SAFETY SCIENCE Monitor

Issue 1 2017

Article 5

VOL 20

PREPAREDNESS FOR MINING INJURY INCIDENTS: INTERVIEWS WITH SWEDISH RESCUERS

SOFIA KARLSSON
Department of Surgical and Perioperative Sciences, Section of Surgery, Umeå University, SE-901 87 Umeå, Sweden. Email: sofia.karlsson@umu.se (Corresponding author)

LINA GYLLENCREUTZ
Department of Nursing, Umeå University, SE-901 87 Umeå, Sweden

GUNNAR ENGSTRÖM
Department of Surgical and Perioperative Sciences, Section of Surgery, Umeå University, Umeå, Sweden and Department of Public Health and Clinical Medicine, Occupational and Environmental Medicine, Umeå University, SE-901 87 Umeå, Sweden.

ULF BJÖRNSTIG
Department of Surgical and Perioperative Sciences, Section of Surgery, Umeå University, SE-901 87 Umeå, Sweden.

BRITT-INGER SAVEMAN
Department of Nursing, Umeå University, SE-901 87 Umeå, Sweden.

ABSTRACT

Objectives. To explore the perceptions and experiences of mining-, rescue service- (RS), and emergency medical service (EMS) personnel regarding how to handle incidents in an underground mine.

Methods. Six focus-group interviews and 10 individual interviews were carried out with groups of mining-, RS and EMS personnel, who served the underground mining industry located in small municipalities in a sparsely populated area of northern Sweden. The transcripts of the interviews were analysed using qualitative content analysis.

Results. The three groups mostly described experiences of minor incidents and announced a limited preparedness for handling major mining incidents. Collaboration was described as being difficult because of limited knowledge about the others' responsibilities and capacities. Few non-mining personnel were trained, or prepared to fulfil their tasks in an underground environment, and some expressed that they would even refuse to go underground because of concerns for their own safety.

*Conclusions***.** There is a need for more collaboration and joint practices between and among the groups involved in rescue operations. Collaboration between mine- and RS personnel exists, but the EMS personnel is largely excluded from this interaction. Therefore, the EMS personnel are insecure about how to handle underground mining incidents. A closer collaboration between all organizations in preparing for mining incidents is emphasized, and would have positive effects on the rescue operation. Some experiences may also be used under similar circumstances, such as incidents in railway and road tunnels.

Keywords: Collaboration, EMS, mine injury incidents, preparedness, rescue operation, rescue service, Sweden, underground mining

INTRODUCTION

A literature review (Engström, Angrén, Björnstig and Saveman, 2017) of mass-casualty incidents in the underground mining industry, with emphasis on factors relevant to the EMS (Emergency Medical Services) identified only a few scientific reports about rescue operations and provided pre-hospital care. Most reports covered information about risk factors for mine incidents, with one exception being the Quecreek mine incident in 2002, in which the rescue operation, also in terms of EMS problems, are addressed (Frank, 2002; Tapia, 2002). Furthermore, in a Swedish exploratory study (Aléx, Joanson, Tageson and Saveman, accepted) addressing preparedness of EMS for underground major rescue operations, about half of the responders stated that they felt unprepared to work under these conditions. Those few trained in handling underground mine incidents, however, reported a higher level of preparedness for carrying out rescue operations than those who were not. Only about one third of the EMS personnel, working in a region with mining industry, had some education or training to increase their understanding of major underground incidents.

Most of the major mining countries in Europe have either company-owned rescue teams or state-owned centralized professional mine-rescue teams. In Sweden, the local RS and EMS (Lehnen, Martens and Rattman, 2013a) have adequate training and are responsible to manage all incidents including mining incidents (Langhelle et al., 2004; Suserud, 2005; Swedish Civil Contingencies Agency, 2008), which makes an efficient collaboration between the rescue organisations (Elmqvist, Brunt, Fridlund & Ekebergh, 2010) and mining companies important. Furthermore, the mining companies themselves are mandated to maintain a preparedness for incidents complementary to that of the local RS (Swedish Civil Contingencies Agency, 2014). In Sweden, with nine underground mines (Geological Survey of Sweden, 2016) only the state-owned large mining company Luossavaara-Kiirunavaara AB (LKAB) keeps its own professional rescue service (RS) (Lehnen, Martens and Rattman, 2013b; Luossavaara-Kiirunavaara AB Communications, 2011).

The mining industry in Sweden is accompanied by high ambitions in occupational health and legislation, but the average risk of injury and fatality is still high compared to other industrial branches (Shooks, Johansson, Andersson and Lööw, 2014). In 2015 there were in total 684 incidents and 2202 near misses. Of the 684 incidents 15 were considered to be severe, and of these 5 occurred in underground mines (The Mining and Mineral Industry's Health and Safety Committee, 2016). Nevertheless, the safety is increasing, which can be attributed to several factors, such as an increased level of automatized working procedures and efforts in incident prevention (Järvholm, 2013). Despite Swedish high standards, there is still room for improvements in order to increase the safety for the mining personnel. Sometimes, an incident is required for the ones involved to take action (Maier, 2011). Major incidents in mines may have serious consequences, but there is a low probability of them happening. Despite measures taken to reduce the risk, there will always be a risk of events (Bealko, Alexander, Chasko and Grayson, 2011). Therefore, the rescue operation needs to function optimally when incidents do happen.

The literature review (Engström et al., 2017), as well as the report of the EMS personnel's preparedness (Aléx et al., accepted), both identified a gap in knowledge when it comes to underground rescue operations, in particular regarding EMS. Therefore, the aim of the present paper was to explore the perceptions and experiences of mining workers and managers, RS personnel, and EMS personnel regarding how to handle incidents in an underground mine.

METHOD

Setting

Of Sweden´s 14 metal- and mineral mines, nine of them are underground entities (Geological Survey of Sweden, 2016). This study was based on two of the underground mines, chosen through convenience sampling. Both of the mines are quite small, one of them have less than 100 and the other about 200 underground workers. The RS and EMS having these mines within their catchment area were approached for interviewing. The mines in this study are located in a rural area in northern Sweden, which is sparsely populated and having a cold climate (Northern Sparsely Populated Areas, 2012). Both these conditions negatively affect a rescue operation. In the last five years, two fire incidents occurred in one of these mines, one in 2013 (Marklund and Haarala, 2014) and the other in 2015. Some of the participants interviewed in this study participated in these underground fire rescue operations.

Swedish context RS and EMS

The Swedish RS is responsible to prevent and manage most incidents in the municipality, for example fires and traffic incidents (Swedish Civil Contingencies Agency, 2008). They are also trained in first aid (Björnstig, 2004) and can therefore assist the EMS in basic life support. The Medical Incident Officer, the RS Incident Commander and the Police Incident Officer will collaborate at the incident scene (Swedish Civil Contingencies

Agency, 2016a). The municipal RS is not responsible for example for mountain, air and sea search and rescue which are the responsibilities of the national authorities (Swedish Civil Contingencies Agency, 2008). There are four different categories of firefighters; fire protection engineers having a university degree (Luleå University of Technology, 2017), full-time firefighters have a two-year degree in rescue- and safety work, part-time firefighters are employed as firefighters but also have another job and volunteer firefighters do not have any formal firefighting education but assist during rescue operations (Swedish Rescue Services Agency, 2008; Swedish Civil Contingencies Agency, 2016b).

The EMS personnel treat injured or sick at the incident site before transporting them to the hospital (Björnstig, 2004). In Sweden there are only advanced life support ambulances. The EMS vehicle in Sweden are operated by at least one RN (registered nurse), more often a specialist RN with a master degree in prehospital care together with another RN or an ambulance technician, who has 40 weeks training in advanced life support (Langhelle et al., 2004; Suserud, 2005). The helicopter EMS units are usually operating with two pilots, one anaesthetic nurse and one anaesthesiologist (Langhelle et al., 2004).

Data collection

In this study, qualitative focus-group interviews and individual semi-structured interviews were applied. The managers of the mine, the RS, and the EMS gave their informed consent for the study. The managers of the mine put together groups of workers that had agreed to participate. Managers and work supervisors were invited to participate as separate groups. The managers of the EMS and RS asked for volunteers among their personnel, for both the focus groups and the individual interviews. In total, 38 individuals participated, 28 in the focus-group interviews and 10 in the individual interviews. The participants are described in Table 1.

Table 1 Description of the participants' background, median (range) age, and working experience in respective organization

Focus-groups	Participants (n = 38)	Age (years)	Working experience (years)
Mining workers group 1	4	26 (23-51)	3 (2-10)
Mining workers group 2	7	31 (22-49)	6 (1.5-10)
Mining management	4	47 (36-55)	22 (6.5-30)
RS personnel group 1	5	57 (35-58)	33 (10-35)
RS personnel group 2	4	49 (34-55)	20 (5-31)
EMS personnel	4+10*	41 (26-56)	10 (1-23)

In total, six focus-group interviews were conducted. Three of these occurred at the mine office, with two groups addressing workers and the other combining managers and work supervisors. In addition, two separate interviews addressed RS personnel and another interview the EMS personnel, all having the particular mine within their catchment area. Furthermore, 10 individual interviews were performed with additional EMS personnel.

The hearings were conducted according to a semi-structured interview protocol containing three scenarios: traffic, fire, and rock fall incidents. The three scenarios described true incidents known from the international literature (Engström et al., 2017; Groves, Kecojevic and Komljenovic, 2007; Hansen and Ingason, 2013; Sanmiquel, Freijo, Edo and Rossell, 2010). The scenarios had a start-up purpose, from which the participants discussed the scenario itself, and if self-experienced, their own perceptions under similar circumstances. The interviewing protocol also included questions relating to safety culture in the work environment.

The focus-group interviews were conducted by two of the authors in an undisturbed milieu at each organization. The individual interviews were conducted by the first author together with two master students. The

focus-group interviews ranged from 90 to 120 minutes, and the individual interviews from 20 to 105 minutes. All interviews were recorded and transcribed verbatim.

Analysis

A qualitative content analysis was used (Graneheim and Lundman, 2004). From the text, meaning units were excerpted to create initial codes (n = 4288), amalgamated, and sorted into subcategories, keeping the text from the three groups of participants separate. During the whole analysis, codes and subcategories were tested and rearranged to fit the purpose of the study. Finally, one category emerged through an abstraction of the subcategories. Created subcategories and the main category are exemplified in Table 2. During this process, OpenCode 4.0 was used (ICT Services and System Development and Division of Epidemiology and Global Health, 2013).

Table 2 Example of the coding process

Meaning unit	Subcategory	Main category
You also know that, if there is a fire, it is not certain that anyone will rescue us. (Mining worker)	The incident as a wake-up call	
You rely on the knowledge of the mining company [...] and the rescue service, because we never visit the mine. (EMS personnel)	The importance of collaboration	The way forward: preparedness and collaboration
…It depends on the rescue operation, we might be 20-25 RS personnel, but at the same time we are limited, e.g. when it comes to the volume of compressed air. (RS personnel)	Preparedness to handle incidents	

Ethical considerations

Before starting the interviews, the authors informed the participants about the study, and guaranteed confidentiality and freedom to withdraw at any time. Thereafter, informed consent was received. Participants' identities cannot be disclosed by the quoted phrases in this report. The ethical aspects followed the Helsinki declaration (World Medical Association, n.d.).

RESULT

A main category was identified; "The way forward: preparedness and collaboration", based on the subcategories i): "The incident as a wake-up call", ii): "Preparedness to handle incidents", and iii): "The importance of collaboration".

The way forward: Preparedness and collaboration

The incident as a wake-up call

The mining managers, supervisors and workers considered all incidents as being wake-up calls, regardless of severity (e.g. a worker being nearly hit by a boulder, or brake failure of a truck causing the truck to back into a wall of the tunnel). Mostly, the workers reported incidents that had occurred, and commonly, actions were taken to solve the underlying problem. Being trapped by a rock fall was a concern that was repeatedly referred by the workers. However, underground fire had the highest rank of concerns, with a perceived fear of making the rescue operation more complicated.

"A fire affects many people. A traffic incident is bad enough but […] if it does not start to burn, the number of involved is limited. A fire may involve many workers over a very long period of time" (mining managers).

Similar to those working in the mine, the RS personnel also considered incidents in the mines as being wake-up calls. However, they felt adequately prepared to handle traffic incidents in a mine, even though most of them had never responded to one underground. The reason why was because they had experience from road-traffic incidents in their usual practice. The RS personnel gave the highest rank of fear to rock-fall incidents, as they felt their equipment and efforts were of little value for rescuing trapped people under rocks. Some of the RS personnel had experienced rock falls with cars and workers being trapped, and in one case, it took several weeks before the buried person was dug out dead.

Those among the RS personnel that had taken part in an underground fire within their district perceived that the rescue operation was not carried out in a safe manner. Complications occurred because the map of the mine was difficult to read for them, and further the radio communication failed. For example, the RS officer in charge lost contact with the crew underground. Afterwards the rescuers said to him: *"You looked kind of relieved when we got out of there"*. During this particular incident, the RS rescuers also went into smoke-filled tunnels, during which they solely relied on guidance from miners for assistance. During this operation they discovered that their self-contained breathing apparatuses were not exchangeable between them when they started to run out of compressed air. Obviously, there was a mismatch of equipment between the RS teams and the workers of the mine trained for guidance.

"The miner guiding me must have air because otherwise I would be stuck myself not knowing the way out of here, I would be totally lost" (RS personnel).

The EMS personnel described mining incidents with respect, being more complicated because a mine is an extraordinary environment which requires extra resources. For example, the EMS personnel considered the number of casualties as a particular risk, as an underground fire and rock-fall occurring in a closed environment may involve many victims and stress the EMS organization. However, they did not consider that caring for the injured in the mine would be more complicated than that otherwise occurring in their daily practice.

"…we are used to handling traffic incidents, we know how to act. In this way, it is not very different being underground" (EMS personnel).

Preparedness to handle incidents

Both the mine managers, supervisors and workers considered it important that everyone feels a joint responsibility for working in a safe way and being prepared in the event of an incident. The managers indicate that there are always factors which can be improved regarding preparedness. The mine has an emergency plan of action until the RS arrive, and the workers are trained to give first aid, cardiopulmonary resuscitation, and the use of defibrillators.

"You try your best to help the injured person. It is your friend, and you expect that others would take care of you if something happened. Then you will do your best and perform the ABC´s of first aid" (mining worker).

The mining personnel stated that they trusted their equipment used for escaping incidents on hand (e.g. respiratory protection), as well as having confidence in their knowledge about the layout of the mine and emergency escape routes. During incidents, refuge chambers can be used (with room for approximately six to

eight workers). A concern repeatedly discussed was the minimum limit of compressed air in these chambers. The chance that all workers in a shift would need to use the same refuge chamber was considered as low by the miners. Nevertheless, the RS personnel mentioned situations with overcrowded refuge chambers and considered the general capacity to be too low. The RS personnel also discussed their own need to use the refuge chambers. This was based on the experiences from one of the fire incidents within the district, during which incompatible breathing equipment led to a lack of air for the RS personnel because they could not refill their tubes from those in the refuge chambers. The mining managers had the opinion that the capacity of the refuge chamber should reflect the mine infrastructure, meaning that with enough escape routes, the need for refuge chamber capacity decreased. Another issue discussed among the workers about refuge chambers was their positioning and knowledge where to find them. This becomes of importance also because the chambers need to be relocated as tunnels are extended into the rock.

In general terms for underground rescue operations, both the RS and EMS personnel perceived themselves to have a limited capability. Apart from not feeling prepared due to few units, limiting details of technical sort were also exemplified by the shortness of self-contained breathing apparatuses or that their own vehicles are unsuitable for underground driving. The interaction between the mine and the RS and EMS described how the mine companies provide them with vehicles which can drive into the mine, but these vehicles often are not suitable for rescue operations. Also, in doing so necessary equipment needs to be shifted over which in part hampers the operability. Examples were referred by the EMS personnel, with varying success, how they tried to drive into the mine with their ambulance vehicles. During some of these occasions, driving into the mine worked well, but on other occasions, the ambulance vehicle was stuck and had to be towed out of the mine. A similar situation was described by the RS personnel, with the risk of their truck becoming an obstacle in a tunnel.

The up-sizing of an event was discussed among the EMS personnel. In the case of a major injury event, extra EMS units would become dispatched. Additionally, there is an ambulance helicopter available within the district with an on-board physician.

"*But if it would be a major event, then we do not have much to contribute with. We have a maximum of four ambulances running in our city, but most of them are usually occupied. Two or three ambulances might be available.* (EMS personnel 1) *Also there is about eighty kilometres to the next ambulance station that we can receive support from if they are available"* (EMS personnel 2).

The importance of collaboration

Both the RS and mining personnel described their collaboration as being good, and they perceived that they had achieved a consensus on how to conduct rescue operations. The mining personnel usually handle most situations by themselves, but in addition, the RS personnel helped with evacuation of those injured, or in the case of fatalities, evacuating bodies. However, this collaboration did not include the EMS personnel, who were not routinely invited for joint training sessions. The experience for mining incidents that have occurred in the district, the EMS personnel mostly have been waiting for the injured to be brought out of the mine. In some situations however, it has been necessary for the EMS to enter the mine, for acute treatment without too long of a delay. These situations emphasizes the importance of including the EMS personnel in collaboration and training to more effectively operate at rescuing. This opinion of the EMS personnel was acknowledged by the RS personnel, but also requires that the EMS personnel show up at the site of the incident. Nevertheless, to enter the mine is at the discretion of the EMS.

"I talked to the EMS personnel at site and asked; How is it for you, can you enter the mine and drive to a safe place, e.g. to the underground cantina, with the ambulance vehicle? If you start to care for the injured at the level of 800 meters you gain half an hour" (RS personnel).

Both the RS and EMS personnel described how they would refuse entering the mine in case of danger to themselves. However, they perceived their knowledge about risks as being limited, making risk judgement more difficult. They also felt unfamiliar with the underground environment to be entirely dependent on guidance by the miners' rescue team. The mine´s perspective, they recommended that both the RS and the EMS personnel should visit the mine to become more prepared for the extraordinary environment. Some of them had visited a mine, and it was a common opinion that doing so would increase their preparedness. The EMS personnel mentioned how they lacked knowledge about the rescue plan of the mines within their district.

"You want to help, but I would probably not be the first person to go down there […], because I feel very uncertain about it and above all, it is an unfamiliar milieu. It is not something I'm used to" (EMS personnel).

Underground rescue operations are obviously an unfamiliar and stressful situation. The RS personnel described that during a fire incident, some of their colleagues did in fact refuse to enter the mine.

"It is also a safety issue that those descending into a mine feel confidence in each other, to know that […] my colleague accepts to be there and does not run away" (RS personnel).

The mining managers stated that collaboration with the EMS leaves many details to improve. Nevertheless, they considered this collaboration as secondary in priority versus that of the RS. This was illustrated in that the mining companies have joint training sessions together with the RS, which mutually appeared to improve their perceived preparedness.

"...I think it [mining incidents, author's remark] *is quite played down at least among us, because we have been able to train more and have had the chance to look at the mine's rescue equipment, and above all, we have twice been through it"* (RS personnel).

At the same time, the mining managers described an uncertainty of how to communicate with the EMS in the event of an injury. This finds support in the wordings of the EMS personnel, that in a case when responding to a mining incident they found it difficult to figure out who was in charge of the rescue operation. The EMS considered it important to have a well-functioning communication and commanding system. They also expressed a hope to more often take part in the joint training sessions at the mine.

"The rescue service and the mining companies have a close collaboration, but they have forgotten about us. They [RS, author's remark] *have more training sessions with the mining companies. And many times we are not able to join them as we have many other duties"* (EMS personnel).

The EMS personnel stated that they could become more involved in the collaboration by teaching the mine workers medical training. The mine workers suggested that at minimum, one person per shift should have basic medical training.

DISCUSSION

This study suggests that the highest perceived preparedness to incidents was reported by the managers of the mining companies. The lowest preparedness was perceived among the EMS personnel. However, all three organizations acknowledged the need for more mutual training and improved collaboration.

In this setting of mining industry, the local RS and EMS are primary responders; and therefore, it becomes of great importance that all involved have a good knowledge of each other and know how to collaborate. It was reported by the EMS personnel a feeling of being left out of the established collaboration between the mining companies and the RS. Consequently, it is here strongly suggested that the EMS personnel become more involved in the collaboration and training, especially since they participate in the rescue operations side-by-side with the RS personnel and the mining company. Johnsson and Kaj (2016) highlighted the importance of practical collaboration and frequent joint training sessions among the groups participating in the rescue operation, although their study only addressed the RS and the mining companies, whereas the EMS personnel was not approached. Furthermore, a similar conclusion was suggested by Jacobsson, Backteman-Erlanson, Brulin and Hörnsten (2014) in which report the RS expressed a need for improved collaboration with the EMS, and more training in emergency medical care. The requirement of collaboration between the organizations is here strongly emphasized, but in practice at the site of an incident, the focus tends to be on intra-organizational development of skills rather than collaboration. These circumstances have led to doubts about the benefits of collaboration among some researchers (Andersson, Carlstrom, Ahgren and Berlin, 2014). From the present analysis, it is obvious that the three organizations are deeply dependent on each other. This is in view of the complexity of mining incidents which require a well-functioning collaboration tactic in a remote area of north Sweden.

In the settings here analysed, the EMS personnel described limited local resources and that reinforcement may be hours away. Compared to EMS the RS units were more numerous. Dispatching additional RS and EMS units may often be necessary to provide effective care and treatment for the victims at major incidents. This situation is shared with many rural areas of Sweden, with only a few EMS teams available, and further, the response and transfer time of these also cause delay (Langhelle et al. 2004).

As described by Bealko et al. (2011) major mining incidents are rare, but when they do happen, they may have serious consequences of mass-casualty. Both the RS and EMS personnel in present study expressed and shared a feeling of high responsibility to keep up their competence to handle incidents in an underground mine. In view of these ambitions, it was apparent that the EMS personnel in particular felt ill-prepared to handle such incidents. They had to rely on standard equipment and their experience from surface rescue operations. Also their

vehicles are not suitable for driving in mine tunnels, and they lacked equipment and were untrained for communication underground. Another detail revealed in the present study was how the EMS personnel lacked adequate knowledge about the mining environment and organizational structure. For example, they were unsure whom to contact when arriving at the mine in the event of an incident. Another shortcoming described by the EMS personnel was uncertainties about established rescue plans. This detail was far better developed for the RS-to-mine interface. It is recommended by the mining industry (Swedish Association of Mines, Metal and Mineral Producers 2009), that a copy of the mines' emergency preparedness plan is handed over to the local RS. This recommendation should be extended to also include the EMS. A strategic recommendation would also be that the EMS medical expertise becomes involved in teaching and training of the mine workers and supervisors. This should include both basic medical care and knowledge about organizational planning at major incidents.

The present study found that not all of the RS or EMS personnel were even willing to enter an underground mine. This was described in term of various reasons, such as claustrophobia or because of safety concerns and family reasons. The lack of preparedness of EMS personnel is also illustrated by another study (Aléx et al., accepted), reporting that approximately half of the EMS personnel felt unprepared for mining rescue operations. This is also in line with the literature review, finding few studies about the rescue operation of mining incidents (Engström et al., 2017). Conti, Chasko and Cool (1999) mentioned that the RS personnel, when practicing in a mine discovered that 'this was not for them'. When training in a smoke-filled mine for the first time, they became disoriented to the extent that they gave up and had to be rescued themselves. These risks must be considered beforehand, and the issue being raised under circumstances that allow for open and non-judgmental dialogue. An opposing issue, not being a primary aim of this study, regarded the 'safety culture' within the different organizations. A rescue team that presumes they have a higher performance than their true skills and training level may add hazards to a rescue operation. In fact, this was identified in a report summarized by the RS after a recent fire in one of the mines within the district here analysed (Marklund and Haarala, 2014).

On the whole, much can be done to improve the collaboration between the three organizations, (*e.g.* sharing information amongst the organizations, focusing on collaboration, shared learning and common training sessions).

CONCLUSION

This study identifies a need for closer collaboration and more joint training sessions among the mine personnel, RS personnel, and EMS personnel, to increase the confidence of how to safely conduct underground rescue operations in a mine. The EMS was largely excluded from existing collaboration and consequently, they described the highest level of insecurity for underground operations. Better collaboration is not only beneficial for those being rescued, but also for the rescuers' own safety. Moreover, RS and EMS teams may become better prepared for similar extraordinary situations, such as for incidents occurring in railway and road tunnels.

ACKNOWLEDGMENTS

This research was supported by funding from the Swedish National Board of Health and Welfare. The authors also thank the participants and mining companies, rescue service and emergency medical service for sharing their experiences with us and donating their time for interviews.

REFERENCES

Aléx, J., Joanson, C., Tageson, H., & Saveman, B.-I. (Accepted). Preparedness of the ambulance personnel for major incidents in underground mines. Accepted.

Andersson, A., Carlstrom, E. D., Ahgren, B., & Berlin, J. M. (2014). Managing boundaries at the accident scene – a qualitative study of collaboration exercises. *International Journal of Emergency Services, 3*(1), 77–94. doi: http://dx.doi.org/10.1108/IJES-02-2013-0003.

Bealko, S. B., Alexander, D. W., Chasko, L. L., & Grayson, R. L. (2011). Mine rescue training facility inventory - compendium of ideas to improve US coal mine rescue training. The National Institute for Occupational Safety and Health (NIOSH). Trans Soc Min Metal Explor TP-09-035, 328, 517–524.

Björnstig, U. (2004). Pre-hospital emergency care in Sweden: with Special Emphasis on Care of Traffic Victims. *IATSS Research, 28*(2), 24-31.

Conti, R. S., Chasko, L. L., & Cool, J. D. (1999). An overview of technology and training simulations for mine rescue teams. *Proceedings of the 28th International Conference of Safety in Mines Research Institutes, Sinaia, Romania, Vol II*, 521–538.

Elmqvist, C., Brunt, D., Fridlund, B., & Ekebergh, M. (2010). Being first on the scene of an accident–experiences of 'doing'prehospital emergency care. *Scandinavian Journal of Caring Sciences*, *24*(2), 266-273. Doi: 10.1111/j.1471-6712.2009.00716.x

Engström, G., Angrén, J., Björnstig, U., & Saveman, B.-I. (2017). Mass-casualty incidents in the underground mining industry: The Haddon's Matrix applied on an integrative literature review. *Disaster Medicine and Public Health Preparedness*. In press.

Frank, I. C. (2002). Miracle of the miners: the Quecreek rescue from an ED perspective. *Journal of Emergency Nursing*, *28*(6), 544–548. doi:10.1067/men.2002.129927

Geological Survey of Sweden (2016). Från dagbrott till underjordsgruva [From open pit to underground mine]. Sweden. Retrieved from: http://www.sgu.se/om-sgu/nyheter/2016/mars/fran-dagbrott-till-underjordsgruva/

Graneheim, U. H., & Lundman, B. (2004). Qualitative content analysis in nursing research: Concepts, procedures and measures to achieve trustworthiness. *Nurse Education Today*, *24*(2), 105–112. doi:10.1016/j.nedt.2003.10.001

Groves, W. A., Kecojevic, V. J., & Komljenovic, D. (2007). Analysis of fatalities and injuries involving mining equipment. *Journal of Safety Research*, *38*(4), 461–470. doi:10.1016/j.jsr.2007.03.011

Hansen, R., & Ingason, H. (2013). Heat release rate measurements of burning mining vehicles in an underground mine. *Fire Safety Journal*, *61*, 12–25. doi:10.1016/j.firesaf.2013.08.009

ICT Services and System Development and Division of Epidemiology and Global Health (2013). OpenCode 4.0. Umeå University, Sweden. Retrieved from http://www.phmed.umu.se/english/units/epidemiology/research/open-code/

Jacobsson, A., Backteman-Erlanson, S., Brulin, C., & Hörnsten, Å. (2015). Experiences of critical incidents among female and male firefighters. *International Emergency Nursing*, *23*(2), 100–104. doi: http://dx.doi.org/10.1016/j.ienj.2014.06.002

Johnsson, L., & Kaj, S. (2016). Räddningsinsatser och brandskydd i underjordsgruva – Rökspridningsberäkningar i Kiruna järnmalmsgruva och arbetsmetoder vid räddningsinsatser i underjordsgruvor [Rescue operations and fire safety in underground mines – Calculations for smoke spread in Kiruna iron ore mine and working methods at rescue operations in underground mines]. Sweden: Luleå University of Technology.

Järvholm, B. (2013). Safety and health in mining in Sweden. In Elgstrand, K. & E. Vingård (Eds.), *Occupational safety and health in mining - Anthology on the situation in 16 mining countries* (pp. 77–86). Sweden: University of Gothenburg.

Langhelle, A., Lossius, H. M., Silfvast, T., Már Björnsson, H., K. Lippert, F., Ersson, A., & Søreide, E. (2004). International EMS systems: the Nordic countries. *Resuscitation*. *61*(1), 9–21. doi: 10.1016/j.resuscitation.2003.12.008

Lehnen, F., Martens, P. N., & Rattmann, L. (2013a, June-July). Challenges in deep mine rescue within the European I^2mine project. In 6th International Conference on Sustainable Development in the Minerals Industry, Milos Island, Greece, RWTH Aachen University, Institute of Mining Engineering I, Germany, 1–6.

Lehnen, F., Martens, P. N. & Rattmann, L. (2013b, May). Evaluation of European mine rescue and its need for internationalization. In Fourth International Symposium Mineral Resources and Mine Development, Aachen International Mining Symposia, RWTH Aachen University, Institute of Mining Engineering I, Germany, 175–186.

Luleå University of Technology. (2017). *Fire Protection Engineer*. https://www.ltu.se/edu/program/TYBRG/TYBRG-Brandingenjor-1.76954?termin=H17&l=en

Luossavaara-Kiirunavaara AB Communications (2011). En tidning för medarbetare i LKAB, Veckobladet Nr 2 [A newspaper for the co-workers at LKAB, the Weekly paper No 2]. Luleå, Sweden. Retrieved from https://www.lkab.com/Global/Documents/Tidningar/Veckobladet/Veckobladet%202011/Veckobladet_2011_Nr2.pdf

Maier, A. (2011). Lessons learned from the Lassing mining disaster?/Lehren aus dem Grubenunglück Lassing?. Geomechanics and Tunnelling. *4*(5), 435–444.

Marklund, J., & Haarala, D. (2014). Fördjupad olycksundersökning gruvbrand 2013-08-25 [Incident investigation of fire in mine 2013-08-25]. Skellefteå Kommun, Räddningstjänsten, Sweden.

The Mining and Mineral Industry's Health and Safety Committee (2016). Occupational injuries and sick-leave in the Swedish mining and mineral industry 2015. Stockholm, Sweden. Swedish Association of Mines, Metal and Mineral Producers.

Northern Sparsely Populated Areas (2012). Northern Sparsely Populated Areas on regional aid guidelines. Retrieved from http://www.nspa-network.eu/media/9203/nspa%20on%20regional%20aid%20guidelines%20vår%202012.pdf

Sanmiquel, L., Freijo, M., Edo, J., & Rossell, J. M. (2010). Analysis of work related accidents in the Spanish mining sector from 1982-2006. *Journal of Safety Research*, *41*(1), 1–7. doi:10.1016/j.jsr.2009.09.008

Shooks, M., Johansson, B., Andersson, E., & Lööw, J. (2014). Safety and health in European mining: A report on safety and health, statistics, tools and laws, produced for the I^2Mine (Innovative Technologies and Concepts for the Intelligent Deep Mine of the Future) project. Sweden: Division of Human Work Science, Luleå University of Technology.

Suserud, B.-O. (2005). A new profession in the pre-hospital care field – the ambulance nurse. *British Association of Critical Care Nurses, Nursing in Critical Care*. 10(6).

Swedish Association of Mines, Metal and Mineral Producers. (2009). Fire safety in mines and underground constructions. Stockholm, Sweden. Retrieved from http://www.svemin.se/?file_download&file=697

Swedish Civil Contingencies Agency. (2008). Statistics and analysis – The Swedish rescue services in figures. Karlstad.

Swedish Civil Contingencies Agency. (2014). Myndigheten för samhällsskydd och beredskaps allmänna råd om skyldigheter vid farlig verksamhet. [Swedish Civil Contingencies Agency's general advice of obligations during dangerous operations]. MSBFS 2014:2.

Swedish Civil Contingencies Agency. (2016a). Akut omhändertagande – för räddningstjänstpersonal. [First aid – for rescue service personnel] Karlstad

Swedish Civil Contingencies Agency. (2016b). Den framtida utbildningsverksamheten – Redovisning av uppdrag den 17 februari 2016. [The future education system – Review from the commission 17th February 2016] Karlstad

Swedish Rescue Services Agency. (2008). Räddningstjänst i samverkan – Ansvar och uppgifter för räddningstjänstansvariga myndigheter och samverkande organ. [Rescue service in collaboration – Responsibility and tasks for the national authorities responsible for the rescue service and collaborating authorities]. Karlstad.

Tapia, C. (2002). Choreographed care at Quecreek Mine rescue. JEMS: *a Journal of Emergency Medical Services*, *27*(10), 130.

World Medical Association (n.d.). World Medical Association declaration of Helsinki – Ethical principles for medical research involving human subjects. Retrieved from http://www.wma.net/en/30publications/10policies/b3/ on February 28, 2017