HHS Public Access

Author manuscript

Min Eng. Author manuscript; available in PMC 2016 December 30.

Published in final edited form as:

Min Eng. 2016 November ; 68(11): 50–54. doi:10.19150/me.6832.

Defining hazard from the mine worker's perspective

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Abstract

In the recent past, the mining industry has witnessed a substantial increase in the numbers of fatalities occurring at metal and nonmetal mine sites, but it is unclear why this is occurring. One possible explanation is that workers struggle with identifying worksite hazards and accurately assessing the associated risk. The purpose of this research was to explore this possibility within the mining industry and to more fully understand stone, sand and gravel (SSG) mine workers' thoughts, understandings and perceptions of worksite hazards and risks. Eight mine workers were interviewed and asked to identify common hazards they come across when doing their jobs and to then discuss their perceptions of the risks associated with those identified hazards. The results of this exploratory study indicate the importance of workers' job-related experience as it applies to hazard identification and risk perception, particularly their knowledge of or familiarity with a task, whether or not they had personal control over that task, and the frequency with which they perform that task.

Introduction

According to the U.S. Mine Safety and Health Administration (MSHA, 2015a), 37 mine workers were fatally injured in accidents at metal and non-metal mine sites between October 2013 and January 2015, following a record low of 16 in 2012 and in 2011. In 2014 alone, 29 mine workers were fatally injured at a metal or nonmetal mine site, and 52 percent of these fatalities occurred at a surface stone, sand or gravel (SSG) mine. In January 2015, Joseph A. Main, Assistant Secretary of Labor for Mine Safety and Health wrote to stakeholders in the metal and nonmetal mining community and identified several areas where improvement was necessary to promote the health and safety of mine workers. One area identified was an increased focus on “daily and effective workplace exams to find and fix hazards” (MSHA, 2015b).

Hazard detection is challenging in the mining industry, despite the existence of regulation. Mining is a major undertaking involving the use of complex heavy machinery, equipment and processes as well as numerous and diverse worker activities that take place in a dynamic, challenging environment (Scharf et al., 2001). In other industries that are similarly dynamic and unpredictable, such as the construction industry, a large proportion of hazards go undetected (Carter and Smith, 2006). It is critical that miners are able to both recognize worksite hazards and accurately assess the risk associated with the hazards, because their health and safety depend on their deciding whether and how to remove hazards and mitigate risks.

This paper distinguishes between hazard recognition and risk perception. According to Mitropoulos et al. (2005), the U.S. National Safety Council defines hazard as “an unsafe condition or activity that, if left uncontrolled, can contribute to an accident.” Hazard recognition is the realization that a condition or behavior can cause harm (Bahn, 2013), and it is a necessary skill for all mine workers. However, hazard recognition is only the first step to a safe work environment, with an understanding of what constitutes risk also being a critical element. Risk is defined by the U.S. National Safety Council (2009) as “an estimate of the probability of a hazards-related incident or exposure occurring and the severity of harm or damage that could result.” A miner must be able to identify a hazard and then recognize the risk associated with the hazard in order to make a decision on how to mitigate the risk and perform the task safely. Risk perception is an individual's assessment of how risky a situation is in terms of the probabilistic estimates of the degree of situational uncertainty, how controlled that uncertainty is, and confidence in those estimates (Baird and Thomas, 1985; Sitkin and Weingart, 1995). Risk perception has been shown to influence decision-making with regard to job safety (Hunter, 2002). Being able to recognize worksite hazards and then accurately perceive the associated risks are critical skills that lead to safe work decisions.

Prior research on hazard recognition confirmed the need to address this capability and suggested some possible factors. Given that hazard recognition is a critical skill, in tasks designed to test worksite hazard recognition abilities, a recognition rate of at least 90 percent has been used as the standard for mastery of the skill (Barrett and Kowalski, 1995). With this criterion, workers tended to underperform in such tests (Barrett and Kowalski, 1995; Bahn, 2013; Perlman, Sacks and Barak, 2014). Several factors can have an impact on a person's ability to recognize worksite hazards. For instance, in the construction industry, Perlman, Sacks and Barak (2014) compared the hazard recognitions of groups with different amounts of workplace experience. Counter to their prediction that superintendents would successfully identify the most hazards, safety directors outperformed both superintendents and civil engineering students, a result which they attributed to experience and formal safety training that the superintendents and students did not have. A lack of recent experience working in a particular environment, such as in situations of layoffs or filling in for an absent employee, can also have an impact on hazard recognition abilities (Barrett and Kowalski, 1995).

Prior research on risk perception shows similar variability. Different people can see the same situation in different ways (Binder et al., 2011; Bahn, 2013). Perlman, Sacks and Barak (2014) observed differences in the levels of risk assessed for construction hazards, with the more experienced groups of workers, including superintendents and safety directors, assessing risk levels higher than inexperienced students. Research by Brewer et al. (2007) and Manuele (2010) indicate that workers often underestimate risk when determining the likelihood that a hazard-related incident will lead to serious harm or injury. Personal experience from a work-related incident can also affect risk perception. A worker who had experienced a “near miss” is more likely to perceive a similar situation as risky or hazardous than he or she would have before the experience (Burke, Scheurer and Meredith, 2007).

Given the increase in fatalities, U.S. National Institute for Occupational Safety and Health (NIOSH) researchers inspected the fatalities that occurred between 2009 and 2014 at surface

SSG mines to determine what types of tasks mine workers were performing when the fatal injuries occurred. They found that 75 percent of fatalities were sustained while performing routine tasks. A routine task is one that takes place with regular frequency. Mine workers are typically familiar with the job process, the work environment, the required personal protective equipment and the potential hazards and risks associated with the task. This percentage is consistent with information reported to MSHA on the Victim Information form (MSHA form 7000-50b) on whether the activity performed at the time of the fatality was part of the worker's regular job. A nonroutine task, according to health and safety experts at The University of Chicago (2015), is one that falls outside of a worker's normal duties, does not have a documented standard operating procedure (SOP), is performed in a different way than the SOP, or is a task that has never been performed before. Whether workers are performing routine or nonroutine tasks, deficiencies and differences in their abilities to recognize hazards and determine associated risk levels is well documented in the literature (Perlman et al., 2014; Bahn, 2013). The current research study was designed to gain a better understanding of SSG mine workers' hazard recognition and risk assessment abilities.

Methods

Participant and mine site characteristics

In July 2014, interviews were conducted with eight male miners employed at one of two separate surface SSG mining operations located in the southeast United States. Participants' mining industry experience ranged from four months to 25 years, with three participants having less than five years, four having five to 10 years and one having 25 years of experience. Participants held one or more of the following positions at their respective mine site: primary equipment operator, haul truck operator, pit loader operator, maintenance worker, foreman, ground man, silo controller, water truck operator.

Interview procedure and interview guide

Four miners were interviewed at each location. Interviews were conducted one on one during participants' regularly scheduled work shifts and lasted approximately one hour. Interviews were conducted in the participant's work environment, such as inside a haul truck or service truck or inside a control room, at one mine site, and in vacant offices above the maintenance shop at the second mine site. All interview locations were private, offering participants an environment where they could speak freely without being overheard.

Interviews were semi-structured, and researchers used a NIOSH Institutional Review Board-approved interview guide. Interviews began with open-ended questions designed to develop rapport with the participants and learn more about their work histories in the mining industry and the responsibilities of their current positions (Exhibit 1).

To get participants thinking about safety, risks and hazards, the participants were asked what their three main safety concerns were while at work. The interviewer then spent a few minutes discussing the difference between hazards, specifically worksite hazards and hazardous tasks, and risks, specifically risks associated with hazardous tasks, risky behaviors and perceived risks. Next, participants were asked to identify common hazards they come

across when doing their jobs and were encouraged to identify as many hazards as possible as the interviewer recorded them in list format. From this list, participants were asked to identify the three to five hazards they considered most risky and say why, and to rank their three to five hazards from most risky to least risky. Next, participants were asked to explain what they would do if they encountered the hazard they had classified as most risky and as least risky. Finally, participants were asked to compare and contrast how they would deal with these two hazards and why they would address different hazards differently.

Interview questions then addressed risky tasks and task frequency. Participants were asked to identify work tasks they perform that they would classify as “risky” or “highly risky” and explain why they would classify them as such. Interviewers then asked participants how often they were required to perform these risky or highly risky tasks and to discuss their thoughts on whether the frequency with which a task is performed contributes to the level of risk associated with that task. Interviewers used numerous probing questions to encourage participants to offer detailed explanations and provide examples from past work experiences.

Additional questions regarding hazardous or high-risk behavior, risk tolerance, decision-making and risk assessment training programs were also asked. Data gathered from those questions will be presented in future publications.

Data analysis

The 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 researchers who conducted the interviews. The results of the coding efforts were compared, and 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. At this point, the final resulting themes and subthemes were given labels. Trustworthiness (Creswell, 1997) of the analysis and categorization of the data is established by providing thick, rich descriptions, including participants' actual words, so that readers can verify the researchers' interpretation of the data, and by bringing in a third analyst not connected with the data collection or the initial coding to independently analyze the data and review the analysis.

Results

Analysis of the interview data revealed two distinct themes: (1) identified hazards varying by job type and (2) task frequency. Definitions as well as examples are provided below for the themes and their subthemes:

Identified hazards varying by job type

The data indicate that the hazards the miners identified as critical were dependent on the type of job they were performing at the mine site. Within this theme, two subthemes emerged: (1) job type framework and (2) locus of control.

Job type framework—Seven out of eight miners identified hazards as critical based on what they were exposed to during their day-to-day jobs. For instance, a pit loader operator identified ground control issues such as falling rock as the most risky and being aware of the location of haul trucks as the second most risky aspects of his job. Similarly, a haul truck operator identified ground control and weather conditions as the two most hazardous aspects of his job, because when those conditions changed they greatly affected his tasks. Conversely, a primary operator who was also responsible for plant maintenance identified lockout/tagout (LOTO) as the most risky, and issues related to belt maintenance, such as rock buildup, guarding, handrails and pull cords, as the second most risky aspect of his job. The three miners identified potential hazards that most commonly occur in the locations where they spend the majority of their work days. There is overlap in the hazards the pit loader operator and haul truck operator identified because miners with these job titles both operate large machinery in the pit throughout the day.

Locus of control—The miners' perceptions of how much control they had over their surroundings also influenced the hazards identified in relation to the jobs they performed. Locus of control is the extent to which people feel they personally control the events in their lives as opposed to those events being controlled by the external environment (Judge et al., 2002; Rotter, 1966). The miners reported concerns related to how their safety was affected by the safety practices of others over whose actions they had no control. An example of this that was commonly offered relates to vehicles on site that were not operated by mine employees. The miners expressed concerns about customer truck drivers because they have no control over a customer truck driver's actions and, because they do not work with these drivers on a daily basis, they have a difficult time predicting what these drivers will do. A haul truck operator said: “Customer trucks are ranked No. 1 because I spend a lot of time at the loading bins where the customer trucks are. The rule here is ‘yield for equipment.’ Ninety-five percent of the time they don't really yield. I guess it just boils back down to you don't really know what they are thinking and what they are going to do.” Several miners indicated that customer truck drivers oftentimes do not abide by mine site traffic rules. One said, “Even though we have signs out here that say ‘yield to equipment,’ I don't know if they can't read, but they don't yield to us. We have to yield to them.”

Task frequency

The data indicate that how often a task occurs affected the way the miners thought about and worked together to perform the task. A majority of the miners discussed differences in hazard identification and perceived risk while performing routine and nonroutine tasks.

Routine—Maintenance and repair tasks such as greasing rollers, replacing beltlines and removing buildup from walkways and conveyors are examples of routine tasks at a surface SSG mine. A majority of the miners interviewed said routine tasks are more hazardous than

tasks they do not perform regularly. One said, “Probably the ones you do daily are riskier. Probably because you get in such a routine. Because if I'm helping someone else, a lot of times I'll stop and ask, but when you do something that's routine, you get so used to it, it can turn into something bad.”

One explanation the miners gave for considering routine tasks as more hazardous is that they take less precaution. One said, “If you've done it so much you're comfortable with it, you know, I know from previous jobs if you become comfortable with something you don't really take as much precaution as you should or something along that lines.”

Also, the miners reported becoming complacent. One said, “I don't see a difference between tasks that happen often and tasks that don't. Miners get complacent when they do tasks every day.” Another said, “On a daily basis I am safe, but there are some things I get complacent with. For example, I sometimes shovel the chutes without gloves on and sometimes I step or stand on the hand rails, and I don't always wear my hearing protection. Working at heights, especially lower heights, but still above the MSHA rule, is a big issue for me. Sometimes I can stand on a guard to reach something instead of going and getting a man lift.”

Nonroutine—Moving a crusher with a crane or performing maintenance and repair on a crusher are examples of nonroutine tasks. The miners indicated that nonroutine tasks are less hazardous than those performed routinely. One said that he did not think infrequent tasks are more dangerous and that they are less dangerous, “You just have to make sure to follow rules like putting locks on for LOTO.”

The miners perceived nonroutine tasks to be less hazardous because they have to pay more attention to what they are doing. One said, “When you are doing a task you don't usually do, you have to take your time and think about the task.” Nonroutine tasks were also perceived as less hazardous because miners worked as a team. One miner said, “When (doing) bigger tasks with more than one person, you look out for each other more and attend more to the task.”

The miners also reported spending time planning ahead for a nonroutine task. Safety awareness increased for tasks that are not done often. They looked more closely and with fresh eyes. For instance, when they had to use a crane, before the job they would talk about the tasks, and each person would know what he was responsible for ahead of time, what to watch out for and that only one person gives signals.

The data also indicate the miners understand the importance of clear and consistent communication with coworkers during nonroutine tasks. One said, “Rebuilding crushers — they don't do them as often as they do other stuff. We try to get every morning, whenever we would work on, we would try to, you know they would say ‘the crane's coming at this time,’ and once we got down there everybody just kind of got some kind of task gave to them to do to where it kind of falls together a little quicker so, I guess there is a lot of communication going on.”

Conclusions

Given a rise in fatalities at surface SSG mines, the goal of this study was to gain a deeper understanding of SSG mine workers' thoughts, understandings and perceptions of worksite hazards and risks. Although this research was limited to interviews with eight miners from two SSG mining operations, this exploratory study indicates the importance of workers' job-related experience, particularly the relevance of a task to that job, and whether or not they have personal control over that task. Additional research is suggested to understand factors such as mining operation size, and conditions like underground versus surface mining.

The finding on job-related experience concurs with prior research. Albert, Hallowell and Kleiner (2014) suggest workers are more likely to identify hazards when they have knowledge of the operation and experience with the task they are performing. The majority of the miners interviewed identified hazards that they regularly encounter. A pit loader operator and a haul truck operator who both spend a great deal of their days working in the pit or traveling on haul roads identified ground control issues as critical potential hazards. Neither identified LOTO, which was identified by a primary operator who is responsible for the maintenance and repair of belts and conveyors.

The miners also perceived actions and situations that are out of their control as being hazardous. An example given was interactions with customer trucks, as they do not share knowledge with customer truck operators and are therefore unable to predict the actions of these drivers.

How often the miners performed a task not only affected the way they thought about the task but also how they got together to perform the task. The majority of the miners indicated they perceived routine tasks as being more hazardous than nonroutine tasks because they tended to take fewer precautions with routine tasks. They also reported becoming complacent while performing routine maintenance and repair tasks. Similarly, participants in Kowalski-Trakofler and Barrett's (2007) study identified complacency as a reason for arc flash incidents at mine sites.

The miners perceived nonroutine tasks as less hazardous, saying they (1) often worked as a team to complete non-routine tasks and (2) participated in planning and preparation to identify hazards and to discuss how to eliminate or minimize risks. There is evidence that worksites where workers participate in more safety meetings have lower injury rates (Geldart et al., 2010). One possible explanation is that discussing potential hazards during safety and preshift meetings primes the miner, thus facilitating recognition of the hazards when encountered (Charlton, 2006). The miners interviewed also reported paying greater attention while performing nonroutine tasks and being aware of coworkers' locations and safety.

Our findings suggest workers are able to correctly identify hazards and perceive risk relevant to their jobs in an interview setting. If this skill is translated into on-the-job hazard recognition and appropriate mitigation strategies, we would not expect to see a rise in fatality numbers. It remains unclear why mine workers are not able to safely respond to hazards in their work environments. Perhaps they are not recognizing hazards on the job or

not correctly analyzing the level of risk associated with a hazard (Abdelhamid and Everett, 2000). Previous research suggests that work experience and safety-specific training enhances hazard recognition abilities (Perlman, Sacks and Barak, 2014). One current solution to address hazard and risk identification in the mining industry is to offer specialized training to help miners identify commonly encountered, difficult-to-see or unknown hazards (Bahn, 2013; Barrett and Kowalski, 1995; Kowalski-Trakofler and Barrett, 2007; Rethi et al., 1999). For any training to resonate with its target audience, it needs to be relevant to the audience and the environment for which it is developed. Such specialized training must target hazards that SSG miners commonly encounter in the tasks they routinely perform.

Acknowledgments

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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Exhibit 1

Interview questions and information for the eight SSG mine workers

Introduction questions used to learn more about the participants' work histories in the mining industry and the roles and responsibilities of their current positions

1. Please start by telling me a little about your history in mining, such as how long you have worked in mining, how long you have worked at this mine, what jobs you have held in your career.
2. Tell me about the roles and responsibilities in your current position. (What do you do as…?)
3. What are your three main safety concerns at your primary worksite?

Information provided to identify the difference between hazards and risks

Before we move forward with more specific questions, I'd like to take a moment to talk about a few terms that I am going to use throughout the interview. I want to make sure that you and I have the same understanding of these terms before beginning.

First, we are going to spend some time talking about *worksite hazards*. For the purposes of our discussion, when I ask you about worksite hazards, I am asking about hazards in the immediate area in which you work and also the general mine site.

I will ask you to think about *hazardous tasks*. When I say hazardous tasks, I am referring to the jobs or tasks that you perform during your work day.

We will also be talking about *hazardous behaviors*. When I say hazardous behaviors, I am referring to the actions you may take while performing your job.

Finally, I am going to ask you to think in terms of how much *risk* you perceive for worksite hazards, tasks and behaviors. In the traditional sense, risk is defined as the combination of the likelihood an event will occur with the adverse consequences of that event. Risk in this sense can therefore be calculated by an organization. We all have the ability to internally assess risk. Your internally assessed risk — what I am going to refer to as *perceived risk* — can be different from the risk calculated by an organization, because it is based on your own thoughts and experiences.

Example

Here is an example of the terms we just talked about from a surface mining site: A common *worksite hazard* at a stone, sand or gravel mine is fall of ground. A fall of ground can occur when loose rocks fall from the high wall after a blast. The shovel operator's job of moving fallen rocks from the floor after a blast is an example of a *hazardous task* because the operator can be struck by the falling rocks. The shovel operator may put himself too close to the high wall after a blast so that he can move all of the fall rock; this is an example of a *hazardous behavior*. In this example, *perceived risk* is based on how likely you think the shovel operator is to be hit by falling rock and also how severe the injury will be if he was hit by the rock.

Questions to identify common hazards the participants come across when doing their jobs and to probe for how identified hazards would be handled

Worksite hazards

For the purposes of our discussion, when I ask you about *worksite hazards*, I am asking about environmental hazards and hazards that are a part of the worksite itself.

1. What are common hazards you come across while doing your job?
2. Of the hazards you just told me about, which would you say are the most risky to you?
3. Why are these hazards (list the hazards from #2 here) the most risky to you?

    (a) What makes these hazards (from #2) different from the others you listed above?

    (a) I'd like you to think about a highly risky hazard and a less risky hazard (have the participant choose one of each of these from the previous list):

        (i) Tell me what you would do if you came across this highly risky hazard while working?

        (ii) Tell me what you would do if you came across this less risky hazard while working?

        (iii) Tell me how you would deal with these two hazards differently.

Interview questions used to probe the participants about risky tasks and task frequency

Hazardous tasks

Just as a reminder, when I ask you to think about *hazardous tasks* I am referring to the jobs or tasks that you perform during your work day.

1. Do you think any of the tasks you do for your job are highly risky?
2. If yes, which tasks are those?
3. Why are those tasks high-risk tasks?
4. How often do you do these high risk tasks?

    (a) Do you think that tasks you don't do very often are riskier than tasks you do all the time?

    (b) If yes, what makes these tasks you don't do very often more risky?