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Imminent danger::

Characterizing uncertainty in critically hazardous mining situations

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Abstract

■ Mineworkers are routinely tasked with making critically important decisions about whether or not a hazard presents an imminent danger. Researchers from the U.S. National Institute for Occupational Safety and Health collected formative data to investigate mine safety professional perspectives on workplace examinations, which revealed a potential gap in how mineworkers are assessing risk. During interviews, participants revealed not having a systematic methodology for mineworkers to use to determine if a hazard is considered imminent danger. In this paper, we identify and describe three distinct categories of imminent danger complexity and discuss potential steps that could lead to improved identification of imminent danger situations. Finally, we identify potential practices to incorporate into risk management efforts, including feedback, communication and specialized training, to increase awareness of imminent danger situations.

Introduction

In recent years, the metal and nonmetal mining sector, as categorized by the U.S. Mine Safety and Health Administration (MSHA), experienced an increase in the number of fatalities occurring at mine sites. From 2013 to 2015, 69 mineworkers were fatally injured, twice the number of fatalities in each of the previous two years (MSHA, 2015a). As a way to address this increase, MSHA issued its P15-IV-01 program policy letter, suggesting that “miners would benefit from rigorous workplace examinations conducted by experienced and trained examiners” (MSHA, 2015b). The goal of these examinations is to find hazards in the field and mitigate them before they cause injury or death to mineworkers. While it is important to identify all hazards in the workplace, it is critically important to identify those hazards that are considered imminent danger because they require an immediate response to avoid a severe or even fatal injury.

In the Federal Mine Safety and Health Act of 1977 (MSHA, 1977), imminent danger is defined as “the existence of any condition or practice in a coal or other mine which could reasonably be expected to cause death or serious physical harm before such condition or practice can be abated.” Later guidance provided in the MSHA Program Policy Manual (MSHA, 1996) on determining what hazards are considered imminent danger is vague. According to the manual, “the imminence of danger is a judgment to be made in light of all relevant circumstances” (MSHA, 1996). Given that imminent danger situations are highly likely to lead to severe or even fatal injury, it is critical to understand how mine operators are preparing their workforce to identify these hazardous situations. U.S. National Institute for

Occupational Safety and Health (NIOSH) researchers are working to identify best practices to help mining companies prepare mineworkers to identify imminent danger situations and, therefore, increase the efficacy of workplace examinations that lead to mineworker safety.

Section 107(a) Imminent Danger Orders.

MSHA maintains records of all Section 107(a) imminent danger orders that are issued. From 2010 through 2016, 1,821 such orders were issued at metal and nonmetal mine sites (MSHA, 2017). During the 2013 to 2015 timeframe when the metal and nonmetal mining sector saw an increase in fatal injuries, 811 of these orders were issued. This indicates there are a significant number of imminent danger situations occurring at metal and nonmetal mine sites.

The purpose of a Section 107(a) imminent danger order is to immediately remove mineworkers from exposure to serious hazards and to prevent them from entering or re-entering the hazardous areas. MSHA safety inspectors have the authority to issue oral or written 107(a) imminent danger orders to mine sites where such conditions exist. If an oral order is issued, a follow-up written order must also then be issued that clearly identifies the imminent danger situation. According to the Federal Mine Safety & Health Act of 1977, Section 107(c), all written orders are required to include the person to whom the order was issued, the time and date when the order was issued, and a brief descriptive narrative of the conditions or practices occurring that constitute imminent danger as well as a description of the area where mineworkers were withdrawn and were prohibited from entering or re-entering (MSHA, 1977).

The following are two examples of narratives included with 107(a) imminent danger orders:

1. “A delivery truck driver was observed, on top of a shipping container, removing a tarp and was not wearing fall protection. The driver was 10 ft. 7 in. above ground level and was seen walking at/near the edge of the shipping container.”
2. “Observed a miner walking across the roof of the #2 electrical trailer. The miner was not wearing fall protection. No hand rails had been installed atop this trailer. Energized electrical wires were also observed laying across the roof of the trailer.”

It is critically important that mine health and safety leadership ensures that mineworkers can identify imminent danger situations, as they are highly risky and have a high potential for severe or even fatal injury. However, as the number of 107(a) records indicate, mineworkers at metal and nonmetal mine sites are not always successfully identifying hazards in these situations. Couple this with the increase in the number of fatal accidents that occurred in this sector within the same timeframe, 2013 to 2015, and it is critical that mineworkers gain a better understanding of imminent danger.

A literature search reveals there is little to no research focused on mineworkers’ knowledge of imminent danger. As there is limited information available, a formative research approach was taken with the goal of understanding how mine operators are preparing their workforce to identify imminent danger situations. To achieve this goal, NIOSH researchers interviewed

mine safety professionals who work closely with mineworkers and are primarily responsible for identifying areas for health and safety improvement from an organizational and systems perspective.

Previous research has shown that analyzing MSHA citations can offer insight into practices that companies and their health and safety leadership can use to improve mineworker health and safety (Yorio, Willmer and Haight, 2014). In their study, Yorio, Willmer and Haight analyzed MSHA citations through a health and safety management system lens to determine the impact on subsequent-year mine-level injuries and illnesses. An interesting finding from the study is that the type of citation, and not necessarily the sheer number of citations, had the greatest impact on subsequent-year injuries and illness. Yorio, Willmer and Haight suggest this may be because mines have time to plan to make specific changes and to check on those changes to determine the effect on injuries and illnesses.

There is a gap in the research literature related to Section 107(a) imminent danger orders. Specifically, these MSHA citations have not been analyzed. The present study represents an initial effort to gain an understanding of imminent danger situations. To do this, NIOSH researchers analyzed the citation narratives to confirm themes shared by safety professionals in their interviews, about imminent danger situations occurring at their mine sites.

Methods

This study uses a qualitative research approach because the goal is to arrive at an understanding of a particular phenomenon from the perspective of the people who are experiencing it (Denzin and Lincoln, 1994). NIOSH researchers first collected data using semi-structured interviews. The data from these guided interviews were analyzed to identify categories and themes related to imminent danger. In order to achieve data triangulation describing imminent danger categories, an analysis of the 107(a) imminent danger orders that were issued by MSHA field inspectors was also conducted. The data sets were then compared for consistency of the imminent danger themes.

Participants.

The interviews took place from December 2016 through May 2017. During that time period, NIOSH researchers interviewed nine health and safety professionals: eight male and one female. Because we were interested in gaining the perspectives of safety and health professionals familiar with metal and nonmetal mine regulations related to workplace examinations, participants were primarily recruited from surface stone, sand and gravel operations. The participants' mining industry experience ranged from four to 45 years, with two participants reporting five years or less, two reporting 15 years, and five reporting more than 20 years of industry experience.

Interview procedure and interview guide.

Seven interviews took place over the telephone, one took place at the NIOSH Pittsburgh Research Facility, and one took place at a surface limestone mine. All of the nine interviews were conducted one-on-one during each participant's regularly scheduled workday and

lasted approximately one hour. There were two NIOSH researchers present during all interviews, one serving as the interview lead and the other acting as note taker.

The interviews were semi-structured with researchers using a NIOSH Institutional Review Board-approved interview guide. The interviews began with open-ended questions designed to both develop rapport with the participants and to learn more about the participants' histories working in the mining industry, and the roles and responsibilities of their current positions.

Initially, to encourage the participants to think about workplace examinations, they were asked to indicate whether they had heard about MSHA's recent policy updates on workplace examination requirements. If they answered yes, that they had heard about these changes, participants were asked to discuss how they heard about these updates and were specifically asked to talk about any interactions where an MSHA inspector explained the policy update at their mine site. Following these introductory questions, the NIOSH interviewer provided the participant with the following language from the regulation pertaining to actions that should be taken when potentially hazardous conditions are encountered: "…conditions that may present an imminent danger which are noted by the person conducting the examination shall be brought to the immediate attention of the operator who shall withdraw all persons from the area affected (except persons referred to in section 104 (c) of the Federal Mine Safety Act of 1977) until the danger is abated" (MSHA, 2011).

Participants were then asked to identify examples of situations that they consider to present imminent danger and explain what makes that situation imminent danger relative to situations that they do not consider imminent danger. Next, they were asked to describe the process they have in place for mineworkers to use when evaluating a situation and deciding whether it is imminent danger or not. Finally, participants were asked to discuss the procedure mineworkers follow to report an imminent danger situation: for example, what do you do first, who do you call first, how do you decide how to mitigate the situation?

Analysis of interview data.

The interview data were analyzed using a grounded theory approach in which themes emerged from the data instead of the data being coded into pre-existing categories (Glaser and Strauss, 1967). Coding was completed independently by the two NIOSH researchers who had conducted the interviews. The results of the coding efforts were compared, and any discrepancies were discussed until consensus was reached.

The first stage of coding, open coding, allowed for as many themes as possible or necessary to be identified (Lindlof and Taylor, 2011). During subsequent axial coding, constant comparison was used to compare themes and create categories of similar examples. The process of combining or separating categories was then used to ensure that each category was distinct and final resulting themes and subthemes were given labels. Trustworthiness (Creswell, 1997) of the analysis and categorization of the data was established by providing thick, rich descriptions, including participants' actual words so that readers could verify the researchers' interpretation of the data.

Results

Analysis of the interview data reveals that examples of imminent danger situations varied in level of complexity for the type of task the mineworker was performing and the number of corrective safety actions the mineworker had to take in order to perform the task safely. Within this theme, three categories of situations that present imminent danger emerged.

Lack of following procedures.

During the interviews, safety professionals described imminent danger situations that had a clear safety procedure a mineworker should take to safely perform the work task: for instance, following the lock out/tag out (LOTO) safety procedure while performing a maintenance task on the beltline. The safety procedures in these imminent danger situations are typical procedural controls that can be identified and implemented using procedural knowledge and skill (McLeod, 2015). Safety professional examples include tasks that mineworkers routinely perform, require the mineworker to take a single basic, corrective action in order to be done safely, and are often covered during Part 46 Annual Refresher training. Examples of corrective actions include using personal protective equipment (PPE) or a safety device, such as a wheel chock to block against movement or a tag line to keep a mineworker out from underneath a suspended load. According to safety professionals, these imminent danger situations are, in their own words, “easy” or “simple” things to identify: for example, not wearing fall protection while working at height, working under a suspended load, and working on equipment that was not properly locked and tagged out. One safety professional provided the example of not checking brakes during the preshift inspection: “Yeah, well, you can go back to the simple things that’s really, really noticeable such as — okay, I get in my truck and I’m doing my preshift. I check the brakes. The brakes feel spongey. That’s immediate danger. That’s easy.”

Another safety professional identified blocking against motion: “Somebody is working under a loader bucket or not having it blocked. There’s a possibility of that bucket falling. If they don’t have the hydraulics or something blocked, and that’s what they’re working on. That would be imminent danger.”

Ignoring the complexity.

The mining environment is a dynamic environment where the mineworker is responsible for performing diverse work activities with a variety of tools and equipment (Scharf et al., 2001). Because of the ever-changing nature of the work environment, mineworkers face complex situations that, relative to procedural situations, require additional cognitive processing because he or she has to identify and implement multiple safety procedures. To successfully identify and implement multiple safety procedures, a mineworker might, for example, have to make multiple judgments and decisions under time pressure while also dividing attention across job tasks (McLeod, 2015). Within the examples given by safety professionals, the defining characteristic of a complex situation was the necessity for the mineworker to use more than one safety procedure or make more than one corrective action to safely perform the work task. To illustrate imminent danger situations that fall within this category, one safety professional discussed an interaction he had with two mineworkers who

were performing maintenance on the beltline: “Two workers were changing rollers on the beltline. They were using a bucket lift and were tied off in the bucket. One worker had to climb onto the catwalk to finish his work. When he did this, he unhooked his fall protection and then rehooked it when he got back into the bucket lift.”

The safety professional first pointed out that this is not the safe way to perform this activity. The worker should have remained tied to the bucket lift while moving from the bucket lift to the belt and back again. Moreover, he reported that when he asked whether they had de-energized the belt and locked it out, the mineworkers answered no, they had not done that.

Limited specialized knowledge.

Safety professionals also indicated that to be able to recognize imminent danger in certain locations or while performing certain types of tasks, it would benefit the mineworker to have domain-specific knowledge, or what we refer to as specialized knowledge. This type of knowledge is specific to an environment or class of problems and a person with specialized knowledge is able to easily recognize patterns and changes in patterns (Chase and Simon, 1973). The theme of specialized knowledge emerged while safety professionals were talking about potential ground control concerns, such as material sloughing from the high wall; issues with stockpiles, such as how freezing and thawing affect pile stability; and changes to structural stability that can result from corrosion. Representative of this category, safety professionals indicated that to be able to recognize imminent danger situations — for example, at the highwall — a mineworker must have specialized knowledge of the geology of the rock they are mining:“…because I’ve gone and evaluated highwall — take, for instance, limestone… When you look at a limestone formation, it’s cubical. You’ve got horizontal and vertical dikes. It’s all kind of like squares laying — like dry staking a wall. Okay, I can look at that wall, and it’s got cracks in it, and I say, okay, that wall is okay. Mainly because they’re all bonding together. The friction between the rocks is holding it up there. But now I look over in this corner of that limestone, and I see wet. That immediately tells me I better be cautious of this area right here because water is a lubricant.”

Analysis of Section 107(a) imminent danger orders

As a first step toward validating the imminent danger categories that were identified during the thematic analysis and to ensure that these categories are reflective of the types of imminent danger situations occurring at metal and nonmetal mine sites, researchers sought data triangulation by analyzing a secondary data source (Denzin, 1978). This data source was 107(a) imminent danger orders written by MSHA field inspectors. The years 2013 through 2015 were included in this analysis because this range corresponds to the time period when the metal and nonmetal mining sector experienced an increase in fatal injuries. There were 811 107(a) imminent danger orders issued at metal and nonmetal mine sites during this time period. For the purposes of the study, we discarded 13 of the orders because they were written in Spanish and one additional order that did not include sufficient information for the researchers to make a decision. The remaining 797 107(a) imminent danger orders were included in the dataset.

The same two researchers who conducted the interviews and completed the thematic analysis performed the cross-check. To do this, the researchers first read and coded a subset of the 107a orders — 50 of the 797 orders — using the imminent danger category definitions of (1) lack of following procedures, (2) ignoring the complexity and (3) limited specialized knowledge. After completing the subset, the researchers compared coding to ensure that category definitions were being applied to the narrative in the same way. The remaining 747 107(a) orders were then coded. There was a difference in codes applied to 50, or 6.7 percent, of the 107(a) orders. The two researchers discussed these differences and were able to reach a consensus for all of the differences.

A large majority of the orders — 516 of the 797, or 65 percent — were categorized as procedural imminent danger situations. In these procedural situations, mineworkers failed to use one necessary safety procedure while performing a task. Table 1 includes an example of a procedural imminent danger situation in which a truck driver was working at height without using fall protection. In this case, the necessary safety procedure was the missing PPE.

Of the remaining 107(a) orders, 150, or 19 percent, were categorized as requiring specialized knowledge and 131, or 16 percent, were categorized as complex situations. As Table 1 shows, the front-end loader operator needed specialized knowledge of ground conditions at the highwall to operate safely. The plant operator who was performing maintenance on a cone crusher was working in a complex situation because he needed to use fall protection, and deenergize and lock out the machine.

Overall, the results reveal strong agreement between the interview data and the Section 107(a) imminent danger orders. Specifically, the three imminent danger categories that emerged during interviews with mine safety professionals were subsequently identified during the 107(a) narrative analysis. The prevalence of the three imminent danger categories in both data sources suggests the mining industry needs to improve on identifying and reporting on these imminent danger situations.

Discussion

One goal of this research was to better understand how mine safety professionals perceive imminent danger. This is important because one of their responsibilities is to ensure that mineworkers can identify imminent danger as they are working in high-risk situations with a high potential for severe or even fatal injury. The results of the interview analysis indicate that there is variability in the processes and procedures used to identify imminent danger situations.

In terms of responding to imminent danger situations, all mine safety professionals described a typical process of first removing mineworkers from the area to limit exposure to the risk, then calling the supervisor to report the situation. All agreed that if mineworkers are able to mitigate the risk on their own, they should do it. If that is not possible, the area should be barricaded until the risk can be mitigated.

There is less consistency, however, in responses related to the process mineworkers are encouraged to use to evaluate a situation in order to determine whether it is imminent danger or not. In fact, five of the nine safety professionals reported not having any process in place for mineworkers to use to make this evaluation. Two safety professionals rely on training to teach mineworkers what situations are imminent danger, with one saying,"…Other than the in-depth training, that's the only way I could see how to teach them what it is and to show them examples of what would be dangerous and what's not…" The remaining two safety professionals indicated encouraging the use of assessment, either a group assessment where the quarry manager, operating officer and safety staff analyze a situation together or a risk assessment where "…anything that would end up in the red category or a high level of risk — we've taken a stance that if it's red, it requires action right away…"

With the knowledge that there is variability in the procedures that mine safety professionals encourage mineworkers to use to recognize imminent danger situations, it is critically important to identify the consistencies within situations that could produce an imminent danger situation. The results of this study reveal that imminent danger situations vary in the level of complexity in a situation which could have important implications for preparing mineworkers to accurately identify and respond to such situations.

For example, in procedural imminent danger situations, a mineworker must take one corrective action or use one procedural control to work safely. Examples of these actions and controls include LOTO, using wheel chocks, or wearing fall protection. The majority of these actions and controls are likely prescribed in the site-specific safety rules that are a part of an organization's risk management system and are likely covered in MSHA's Rules to Live By as well as during Part 46 New Miner and Annual Refresher Training. During interviews, it was clear that mine safety professionals considered these situations "easy" to identify. The proportion of procedural situations identified during the 107(a) orders analysis, 65 percent, suggests the opposite. From the data, it is unclear why mineworkers are not using procedural controls. One possible reason is that mineworkers report becoming complacent while performing routine tasks, such as maintenance and repair (Eiter, Kosmoski and Connor, 2016). To improve knowledge and awareness of procedural controls, one manager in Willmer and Haas's (2016) study suggested addressing instances with work crews as he observed them, such as communicating the protective value of safety vests when he observed a mineworker not wearing one.

Secondly, mine safety professionals discussed imminent danger situations that were more complex for the mineworker. In these complex situations, mineworkers have to use more than one procedural control or make more than one corrective action to work safely: for example, during a maintenance activity a mineworker has to both wear fall protection and de-energize and LOTO a crusher. Because of the dynamic nature of the mining environment, the variety of tasks being performed, and the presence of heavy equipment and machinery, mineworkers are continuously assessing their workplace for risks and making decisions about how to manage those risks. Some risks in complex situations are likely to be considered higher priority or to have a significantly greater consequence to the mineworker than other risks (McLeod, 2015). As a result, the mineworker may not be aware of some hazards and, therefore, not use the necessary procedural controls. Willmer and Haas (2016)

suggested formalizing risk management practices as a way to improve situational awareness and communication so that mineworkers increase their level of awareness of hazards.

Finally, during interviews, mine safety professionals identified a third type of imminent danger situation that requires specialized knowledge for the mineworker to be able to recognize. This type of knowledge is specific, for example, to an environment, class of problems, or occupation. Research shows that a person with specialized, or expert, knowledge is better able to recognize patterns and changes in patterns than nonexperts (Chase and Simon, 1973). According the mine safety professionals, this expert knowledge is critical for recognizing hazards while performing tasks in specific locations: for example, recognizing changes to stability of the highwall. Imminent danger situations arise in these locations because not all mineworkers have the level of specific knowledge necessary to identify these risks and are, therefore, unable to recognize how certain factors, such as the weather, can affect highwall stability. Mine safety professionals also suggest that a lack of specific knowledge may compromise situation awareness as well. To demonstrate this point, one mine safety professional used corrosion control as an example: “It’s too hard to determine — okay, I’ve got rust on some bolts. That’s not imminent danger. But if somebody put the wrong grade of bolt in there. Given over time with rusting and wearing from the materials going in there, those bolts will either pop out or the whole panel is going to turn loose. Those are the things that’s not very easily seen as imminent danger.” One current solution to address the need for specific knowledge is to offer specialized training to help miners identify commonly encountered, difficult-to-see or unknown hazards (Bahn, 2013; Barrett and Kowalski, 1995).

Conclusion

Given a rise in fatalities and the high number of 107(a) imminent danger orders issued at metal and nonmetal mine sites, the goal of this study was to address a gap in the knowledge related to imminent danger. While our findings indicate that mine safety professionals tend to characterize imminent danger into three distinct categories related to situation complexity, this was an exploratory study that was limited to nine interviews with mine safety professionals working for surface stone, sand and gravel mining companies. The results, therefore, are not necessarily generalizable to perceptions of imminent danger situations occurring in other mining sectors. As a means to address this limitation, we analyzed the narratives for 107(a) orders issued to all metal and nonmetal mine sites. While we were able to validate the categories that emerged, a second limitation of the study is the broad nature of the definitions of the imminent danger categories. One reason the category definitions are so broad could be because they were established through the analysis of the interview data from mine safety professionals who were asked to give hypothetical examples of imminent danger.

Further analysis of the 107(a) orders of actual imminent danger situations could result in further dissection of categories and more specific recommendations for how to address each of the categories. NIOSH researchers will be better able to determine effective strategies for improving imminent danger identification with more fully defined imminent danger categories. Therefore, future research is necessary to further investigate these categories to

better characterize who is involved in imminent danger situations, what safety procedures are necessary that are not being followed, and where these imminent danger situations are occurring in the mine site. This research may help determine what organizational practices, tasks, and equipment redesigns are necessary to effectively manage imminent danger in the work environment. ■

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Disclaimer

The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of NIOSH. Mention of company names or products does not constitute endorsement by the Centers for Disease Control and Prevention.

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■ Table 1

Examples of Section 107(a) imminent danger orders, by NIOSH category, and corrective actions required for safe work.

Category	Example of imminent danger order	Corrective action required
Lack of following procedures.	The truck driver was issued an imminent danger order when he was observed on the top of his tank truck without the use of fall protection or hand rails. The area where the driver was standing was approximately 11 ft above ground level.	Fall protection required.
Ignoring the complexity.	The plant operator was not wearing fall protection when he was attempting to dislodge stone that was being fed into the Allis-Chalmers 1260 cone crusher located at the secondary plant. The plant operator was observed on the platform bending over the cone crusher with the railings removed while the cone crusher was still in operation.	Fall protection required. De-energize crusher. Lock out/tag out (LOTO).
Limited specialized knowledge.	The 988H CAT front-end loader was loading out the muck pile in the quarry with hazardous ground conditions that had not been taken down or supported on the top of the west high wall. There was loose unconsolidated material and a boulder that was about 5 by 4 by 4 ft in size.	Knowledge of the geology of the highwall.