in Sweden apart from many other mining countries, it is not common with mine rescue teams, only one company use them for the first response, otherwise it is up to the municipal rescue service to carry out rescue operations into the mine (Lehnen *et al.*, 2013). Because mine rescue is dependent on the municipal rescue service they have to closely collaborate with the mine managers to be able to plan the rescue operation and when entering the mine having help of trained mine guides to be able to find their way (Karlsson *et al.*, 2017). Injured underground mine workers must be transported to the surface before they can be taken to hospital by EMS personnel (Enright, 2017). Most often the injured mine workers can be brought up from the mine to the waiting EMS personnel, but in some cases when it is necessary with acute lifesaving treatment the EMS personnel might have to enter the mine. Thus, collaboration is important. However, EMS personnel have not been included in the existing collaboration between the mining industry and the rescue service (Karlsson *et al.*, 2017). It is therefore of interest to highlight the EMS perspective of major mining incidents. The aim of this study was to examine the perceptions and experiences of EMS personnel regarding the management of underground mining incidents.

Methods

Setting

Sweden has nine mineral and metalliferous underground mines. The mines are located in Northern and Central Sweden, some of them in sparsely populated areas.

A Swedish ambulance crew comprises of at least one registered nurse (RN), some of them specializing in prehospital care, together with another RN or an emergency medical technician. The RN is educated and trained in advanced life support while the emergency medical technician is educated and trained in basic life support (Langhelle *et al.*, 2004). Swedish EMS personnel are educated in the command and control of major incidents. The medical command and control at a major incident site is managed by the ambulance incident commander and the medical incident commander. The ambulance incident commander is responsible for the on-site medical response, safety, resources, collaboration with other organizations and communication. The medical incident commander is responsible for injured persons and for making medical assessments and providing the ambulance incident commander with information about injured persons for example (R  ter *et al.*, 2006).

Data collection

In this study, semi-structured individual interviews were performed during October and November 2016. Both written and verbal information about the study was provided to 10 out of a total of 11 EMS managers with an underground mine in their catchment area. The one not contacted had recently participated in another research study (Karlsson *et al.*, 2017).

The managers notified all of their personnel of the study and interested personnel were invited to participate. In total, 13 respondents from five EMS stations participated, and the number of respondents per station ranged from 1 to 6.

Eight of the respondents were RNs, four were RNs specializing in prehospital emergency care and one was an emergency medical technician. There were seven males and six females, aged 26–62 years, mean age 42 years, with work experience ranging from 1 to 42 years, mean 14 years. Nine of the respondents had experienced a mining incident.

A semi-structured interview guide included open-ended questions about the EMS personnel's experiences of care during underground mining incidents. A test interview was performed that enabled the development of the interview guide. The opening question was about whether the respondents had ever experienced an incident in a mine, followed by several probing questions to gain further information, e.g. what injuries the mine workers had sustained and what difficulties the respondents had encountered during the rescue operation.

Out of the 13 individual interviews, 11 were performed at the respondents' work place and two individual interviews were conducted over the phone. The interviews ranged from 20 to 105 min, with a mean of 48 min. All interviews were recorded and transcribed verbatim.

Analysis

The individual interviews were analyzed using qualitative content analysis (Graneheim *et al.*, 2017). The authors analyzed the manifest content by reading the interview transcripts several times. Meaning units covering the aim were extracted from the text. Most of the text was converted into meaning units and included in the analysis. From the meaning units codes were formulated. The authors then continued to analyze the latent content in the text together with the codes thereby forming sub-themes and themes. The results are presented with sub-themes and themes discovered in the text (Table I).

Ethical considerations

This study was performed in accordance with the Helsinki Declaration (World Medical Association, 2013). The respondents were informed of the study both verbally and in writing, guaranteed confidentiality and the right to withdraw from the study at any time. The respondents gave their written informed consent to participate in the study. The identity of the respondents cannot be revealed from the quotes or the analyzed text of this study. The respondents chose to participate in the study of their own free will and there was no dependency between the participants and the researchers. The study's objectives and methods are not covered by the Swedish Act concerning the Ethical Review of Research Involving Humans. Thus, approval from the Regional Ethical Review Board for this study has not been sought.

Results

The respondents' experiences of major incidents can be interpreted in terms of operating in an unfamiliar environment being characterized by accepting uncontrolled and unsafe conditions and adopting a passive role in the rescue team (Table I).

Sub-themes	Theme
Preparing for an unspecific task with unclear information	Operating in an unfamiliar environment is characterized by adopting a passive role in the rescue team because of uncontrolled and unsafe conditions
Accepting a challenging rescue environment	
Providing care with limited resources	
Enduring the feeling of uncertainty and powerlessness	

Table I.
Theme and sub-themes

Operating in an unfamiliar environment is characterized by adopting a passive role in the rescue team because of uncontrolled and unsafe conditions

The theme that emerged from the respondents' descriptions of their perceptions and experiences of major incidents in underground mines was that they had been dispatched to an unfamiliar environment, which led them to adopt a passive role in the rescue team because of uncontrolled and unsafe conditions. A major incident in an underground mine was considered to be unsafe to enter. Thus, EMS personnel adopted a passive role and trusted the rescue service and the mining company to manage the situation and to rescue the injured. They stated that they were at the disposal of the rescue service and played a secondary role, although EMS personnel had primary responsibility for the health of injured mine workers. Some of the respondents felt they could enter the mine to gain quicker access to injured mine workers, while others thought it would be better if injured mine workers were transported out of the mine by either the rescue service or mining personnel before being treated by EMS personnel. The sub-themes are described below and illustrated by quotations.

Preparing for an unspecific task with unclear information. An alarm regarding an incident in which an injury has occurred in an underground mine is not regarded by EMS personnel as an ordinary everyday event. They stated that they did not really know what to expect in a mine, which led to uncertainty. Thus, such tasks and responsibilities require more planning. Because information from an injury incident in a mine must be communicated to several "intermediaries" – mine workers, mining management and the emergency dispatch center – before it reaches the EMS personnel, they stated that they often received incomplete information or no information at all about what had occurred in the mine. This uncertainty affected the EMS personnel's capability and influenced their ability to make preparations. The respondents also stated that it was not obvious who they should contact in the mine when they arrived:

It is how we should manage it organizationally rather than in terms of the medical response. Who should we contact? How should we organize the work? And how do we always get such things to work properly? Several situations like this have arisen in which the medical response system is still searching for answers, because we have no clear idea of the actual situation in such extreme environments, how we are supposed to react.

Collaboration between the organizations and a joint response plan was perceived as being of vital importance for the effectiveness of immediate medical care during a mining incident. EMS personnel with previous experience of working with mine incidents in which an injury occurs state that they feel that the joint collaboration has worked well. They felt that there had been clear roles, that everyone had assisted in the assessment of the incident, and that every organization was involved in how the situation needed to be resolved. However, some EMS personnel felt it was unclear which organization had overall responsibility for the incident site and that it took a very long time for all decisions to be made before the rescue operation could commence.

The respondents stated that well-functioning communication facilitates rescue operations in the mine, which may be difficult to achieve. They stated that in some instances they used the mine's communication equipment because the EMS's communication equipment had no coverage beneath ground level:

Similarly, I am unable to deal properly with communications on my own. I am unable to make contact with the emergency dispatch center in order to request whatever I need at the time. Rather, I have to go via an employee of the mining company, who will contact someone on the surface who, in turn, will communicate it to someone in my own organization, who will finally call the emergency dispatch center. So you have a situation that involves multiple channels and obtaining first-hand information is, of course, difficult, to the extent that some information will disappear.

It has been stated that in injury incidents where communications have failed or were inadequate, interaction and collaboration have been affected. EMS personnel with experience of this stated how they had to search for information and were faced with a situation in which they were just standing around with nothing to do, which meant they felt that they had no control over the event. A couple of difficult situations were described: in one incident in which all EMS personnel descended into the mine, there was no communication with the ambulance helicopter, and on another occasion the EMS personnel stayed above ground and a medical team descended into the mine without any means of communication in order to attend to the victims. They also felt that the other organizations did not always have complete control of the situation. The EMS personnel stated that at an incident involving a fire in a mine, smoke divers intended to search for the injured, which was described as being exceptionally difficult and chaotic. There was so much smoke in the mine that the smoke divers could not see each other, and the EMS personnel felt that the safety of the smoke divers had been compromised.

Accepting a challenging rescue environment. The mine's environment was described as unwieldy and difficult to work in. The EMS personnel felt that it was more difficult to carry out a rescue operation in the mine as it was a confined, narrow, dark place, not without serious risk of harm. Working in the dark in the mine was considered to hamper their work at the incident site, increasing the risk of falls and causing difficulties in operating vehicles. The respondents described the environment as unsuitable for an ambulance vehicle, with narrow, slippery pathways, resulting in excessive wear on the brakes. The mine was also very humid and produced moisture on the windscreen, unless the fan was operating at full capacity. Respondents who had experienced adverse incidents involving injury in a mining environment felt that rescue work was more complicated than similar work above ground. The respondents felt that the mining environment constituted an extreme environment with regard to emergency response and immediate medical care.

The respondents also described a feeling of surrealism when they descended into the mine, for example, the underground canteen had painted windows so that it would feel like being above ground. The respondents who had experienced adverse events in a mine described it as a maze. It was considered to be very easy to get lost in a mine:

[...] it is all just like a spiral that keeps going on and on and 800 meters is a long way down, almost one kilometer, and it is a narrow, cramped space and it is dark as there is not much lighting along the paths on the way down – you do not know where you are or anything [...].

The EMS personnel felt that the immediate medical care of a patient in a mining environment is no different from a patient above ground. Irrespective of location, patients are assessed and treated based on systematic, immediate medical care. The difference is that it is difficult to gain an overview of the incident site and it takes a long time to gain access to the patients. Thus, the objective is described as fast and safe transportation of the patient to the surface.

Providing care with limited resources. The EMS personnel felt that they had guidelines for the patient's immediate medical care but no specific guidelines for operational actions in an extreme environment, such as underground mines. Thus, they felt the existing guidelines had not been adapted to extreme conditions. They therefore requested comprehensive guidelines. However, different opinions were expressed about EMS personnel being present in the mine. Some of them felt that it would be better to set up a casualty assembly point and to conduct immediate medical care and initial treatment above ground, as they believed that treating patients down in the mine did not save lives. Thus, their goal was not to go underground. EMS personnel who had experienced incidents in which an injury occurred in a mine stated that by descending into the mine faster they had quickly gained access to the patients so they could conduct an assessment and administer immediate medical treatment.

The EMS personnel stated that they cannot do anything on their own initiative in a mine incident but that they must follow the mining company's instructions. They perceived that the mining company consider that it is good for EMS personnel to be on site at the mine, but that they are not assigned any tasks until more information is available regarding the incident. The feeling was that the mining company was involved at the beginning of the incident but then withdrew to the background. Upon arriving at the mine, someone working at the mining company meets the EMS personnel but then hands responsibility over to the EMS personnel. However, the mining personnel could assist by offering help and resources, if required. They felt that mining personnel shared their knowledge and, in cases in which EMS personnel descended into the mine, they required a guide from the mine to lead them. If the ambulance vehicle could not access the mine, it might be necessary to transfer medical equipment into one of the mining company's vehicles. The respondents stated that it most likely would be limitations in terms of the equipment that could be taken down in the mine, meaning a decision must be taken about which equipment is necessary:

I actually think that you probably never have sufficient equipment to handle all situations. [...] We simply need to work with the equipment we have and try to make the situation work.

Some EMS personnel felt that the rescue services received greater responsibility underground. Thus, they should assist the rescue services in their work as the rescue services had primary responsibility in a mining environment and that the EMS personnel had a supporting role. It has been the rescue services that decide whether or not EMS personnel will go down into a mine. The EMS personnel regarded the situation as one in which they themselves were working under the direction of the rescue services and stated that they had no general overview of an incident:

[...] then you had to wait and wait and then all of a sudden everyone had to get ready; the smoke divers would descend into the mine and we would descend and it was like a long process, and everything was hurried and then things had to get done.

Enduring the feeling of uncertainty and powerlessness. In the case of major injury incidents, the mining environment felt unfamiliar and unsafe to the EMS personnel. Some EMS personnel regarded themselves as being well prepared to go underground into a mine, while others did not regard themselves as being ready. Those who had previously entered a mine described experiences such as discomfort, a sense of feeling small, and the belief that they would be unable to get out of the mine without someone else's help. Descending into a mine could be described as a disorienting, shocking experience and that returning to the surface again felt great. There were also a number of respondents who did not regard a mining environment as being anything special but rather that it felt like a calm place and that they were not concerned or nervous about being so far underground. Nevertheless, most of them understood how others might feel uncomfortable being underground.

EMS personnel feel that experience and lessons learned from past incidents in a mine contribute to a feeling of being prepared. They know what needs to be done and what works or does not work. In such case it is easier to feel confident and secure, and less nervous. Experience of previous incidents also provides knowledge of one's own reactions. This was considered positive:

But you are always more mentally prepared if you have been there before and have seen and know how it works. [...] it is not only about gaining knowledge of the premises; you know where to go, how their system works, who they should contact and meet up with. So just having a routine means that it feels a whole lot better.

During a major incident in an underground mine, the EMS personnel who were the first to arrive at the mine felt rather impotent as they had to wait for further resources. At such

incidents, EMS personnel stated that having several EMS personnel on site is a way of enduring the feeling of uncertainty and powerlessness, as they are able to discuss among themselves what they needed to do. They described themselves as a tightly knit group that discussed the extraordinary incident and helped each other out. Also, the EMS personnel felt calm once the helicopter was in place as it carried a doctor and could shorten the time until the patient received definitive care:

In such situations I think you would also feel a bit powerless at the beginning because, as the first ambulance, we will not even enter the mine. Instead, we must take care of communications and it feels conflicting and difficult because you want to go down and do something, rather than simply stand there.

The safety of personnel is highly valued by EMS personnel, and they want to be sure that the site is safe before they start to provide immediate medical care. However, the EMS personnel stated that they lacked the assessment tools necessary for them to be able to assess the safety of the mine. They felt that there were risks in the mine, for example, a collapse and the development of smoke, of which they had minimal knowledge. Thus, one way of enduring the feeling of uncertainty and powerlessness was to feel confidence in the rescue services and the mine's safety assessment. Handing over the task of risk assessment to others with more expertise was regarded as obvious to some, even though there were mixed feelings. For instance, EMS personnel felt insecure and uncertain when mine personnel appeared to be under stress:

We have knowledge and experience of medical care. However with regards to safety, that is something that feels like [...] yes, they say it is safe, so then we have to believe them. And it is [...] you grow accustomed to believing in the rescue services but you are not familiar with the mine workers who make the decision because, after all, it is these mine workers who understand the situation. Not the rescue services, they were not down there.

If the safety of EMS personnel could not be guaranteed, the overall general attitude was that EMS personnel should not descend into the mine. If, on the other hand, the site was considered safe, it was felt that there was no reason why EMS personnel could not descend into the mine. The EMS personnel often felt that they wanted to descend into the mine. However they were not permitted to do so as the mine personnel could not guarantee their safety.

Discussion

The theme that emerged from the EMS personnel's descriptions of their perceptions and experiences of major incidents in underground mines was "Operating in an unfamiliar environment is characterized by adopting a passive role in the rescue team because of uncontrolled and unsafe conditions". The following aspects of the results are discussed: the EMS personnel's passivity in making decisions, lack of guidelines, uncertainty, safety and collaboration.

The EMS personnel in the present study described a passiveness in making decisions in a mining environment, situations in which they handed over responsibility to the rescue service or the mining company. They described situations in which their own responsibilities were managed by the rescue service or the mining company. This could be related to that they do not feel comfortable making decisions in an unknown and potentially hazardous environment. One study (Stjerna Doohan *et al.*, personal communication) supports present results, showing that during tunnel incidents and exercises, because EMS personnel lack knowledge about a tunnel environment, the rescue service take the leading role. The passiveness described in present study can be compared to what another study (House *et al.*, 2014) described as uncertainty of the situation, not knowing possible actions or consequences which make EMS

personnel avoid taking decisions. Another aspect related to passiveness in the present study is the lack of guidelines for operational actions concerning appropriate management of mining injury incidents. EMS personnel only have guidelines for immediate medical care and use them to ensure that they make the right decisions about appropriate care (Burgers *et al.*, 2013). Thus, there is a risk that EMS personnel who are not accustomed to a mining environment will be unaware of the appropriate decisions which must be taken. EMS personnel are used to work in unpredictable settings and sometimes make decisions that are not supported by guidelines (Abelsson and Lindwall, 2012), acting instead on their experience (Juffermans and Bierens, 2010). In order to be able to manage mining injury incidents in the extreme environment EMS personnel need decision-making guidelines.

In the Swedish context all EMS personnel should be able to manage major incidents, which means they have a comprehensive knowledge of caring for all types of illnesses and injures in most situations. However, in incidents in extreme environments or industries dealing with hazardous materials, a more specialized knowledge might be necessary. Some individuals within the EMS organization could receive more training in how to manage these incidents in extreme environments. A few countries have operated special medical response teams with good results during incidents in underground environments (Special Medical Response Team; Frank, 2002). Thus, it is important that the EMS personnel in collaboration with the other organizations are well trained and prepared for major incidents in underground environments.

In the present study safety was an important aspect to consider due to the new and extreme environment. With regard to the missing guidelines, EMS personnel were uncertain as to whether or not they could enter an underground mine. Some EMS personnel believed they could enter an underground mine in order to gain quicker access to patients, although some considered it was better if patients were treated on the surface. In another study (Smith *et al.*, 2018), EMS personnel believe they have a duty to treat their patients, but not if the environment is too hazardous. Even if entering a mine might be considered hazardous, a timely response is necessary in order to rescue the mine workers. The decision to enter a mine has to be based on accurate information (Fuller *et al.*, 2012), for example, the rescue service notify EMS personnel about risks in the environment. Nonetheless, it is the responsibility of the EMS personnel to assess whether the situation is safe enough for them to work in (Rüter *et al.*, 2006). If EMS personnel are uncertain about their own safety, they rely on the rescue service's assessment of the environment and risks (Stjerna Doohan *et al.*, Personal communication). However, the present result indicates that the EMS personnel might not always feel that the other organizations have complete control of the rescue operation. This could well be the case, but it is also a possibility that the EMS personnel do not have enough knowledge of the other organizations' roles and responsibilities during major incidents in underground mines. Thus, it is important that EMS personnel become knowledgeable about their own specific role as well as the other organizations, the mining environment and the risks associated with injury incidents in underground mines in order to deliver immediate medical care.

EMS personnel in present study felt that experiences of previous incidents in underground mines helped them feel more prepared. Previous experiences of similar situations are important for enabling EMS personnel to manage major incidents (Gunnarsson and Warren Stomberg, 2009). EMS personnel usually have limited experiences of managing major incidents (Stjerna Doohan *et al.*, personal communication). It is EMS personnel who are responsible for the care of patients and directing the other organizations in prioritizing patient-related work at the incident site (Abelsson and Lindwall, 2012). They might feel that during major incidents they are exposed and left to resolve complex situations on their own, as well as being unable to focus on one task at a time (Elmqvist *et al.*, 2010). To increase the preparedness of the EMS personnel for major incidents in underground mines, there is a need to increase their experiences by training and reflection.

In the present study, EMS personnel felt there is a need for more structured collaboration. Another study mentioned that rescue service personnel feel that collaboration with EMS personnel depends on the EMS personnel's individual experiences of responses to major incidents (Stjerna Doohan *et al.*, personal communication). The organizations also have to be capable of adapting and being flexible in order for the collaboration to work (Donahue and Tuohy, 2006). In a major incident the organizations are task interdependent of each other during a rescue operation (Janssen *et al.*, 2010). Synchronous "seamless" collaboration is preferred during decision making involving all organizations, but it is hard to accomplish during major incidents. Parallel collaboration is more common, i.e., that the organizations work with their respective tasks alongside each other with limited coordination (Berlin and Carlström, 2011). A lack of collaboration could be harmful, because it could render the rescue operation ineffective, thereby affecting patient care. Further research is needed to examine the decision making during major incidents, considering when parallel or synchronous collaboration is required.

Methodological considerations

One advantage of this study is that the respondents come from five EMS stations located in different parts of Sweden that respond to incidents in the mines in their respective catchment areas. The study also has a diversity of perspectives, with regard to gender, age and work experiences. Because major mining incidents are uncommon, some of the respondents had no experience of incidents in underground mines. A decision to include respondents with no experience of mining incidents was taken in order to also include their perspective. The respondents provided comprehensive accounts of their perceptions and experiences, the interviews were comprehensive and the answers were deemed sufficient. Using a qualitative content analysis and working through the text in a structured way by going back and forth between the text and the upcoming interpretation gave the most optimal results, even if other researchers might arrive at alternative interpretations. The use of quotations in the results is a way of showing internal consistency and thereby increasing validity of the study. A limitation of this study could be the limited context in which the results are transferable: underground environments such as other mines and tunnels. However, EMS personnel who work in major incidents in extreme environments might benefit from these results.

Conclusion

EMS personnel became passive in this unfamiliar environment because of their uncertainty and because they did not have any specific guidelines for operational actions. In an unfamiliar and unsafe environment such as an underground mine, it is easier to rely on the rescue service and mining company, rather than taking own decisions. However, the care of injured mine workers is the responsibility of EMS personnel. They should therefore be part of the decision-making process together with the other organizations involved. Thus, preparing and training the EMS personnel that could be dispatched to mine incidents could improve their confidence in managing both less serious as well as major incidents in underground mines. They could also visit the mine and be part of full-scale exercises to become familiar with the mining environment. Some in the EMS organization could receive further training in how to manage major incidents in certain sectors, e.g., extreme environments or industries. Further studies in extreme environments, such as underground mines, are warranted, for example, the study of EMS personnel's actions during full-scale and table-top exercises in order to be able to generate a comprehensive set of guidelines. Such guidelines could include relevant management decisions which must be taken in collaboration with the rescue service and the mining company.

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