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Assessing the Impact of Safety Climate Constructs on Worker Performance in the Mining Industry

Centers for Disease Control and Prevention
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Acronyms and Abbreviations

ART	annual refresher training
CPWR	Center for Construction Research and Training
H&S	health and safety
HSMS	health and safety management system
ICMM	International Council on Mining and Metals
MSHA	Mine Safety and Health Administration
NAS	National Academy of Sciences
NMA	National Mining Association
NIOSH	National Institute for Occupational Safety and Health
NRC	National Research Council
OSHA	Occupational Safety and Health Administration
PPE	personal protective equipment
RS-RW	rescaled relative weights
RWA	relative weights analysis
SPSS	Statistical Package for the Social Sciences

Executive Summary

To advance a more tangible understanding of health and safety climate in the U.S. mining industry, the National Institute for Occupational Safety and Health (NIOSH) surveyed members of mining workforces about experiences at their respective mine operations. The survey measured four personal (i.e., risk tolerance, thoroughness, sense of control, and adaptability) and six organizational (i.e., organizational support, supervisor support, supervisor communication, coworker communication, worker engagement, and training) constructs to determine significant influences on health and safety (H&S) performance, which was measured in the form of worker proactivity, compliance, and reported near misses or other incidents. This report, unlike other safety climate reports, focuses on individual perceived safety climate [Neal and Griffin 2006] versus crew-based approaches to such assessments.

Participants consisted of 2,683 workers—both salaried and hourly—at 39 mine sites throughout 17 states. The mines represented nine major companies and three mining subsectors (coal, stone, sand, and gravel, and industrial minerals). This report analyzes, assesses, and presents data about these safety climate constructs to help those who manage companies, mine organizations, or groups of workers, to develop, target and improve, or implement parts of a health and safety management system (HSMS) to support workers' H&S performance while reducing the likelihood of workplace incidents.

The results within this report establish initial benchmarking data for each construct measured. The overall benchmarking data, or averages, along with the benchmarks for each subsector, are visually shown in Figures 1 to 14. A score of six represents the highest perception of the construct being measured. In general, most averages were between 4.5 and 5.5, indicating generally positive perceptions. Regarding the regression analyses, some highlights include the following:

- All 10 safety climate constructs were statistically significant predictors of proactivity; the overall model fit was $R^2 = .32$, or 32.24%. Thoroughness and sense of control were the highest predictors at 21% and 17% of the total variance, respectively. Workers' personal levels of risk tolerance (13%) and their engagement in H&S activities (12%) were also strong predictors.
- All 10 safety climate constructs were statistically significant predictors of compliance; the overall model fit was $R^2 = .46$, or 46.70%. Workers' risk tolerance was the predominant predictor at almost 31% of the total variance of R^2. Workers' thoroughness (23%) and then coworker communication (11%) were strong predictors of workers' compliant behaviors. H&S training, although a significant predictor, only contributed about 5% to the total variance of the 46.7% model. Organizational support for H&S contributed about 4%.
- The overall fit for the knowledge model was $R^2 = .5$, or 50.03%. The fit for the motivation model was $R^2 = .39$, or 39.74%. Although training significantly and heavily contributed to workers' knowledge and motivation, the proactivity and compliance models show that it does not necessarily translate to H&S performance.

- The final models included the four incident-related variables measured in the survey. Together, the 10 safety climate constructs predicted approximately 8% (R^2 = 8.26%) of near misses experienced; 6% (R^2 = 5.72%) of first aid incidents experienced; 7% (R^2 = 7.29%) of incidents experienced that required medical treatment; and 6% (R^2 = 6.13%) of days lost among participants.

Implications for Improving Safety Management Practices

The results provide insights into how to support workers' H&S on the job as well as support what previous reports have found. Notably, the results showed that the personal constructs were the most influential safety climate constructs in predicting workers' H&S performance. These results also show the value of organizations accounting for and addressing both the organizational and personal factors where possible. In response, interventions can be employed on an organizational level among varying types of management to influence workers' personal-based factors on the job.

Broadly, NIOSH researchers identified five areas of focus that emerged from the results. These areas can be used to develop or enhance various workplace HSMS interventions. These areas, detailed below, are presented in no particular order, as each organization likely has a different culture with strengths and weaknesses. It is anticipated, however, that at least one of these areas is ripe for intervention with an organization.

1. Go Beyond Annual Refresher Training

Although training emerged as a strong predictor of workers' knowledge on the job, it had a smaller effect on workers' actual H&S performance in terms of proactivity and subsequent decision making. Future research will need to determine if these results are a result of the training itself, or the support from management subsequent to the training. Assuming that most training is adequate, considering the high benchmark as well as its significant contribution to worker knowledge within the study, management may need to focus on improving workers' opportunities and involvement regarding their roles in work processes and practices to increase workers' sense of control, as well as actual control, and confidence. Research has shown that the transfer of any knowledge gained through training will not occur if workers do not have adequate levels of self-efficacy and control as well as support from their management [Grossman and Salas 2011]. Therefore, rather than work to "provide more training," improving the content of training as well as the level of follow-up and communication that takes place when the training is over should be considered. Examples of how some companies have tried to address soft skills during trainings and subsequently on the job are discussed in this report.

2. Acknowledge and Address Risk Tolerance and Associated Decisions

Risk tolerance emerged as a steady, significant predictor of worker H&S performance—particularly among workers' compliant decisions to follow rules. Risk tolerance is an emergent state that can be changed over time and it could behoove management to address this factor. In general, most operations have mechanisms in place for hazard identification and subsequent risk perception such as job safety analyses, as reported by the Occupational Safety and Health Administration (OSHA) [OSHA 2002]. However, the greatest threat is usually not missing a hazard but rather, failing to mitigate the hazard due to a high tolerance for risks [Fennell 2015; Jones 2015]. These researchers argued that, rather than build knowledge around hazard

recognition and risk perception, more attention should be given to enhancing not only knowledge and skills but also autonomy around third step—the decision-making process. Fennell [2017, 2015] has proposed 10 factors that are similar to findings from previous research [e.g., Eklöf and Törner 2002; Harrell 1990; Huang et al. 2007; Mearns et al. 2001b; Rundmo 2001] that influence risk tolerance. These factors can be and have been observed at several mine sites, where they were seen to prompt specific conversations around this issue.

3. Enhance Worker Engagement Opportunities

Engagement, although measured as an organizational construct in the NIOSH survey, has both organizational and individual origins, which may be one of the reasons it was a significant, moderately sized predictor within all of the models. Although engagement as a construct in the current research effort scored as one of the lowest perceived organizational factors, it is important to note that engagement is made up of quickly changing moments and occurs in more of an ebb and flow [Kahn 1990]. Examples that participants and organizational management discussed as employee-involvement initiatives that seemed to "work" on site in terms of being recognized by workers include:

- Letting workers choose a new type of personal protective equipment (PPE) based on a variety of approved options.
- Creating and involving workers on different health and safety committees, including participation in walk-throughs and debriefs on site. Additionally, targeting groups who appear to have lower perceptions of the degree of risk or morale has shown success.
- Improving communication quantity and quality throughout the workday.

4. Maintain Worker Thoroughness and Improve Sense of Control

While making some of the aforementioned changes to the organization's HSMS, it is important to keep in mind that the safety climate results showed that workers' personal factors have a larger impact on their H&S performance. Although these are personal factors, these individual states can be influenced by organizational characteristics such as decision-making authority bestowed onto an individual, opportunities provided to use knowledge and skills, and the option and ability to participate [Karasek and Theorell 1990]. It can be suggested, then, that the root cause, and perhaps a potential solution, of organizational conflicts regarding workplace safety may reside in understanding the processes undertaken by organizations to communicate with individuals. For example, determining if a safety initiative is not endorsed as it should be can be useful in determining misaligned communications. Through increased engagement and collaboration efforts, it may be easier to facilitate alignment between management and hourly workers.

5. Be Accountable for Communication Practices

Because safety communication has been continuously encouraged in high-risk industries as an effective mechanism to enhance workers' awareness of safety and appropriate response to risks [Clarke 2003; Griffin and Neal 2000; Mearns et al. 2003; Probst 2004], results from NIOSH's safety climate survey can be used to improve communication quantity and quality. NIOSH research has been able to show gaps and best practices [Haas 2019; Haas et al. 2018b; Haas et al. 2016; Haas and Yorio 2016] and that there is room for improvement. Building on this research, NIOSH used the current results and additional data points to develop communication

accountability scorecards to improve the transparency of organizational communication. Using such tools (Appendices J, K, L) can help make communication more tangible.

Summary

Besides establishing current benchmarks of safety climate in the mining industry, these results show the impact that organizational and personal safety climate factors can have on workers' H&S performance. Specifically, this report provides some guidance to mines for improving organizational factors to help enhance the overall culture, regardless of the starting perspectives or points of view of individual miners. It is believed that organizations can start to address a select number of HSMS practices and, over time, scale their systems to include additional indicators.

An Overview of Safety Climate, Culture, and their Link to Health and Safety Management Systems

Although the term "safety climate" was not coined until 1980 when Zohar discussed workers' attitudes towards safety, such measurements were occurring much earlier [Healey et al. 2012; Zohar 1980]. Specifically, organizational behavior literature has been concerned with organizational climate since the 1960s [see Frederikson 1966; Friedlander and Margulies 1969; Schneider and Barbera 2014; Tagiuri and Litwin 1968]. Scholars discuss organizational climate as any perception that emerges as a result of individual's activities and interactions within their organization [Schneider and Hall 1972]. In occupational health and safety (H&S), it is common to focus on safety when referring to an organization's climate—hence the arrival of the heavily used term *safety climate*. An organization's safety climate refers to employees' perceptions of their organization's values and priority of H&S on the job [Griffin and Curcuruto 2016]. The interaction between individual and organizational factors plays a critical role in maintaining a satisfactory safety climate and, in turn, safe work practices and operations [Christian et al. 2009; Hofmann et al. 2003; Reason 2016].

Although safety climate is often studied and referenced as a leading indicator of incidents [Haas and Yorio 2016; Juglaret et al. 2011; Mearns et al. 2001a; Payne et al. 2009; Schneider 2017], identifying and implementing tangible methods to improve an organization's safety climate is not well understood, particularly in organizations whose environments are in a state of constant change. Research continues to suggest that safety climate models can support root cause analyses and trends, particularly to identify vulnerable areas within a company's health and safety management system [Griffin and Curcuruto 2016; Reason 2008]. Specific to mining, the National Research Council's (NRC) National Academy of Sciences (NAS) [NRC 2013] indicated that a positive safety culture is a critical aspect of preparation that needs to be considered within any HSMS. To that end, this report focuses on (1) the assessment of workers' perceptions of safety climate; (2) which safety climate constructs have a greater impact on worker H&S performance (performance is comprised of proactive and compliant behaviors on the job); and (3) how organizations can effectively use HSMS interventions to improve select safety climate constructs that are significant predictors of workers' H&S performance.

Objectives

To advance a more tangible understanding of safety climate, the National Institute for Occupational Safety and Health (NIOSH) surveyed members of mining workforces about experiences at their respective mine operations. The survey measured personal and organizational constructs, or factors, to determine significant influences on H&S performance. This report conveys information about these safety climate constructs to help those who manage mine companies, a mine organization, or groups of workers, to develop, improve, and implement parts of an HSMS to support worker H&S performance while reducing the likelihood of workplace incidents. To that end, this report includes the following:

- A review of safety climate, culture, and health and safety management systems.
- Safety climate constructs measured to predict worker proactivity and compliance.

- Key findings about workers' perceptions of safety climate constructs, including differences among the mining subsectors that were surveyed as well as a benchmark of perceived norms for each construct measured.

- Key findings about safety climate constructs that significantly predict workers' proactive and compliant behaviors on the job.

- Considerations for organizational leadership to help improve and maintain critical safety climate constructs to support the organization's execution of its HSMS.

Distinguishing between Climate and Culture

The current report specifically addresses constructs of safety climate. Specifically, this report, unlike other safety climate reports, focuses on individual perceived safety climate versus crew-based approaches to such assessments [Christian et al. 2009; Neal and Griffin 2006]. However, safety climate and safety culture, despite having distinctions that make them unique, are often used interchangeably, both in the literature and in practice [Cox and Flin 1998]. Some of their unique characteristics, including definitions and measurement issues, are highlighted in Table 1.

Table 1. Characteristics of safety climate and safety culture

Characteristics	Safety climate	Safety culture
Paraphrased definitions	• Perceived priority of values and assumptions at a given point in time with regard to policies, practices, and processes [Guldenmund 2010; Zohar 2010] • "A summary of molar perceptions that employees share about their work environments" [Zohar 1980, p. 96] • A snapshot of the current state of safety [Lee 1981] or what happens on a day-to-day basis [Gillen et al. 2014]	• Implicit safety values and assumptions that guide workers' practices [Griffin and Curcuruto 2016] • "Shared and learned meanings, experiences, and interpretations of work and safety" that are fostered within an organization over time [Richter and Koch 2004, p. 704] • A set of dominant indicators, beliefs, and values with regard to job safety [Fang et al. 2006] that eventually manifest in safety-related actions [Gillen et al. 2014]
Measurement issues	• Tend to capture a poor-to-positive perception of safety features (e.g., where lower scores represent a poor safety climate and higher scores represent a positive safety climate) [Neal et al. 2000]	• Harder to study, measure, and assess [Schein 1990] and researchers are skeptical about only quantitative measurements of safety culture [Guldemund 2007]
Other conceptual issues	• Neal et al. [2000] conceptualized a higher order of organizational safety climate that includes four dimensions of climate: 1. management values; 2. safety communication; 3. safety training; and 4. safety systems	• Schein [1999] conceptualized three embedded levels of culture: 1. organizational artefacts; 2. organizational norms and values that contribute to how artefacts are modelled; and 3. basic assumptions that members hold about their organization's reality and functioning

Importantly, an agreed-upon characteristic that distinguishes these two concepts is that safety climate assessments provide an understanding of the current safety conditions and values to provide guidance into factors that can be positively altered [Curcuruto and Griffin 2018; Curcuruto et al. 2016]. In other words, aspects of safety climate can be more readily measured and alerted to improve H&S performance. Therefore, this study focused on safety climate in the mining sector to provide targeted insights into what aspects of an organization's climate can be developed or more effectively implemented through the HSMS to improve organizational and worker H&S performance.

The Relationships among Safety Climate, Health and Safety Management Systems, and Worker H&S Performance

Health and safety management systems are commonly referred to as a set of institutionalized, interrelated, and interacting practices used to establish and achieve occupational H&S goals (ANSI/AIHA Z-10; OHSAS 18001). Even if definitions vary, actions implemented by organizations usually entail steps around the Plan-Do-Check-Act cycle [PCDA; aka, "the Shewhart cycle,"] [Deming 1986]. Research has argued for a focus on specific elements within an HSMS. Specifically, it has been argued that an explicit and implicit goal of an HSMS should be to develop a strong safety climate [Health and Safety Executive 1991]. Additionally, organizations are encouraged and, to some degree, expected to employ a risk-based framework for hazard identification and mitigation [Frick et al. 2000; Grayson et al. 2006; International Council on Mining and Metals (ICMM) 2015]. Such risk-based processes also include the application of controls to minimize negative outcomes as well as verifying that controls remain effective over time.

Despite a common understanding of the importance of having an HSMS, integrating the use of formal tools, interventions, and practices has been challenging. Difficulties in committing to the development and evaluation of HSMS interventions, specifically, have created a lack of understanding about the implementation of these systems and its ties to safety climate in a given organization [ICMM 2015; Robson et al. 2007]. However, an examination of the common elements and practices of company health, safety, and risk management systems as well as common constructs of safety climate show overlap in key dimensions such as leadership, communication, risk assessment, and worker involvement [Bushnell 1992; Deming 1986; Haas et al. 2018a]. Therefore, it is plausible to believe that measurements of safety climate can be better integrated into a continuous HSMS cycle and, as a result, effectively alter and improve work practices and H&S performance on site.

Research has argued that if there are too few dimensions of safety climate measurement and focus, interventions might not align with the most important aspects of an organization's HSMS and, consequently, be less effective [Zohar 2010]. Therefore, a positive safety climate and complementary HSMS are more likely to occur if workers are motivated and feel supported in complying with organizational procedures and processes. Thus, understanding how to best assess and improve safety climate is critical to the effective implementation of HSMSs and subsequent incident prevention.

Meta-analyses have identified connections between organizational aspects of safety climate and workers' proactive H&S performance [see Brondino et al. 2012; Bronkhorst 2015; Dahl and Kongsvik 2018; Flin et al. 2000; Nahrgang et al. 2011; Neal and Griffin 2006]. Therefore, it is

not surprising that safety climate has also been linked to safety outcomes [Clarke and Ward, 2006; DeJoy 2005; Neal and Griffin 2006]. Although research has shown that worker proactivity and compliance can predict job performance [Grant et al. 2009; Thompson 2005; Crant 1995], the constructs that most influence these actions are not clear, emphasizing the value of further inquiry [Parker et al. 2006]. On an organizational level, empirical evidence is needed to understand how and in what ways the organization's safety climate intersects with workers' perceptions and performance within the overall HSMS.

Worker H&S Performance

Previous research [Griffin and Neal 2000; Christian et al. 2009; Neal and Griffin 2006] has positioned organizational- and personal-related factors as antecedents, or predictors, of worker safety knowledge and motivation, which, in turn, predicts worker behaviors, which then predicts incidents. Reason et al. [1998] suggest that, rather than focus on injuries that contribute to days lost which are (fortunately) rare occurrences, broader measures around knowledge, motivation, and behavior are able to provide organizations with continuous feedback. Specifically, the personal safety perceptions of workers and the less severe incidents that they experience are always present and give a current snapshot of H&S in the organization [Zacharatos et al. 2005]. Consequently, in the current NIOSH study, the dependent variables measured were worker knowledge, motivation, and behavior. Behavior was studied through measures of H&S performance in the form of proactivity and compliance. The determinants of H&S performance have been shown to represent factors directly responsible for compliance and proactivity [Campbell et al. 1993; Neal et al. 2000]. These dependent variables are highlighted below.

Worker Proactivity: Survey items 1–5

Proactivity (discussed as *participation* in some studies) is an extra-role behavior. Actions include anticipating future events, taking initiative to improve current conditions, not passively adapting to present conditions, being self-starting and taking charge, speaking out with ideas, and overcoming safety barriers [Clarke and Ward 2006; Crant 2000; Frese et al. 1996; Hofmann et al. 2017; Griffin and Neal 2000; Parker et al. 2010]. Worker proactivity has also been shown to predict workers' actions which stems, in part, from workers' increased likelihood to engage in situational awareness and voice concerns about safety [Grant et al. 2009; Thompson 2005; Tucker and Turner 2015]. Despite research documenting common features of proactivity, little is known about what organizational and personal factors influence these extra-role behaviors taken on by workers [Parker et al. 2006]. A proactivity scale was adapted from Neal et al. [2000] to measure workers' proactive safety actions. These are items 1–5 in the survey.

Worker Compliance: Survey items 6–9

Safety compliance is defined by Griffin and Neal [2000] as "the core safety activities that need to be carried out by individuals to maintain workplace safety" [p. 349]. These researchers contend that safety compliance is a function of knowledge, skills, and motivation to comply with safety policies and processes. In other words, compliance involves inner-task role behaviors such as wearing proper personal protective equipment and following workplace rules [Clarke and Ward 2006]. A safety compliance scale was adapted from Neal et al. [2000] and Zacharatos et al. [2005] to measure workers' compliance with safety procedures. These are items 6–9 in the survey.

Worker Knowledge and Motivation: Survey items 43–45 and 46–48

An organization's safety climate has been shown to influence worker knowledge, motivation, and skills through increased participation and adherence to H&S activities [Morrison et al. 1997; Neal et al. 2000; Zacharatos et al. 2005]. Specifically, worker knowledge and motivation have been shown as determinants of differences in individual worker performance [Campbell et al. 1993]. The current survey adapted items from previous studies [Neal et al. 2000; Zacharatos et al. 2005] to assess worker knowledge and motivation. These are items 43–45 and 46–48 in the survey.

Near Misses and other Incidents: Survey items 55–58

Workers who participated in the survey were asked to report their frequency of near misses and other incident occurrences on site in the last six months. According to the National Safety Council [NSC 2013], a near miss is an "unplanned event that did not result in injury, illness, or damage—but had the potential to do so" (np). Regarding accuracy, six months is the recommended maximum time over which workers should be asked to recall injuries [Veazie et al. 1994; Zacharatos et al. 2005]. To that end, each participant was asked how often they were involved in the following in the last six months: a near miss incident; incident that required first aid; incident that required medical treatment; incident that resulted in days lost on the job. Each participant was prompted to check one of the following: Never, Once, 2 times, 3 times, 4 times, or 5+ times. These are items 55–58 in the survey.

Although there is regulatory oversight within the U.S. mining industry to require near miss reporting, it is well known that underreporting occurs in the industry [Nowrouzi-Kia et al. 2017]. However, many mine sites, including those who participated in the study, do have informal and formal near miss reporting procedures and forms that encourage workers to complete any near miss observed, prevented, or fixed on site. For most of the sample, the four types of incidents could be cross-checked with the participating mine sites due to their own reporting and auditing of incidents. At those sites who engaged in cross-checking, the results were often very close, indicating an understanding and accurate recollection of near misses or incidents experienced in the last six months. Obviously, this cross-checking was not possible with all participating mines and it can be assumed that underreporting still existed in some areas. However, an analysis of the near miss data in the middle of data collection showed that, although about half of the sample indicated experiencing no incidents, the model was not subject to a zero-inflated model with the mean of near misses being .83 [Haas and Yorio 2019]. Rather, zero-inflated models should be considered when the mean is <.07 or <.05 [Lord et al. 2005]. Therefore, researchers were comfortable with the incident reporting provided by participants.

Safety Climate Benchmarks

For the mining sector to assess and improve safety climate at the organizational level, it is necessary to establish benchmarks to enable future measurement. A recent review of H&S literature in the past 100 years found that, both within the literature and among practitioners, no consistent measure of safety climate exists [Hofmann et al. 2017]. Additionally, an NAS report by the NRC [2013] advocated that more data encompassing the general mining industry was needed to make more generalizable conclusions as well as establish benchmarks within the

industry. Thus, the establishment of benchmarks for future mining assessments was one goal of this investigation.

Benchmarking is defined as "a process of continuously measuring and comparing an organization's business processes against those of process leaders anywhere in the world to gain information which will help the organization to take action to improve its performance" [American Productivity & Quality Centre 1993, p. 1]. Another definition describes benchmarking as, "A method of measuring and improving organizational performance by comparing with the best" [Stapenhurst 2009, p. 6]. In other words, benchmarking allows organizations to identify areas where they are doing well as well as areas that need improvement [Healey et al. 2012].

Researchers [Ahmed and Rafiq 1998; Stapenhurst 2009] suggested practical aspects of benchmarking such as being able to employ systematic procedures to allow for the comparison of performance levels among organizations and groups. Another example provided was being able to emphasize continuous improvement through the identification and adoption of practices that can lead to greater levels of performance. Benchmarking safety climate in the mining industry allows organizations to quantify performance levels and identify gaps in which organizational constructs could be improved upon to support improved proactive and compliant performance.

The current safety climate data serve as benchmarks for mine organizations to gauge their performance in advancing worker H&S through a stronger, more integrated health, safety, and risk management strategy. Even more importantly, prioritizing the impact of climate constructs gives practitioners a road map of where to focus intervention efforts, based on which constructs need attention. Therefore, the current analysis process, like others in high-risk occupations [e.g., Mearns et al. 2001b], identifies areas in which mine organizations can improve. However, the organization's actual improvement ultimately depends on how each respective organization chooses to use the results to make changes.

Research Objectives

This study sought to accomplish the following research objectives:

- Determine a benchmark of each safety climate construct measured to enable other organizations to quantify and compare their current safety climate within the context of NIOSH's sample.
- Among the personal and organizational safety climate constructs measured, determine which are the most influential in predicting **proactive performance** among workers.
- Among the personal and organizational safety climate constructs measured, determine which are the most influential in predicting **compliant performance** among workers.
- Determine implementation efforts to inform communication and assessment at varying levels within mine organizations.

Methodology

NIOSH assembled a safety climate survey specific to the mining sector that was used to assess workers' perceptions of several personal and organizational constructs.

Safety Climate Survey Development

A literature review was conducted focusing on a variety of terms and concepts related to safety climate and culture measurement in high-risk occupations. Specifically, literature on safety climate, safety culture, HSMSs, and organizational values rendered common measures or predictors used to assess safety climate. Common measures applicable to the mining industry were selected including those that were organizational and personal predictors of workers' H&S performance (hereafter known as worker proactivity and worker compliance). Specifically, prominent causal and theoretical models of workplace safety were consulted to identify relevant constructs [e.g. Christian et al. 2009; Neal and Griffin 2000; Griffin and Neal 2000; Mearns et al. 2001a, b; Zacharatos et al. 2005]. NIOSH utilized several key constructs from the model depicted in the Christian et al. [2009] meta-analysis. A unique contribution argued by these researchers is the promotion of both organizational- and person-related factors as predictors.

NIOSH identified six organizational constructs and four personal constructs deemed necessary to foster a positive safety climate that could also influence H&S behaviors. NIOSH researchers were also able to locate existing validated scales through the cross-industry occupational H&S peer-reviewed literature that were ripe for adaptation to the mining industry. This approach is common when developing quantitative instruments [DeVellis 2012]. Adapted questions within each scale were tested with a subject matter expert in the mining industry prior to pilot testing in the field. Tables 2 and 3 list each construct, a brief definition, and original sources for scale adaptation. Each construct is detailed in Appendix A. The survey is shown in Appendix B.

Table 2. Organizational factors that predict performance

Scale Construct	Definition	Previous Validation
Supervisor H&S Support	Supervisors' valuing employees' contributions to the organization, caring about their personal well-being, and emphasizing safe choices	Eisenberger et al. 2002
Supervisor H&S Communication	Supervisors' sharing of safety information and the ease with which workers can communicate with their supervisors about H&S issues	Casey and Krauss 2013
Organizational H&S Support	The organization's priority for safety, including expectations about the balance of work pace, workload, and production pressure	Katz-Navon et al. 2005
Adequate H&S Training	The quantity and quality of training in increasing knowledge, awareness of hazards, and behaviors needed to avoid injury	Zacharatos et al. 2005
Worker Engagement	Willingness of the organization to involve employees in decision-making processes about procedures that influence their tasks	Niehoff and Moorman 1993; Zacharatos et al. 2005
Coworker Communication	Coworkers' talking about H&S, holding each other accountable for safe work practices, and accepting mistakes as learning experiences	Zacharatos et al. 2005

Table 3. Person-related factors that predict performance

Scale Construct	Definition	Previous Validation
Adaptability	Active-change orientation to bring about constructive change, similar to "felt responsibility for change"	Parker et al. 2006
Sense of Control/Efficacy	Subjective well-being, job satisfaction, and sense of control over their outcomes	Judge et al, 2003; Gardner and Pierce 2010
Risk Avoidance	General tendency to take risks or avoid risks on the job	Meertens and Lion 2008
Thoroughness	The degree to which individuals believe they are orderly, dependable, and responsible	Barrick and Mount 1991; Poropat 2009

These factors have been used in previous studies to predict proactivity, compliance, or incidents. The survey used a 6-point Likert scale, with responses ranging from Strongly Disagree to Strongly Agree. Each item relates to one of a series of constructs, and responses were used to calculate a mean score for each construct. A score of 6 represents a high perception of the safety climate construct while a score closer to 1 represents a poor perception of the construct.

Survey Validation

After the NIOSH Institutional Review Board approved the survey and research design, the survey was piloted in 2015 during several field visits. These pilot-tested data were not part of the

final survey sample. In this initial pilot, the Cronbach alpha's ranged from .6 to .9, which are acceptable values [Bland and Altman 1997; Devellis 2012; Nunnally and Bernstein, 1994]. In addition, reliability checks were completed at two other time points throughout data collection at which the alpha levels remained steady.

After initial pilot testing, the age and experience categories were slightly edited in response to mine corporate-level feedback. Particularly, with baby boomers getting ready to retire, industry representatives felt that over 16 years in the experience categories would render too large a sample; they recommended the survey have a 16–20-year option and then an option with more than 20 years of experience. Similarly, they felt that the age category required additional breakdowns to allow for more options and targeting, if needed. For results from smaller mine sites, NIOSH researchers tended to collapse some of these categories to allow for statistical testing.

Recruitment and Data Collection

NIOSH received approval from the Office of Management and Budget in February 2016. Data collection occurred between February 2016 and March 2018. Individual mines were initially recruited through research contacts. Once initial data collection with the first company was completed and pilot results were communicated during various mining trade and conference presentations, subsequent participating sites began to contact NIOSH to participate. Although NIOSH did not have to engage in extensive recruiting due to industry interest, the final sample rendered participation from three common subsectors as well as a larger sample than anticipated.

Upon being contacted by a corporate H&S leader, mine operator, or H&S manager, a mutually agreed-upon time was chosen to travel to the mine and administer the survey. If an upcoming Mine Safety and Health Administration (MSHA) annual refresher training (ART) was scheduled, researchers often visited the mine because everyone was together at one time. If an upcoming ART or other training was not on the mine's schedule soon, researchers worked with the mine to pick one or two days that were convenient to attend pre-shift safety meetings to collect the survey data. In this scenario, researchers would often be present at the mine location all day to catch varying shift rotations.

Mine management and hourly workers were briefed about the purpose of the survey and told that their responses would be anonymous and not be seen by their supervisors. Everyone was given the option to voluntarily participate and given contact information of the principal investigator with follow-up questions. To the authors' knowledge, no one refused to participate. The survey took approximately 15 minutes for participants to complete.

Researchers collected the hard copy surveys and subsequently they were entered into a Statistical Package for the Social Sciences (SPSS) file for cleaning and analysis. In some cases, entire surveys were discarded if it was clear that participants were not reading the questions (i.e., responding with all 6's or all 1's). This did not occur often—in general, a few surveys per mine site, which was usually about two to three percent of the sample at a mine site. Additionally, any responses that were not answered within each survey were coded as "missing data" during the data cleaning process.

Survey Participants

Participants consisted of 2,683 workers—both salaried and hourly—at 39 mine sites throughout 17 states. The mines represented nine major companies and three mining subsectors (i.e., coal; stone, sand and gravel; and industrial minerals). To the authors' knowledge, everyone who was present on-site during data collection completed the survey, including office workers and management. The breakdown of participation by subsector is in Table 4. The remaining demographic characteristics of the sample are reported in Tables 5–8.

Table 4. Breakdown of participation by mined subsector

Mine Subsector	Survey Count	Percent of Sample	Mine Count
Coal	358	13	2
Industrial minerals	907	34	9
Stone, sand, and gravel	1,418	53	28

Table 5. Demographic characteristics of participants

Demographic Characteristics	Survey Count	Percent
Gender (72 missing)		
Male	2,438	93.4
Female	173	6.6
Job classification (94 missing)		
Salaried	569	22.0
Hourly	2,020	78.0
Age range (79 missing)		
18–24	134	5.1
25–34	523	20.1
35–44	596	22.9
45–54	730	28.0
55–64	561	21.5
65+	60	2.3
Highest level of education: (77 missing)		
Less than high school	75	2.9
High school	1,532	58.8
Associate's degree/Trade certificate	686	26.3
Bachelor's degree	244	9.4

Demographic Characteristics	Survey Count	Percent
Master's degree or higher	69	2.6
Family mining history: (135 missing)		
First-generation mineworker	1,682	66.0
Multi-generation mineworker	866	34.0

Table 6. Experience in current job (69 missing)

Experience level	Survey Count	Percent
Under 1 year	371	14.2
1–5 years	723	27.7
6–10 years	438	16.8
11–15 years	327	12.5
16–20 years	204	7.8
20+ years	551	21.1

Table 7. Experience at current mine (155 missing)

Experience at Current Mine	Survey Count	Percent
Under 1 year	354	14.0
1–5 years	574	22.7
6–10 years	407	16.1
11–15 years	351	13.9
16–20 years	217	8.6
20+ years	625	24.7

Table 8. Experience in the mining industry (106 missing)

Experience in Mining Industry	Frequency	Valid Percent
Under 1 year	239	9.3
1–5 years	470	18.2
6–10 years	448	17.4
11–15 years	397	15.4
16–20 years	245	9.5
20+ years	778	30.2

Data Analysis

Within the 58-item survey, eight of the items were reversed-scored—a common approach to ensure participants were alert and paying attention to the questions [Devellis 2012]. Using this approach, NIOSH researchers were able to easily eliminate surveys for those people who were not reading the questions or not taking the time to respond. In general, anywhere from 0–5 (0%–3%) surveys at each participating mine were eliminated using this screening approach. These negatively worded items were reverse-scored prior to analysis, during the data cleaning stage, to ensure that their directionality matched the other 50 items in the survey.

To answer the first research objective (i.e., determine benchmarks of each safety climate construct), the average score for each item and construct was calculated. Given that the dependent variables were skewed, Kruskal-Wallis tests, a non-parametric statistical test, were used to determine if significant differences existed among commodities. The Kruskal-Wallis allowed researchers to determine if the subsectors were statistically different from each other.

Establishing Benchmarks using Construct Averages

The use of benchmarking was similar to that of typical psychometric survey studies [i.e., Healey et al. 2012; Mearns et al. 2001a; Miller and Cox 1997]. Specifically, the use of means and frequency distributions were used as benchmarking tools [Stapenhurst 2009]. The means allowed interpretation at the aggregate level and comparison of individual sites with the overall average. Therefore, the mean was calculated for each of the constructs. High scores (6) represented favorable ratings and low scores (1) represented negative views of the construct being measured.

$$Mean = \left(\sum x_i\right)/n$$

For the purposes of this study, the benchmarks enable organizations to prioritize safety-related deficiencies for intervention. Additionally, organizations are able to compare constructs within their safety climate to those of other subsectors or the overall average. This comparison facilitates a response to areas that scored “lower” at respective companies.

Frequency distributions were reported at the aggregate level as well. These two approaches occurred for the overall sample as well as for each of the three participating subsectors. This allowed researchers to make visual and statistical comparisons of the difference in averages [Healey et al. 2012].

Using Relative Weights to Identify Significant Predictors

The second and third objectives (i.e., determine the most influential personal and organizational constructs on workers’ H&S proactivity and compliance) were addressed using relative weights analysis (RWA) [Johnson 2000; Tonidandel et al. 2009; Tonidandel and LeBreton 2011]. In the context of multiple regression, RWA was used to examine the relative contribution of the six organizational and four personal safety climate constructs in predicting worker H&S proactivity and compliance, knowledge, motivation, near misses, and other incident outcomes. RWA is used in situations where the relative importance of numerous correlated predictors is of interest. The method decomposes the total variance in a dependent variable that is explained by a set of correlated predictors into an accurate set of weights that reflect the proportional contribution of each of the predictors in the model [Tonidandel and LeBreton 2011]. In this context, RWA

methodology uses a series of orthogonally transformed regressions to determine the importance of each predictor in the prediction of the dependent variables.

Prior to the development of RWA, the relative importance of predictors could be estimated by examining and comparing the standardized regression coefficients for a set of predictors. However, this method does not account for the potential inter-correlations among the set of predictors. Using relative weights solves the inter-correlation problem by transforming the set of predictors so that they are uncorrelated prior to examining their relative importance [Johnson 2000; Tonidandel at al. 2009; Tonidandel and LeBreton, 2011]. This was a necessary step to ensure a reliable analysis. Researchers used processes defined and illustrated by Tonidandel and LeBreton [2011] to derive the relative weights for each of the 10 predictors included in the current study. Analysis was done in R using the macro developed by Tonidandel and LeBreton [2015] (http://relativeimportance.davidson.edu/). This developed routine uses a bootstrapping approach to derive confidence intervals and tests of significance for each of the predictor's relative importance parameters.

Results

Results by question for the overall sample and by commodity are listed in Appendix C, and the results by question for the coal, stone, sand, and gravel (SSG), and industrial minerals subsectors are listed in Appendices D, E, and F. For each question, the frequency distribution, or aggregate measurement for each category, is listed. The reporting of results back to mine sites in this fashion was desirable for the mine's benefit. For example, while an average could have resulted in a high 4, trending toward agreement, there may have been a large percentage of a mine's sample disagreeing with certain construct items. The percentages gave mines more information and allowed them to target specific interventions not only by construct, but by question. For these reasons, both the mean and frequency distribution communicated different and very important pieces of information for benchmarking purposes.

Additional analyses have also been completed and published to examine differences in certain demographics and impact on workers' perceptions and H&S performance. One paper [Haas et al. 2018b] examined the differences in safety climate perceptions between mining companies who promote autonomous work environments versus those who maintain more general management. Other papers [Haas et al. 2019; Hoebbel et al. 2019] have examined differences in workers' experience levels and impact on risk tolerance, compliance, and overall H&S performance in the industry. Finally, analyses have examined the role of demographic variables in workers' risk tolerance, sense of control, and experiencing near miss incidents [Haas and Yorio 2019]. Results found that education was the only significant variable impacting near miss experiences.

Safety Climate Benchmarks in the Mining Sector

In this section, initial benchmarking data for each safety climate construct are reported and established, including the dependent variables measured within the survey. The figures within this section visually show the benchmarks, or averages, for the overall sample and within each subsector. The figures show the results on the 1 to 6 Likert-based scale.

Proactivity: Survey items 1–5

The averages for proactivity among each subsector were close to the overall sector average. As shown in Figure 1, coal and industrial minerals rendered a slightly lower average (4.85 on a six-point scale) than the overall average, while SSG came out with a slightly higher average (4.98). These averages, all nearing 5 or "agree," indicate that workers perceive themselves to be proactive and make efforts within their control to identify, report, and fix potential hazards. The omnibus Kruskal-Wallis test showed a statistically significant difference across the three mining subsectors (2, n = 2,646) =18.42, $p < 0.001$. Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level (0.05/3 = 0.016667) suggested that SSG was significantly different from both coal and industrial minerals ($p<0.001$). Coal and industrial minerals were not significantly different from each other ($p=0.89$). However, with the minimal deviation in averages, the differences are likely not practically significant. The 95% confidence intervals are: overall (4.88–4.95); coal (4.76–4.94); industrial minerals (4.79–4.91); and SSG (4.88–4.95).

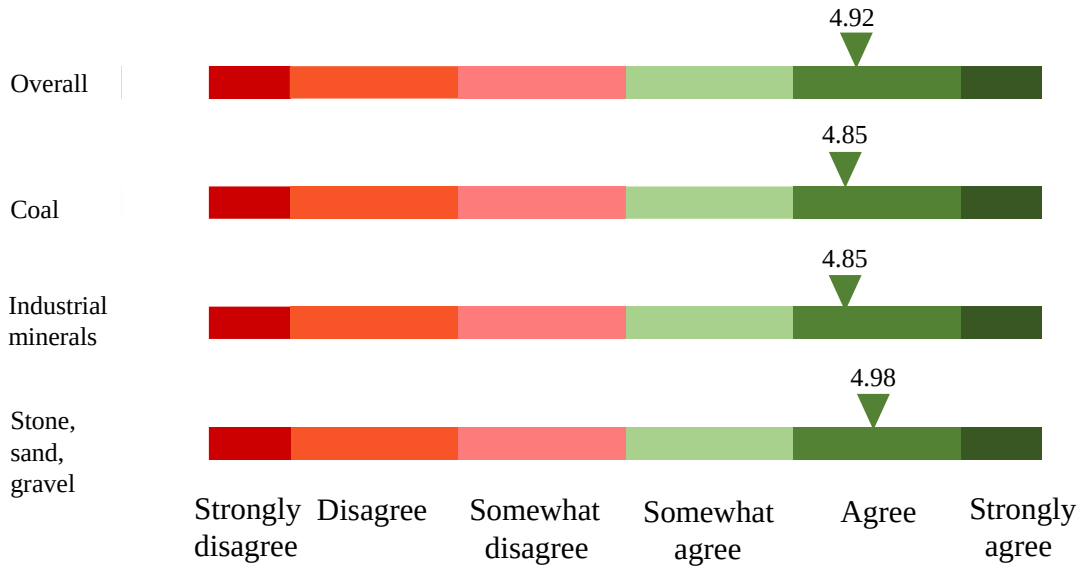

Figure 1. Proactivity averages overall and by subsector.

Compliance: Survey items 6–9

Figure 2 shows that the average for compliance was 5.26, which is a positive average and shows workers' strong perceptions of their rule-following practices on the job. As shown in Figure 2, coal is more than a quarter point lower than the average (4.95), whereas industrial minerals and SSG are both slightly higher than the average (5.31). The Kruskal-Wallis ((2, n = 2,634) = 60.68, $p < 0.001$) indicates that these differences among the three subsectors are statistically significant. Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that coal was significantly different from both SSG and industrial minerals ($p<0.001$). SSG and industrial minerals were not significantly different from each other ($p=0.70$). Notably, it appears that the compliant practices of coal miners may be significantly lower than the other two subsectors.

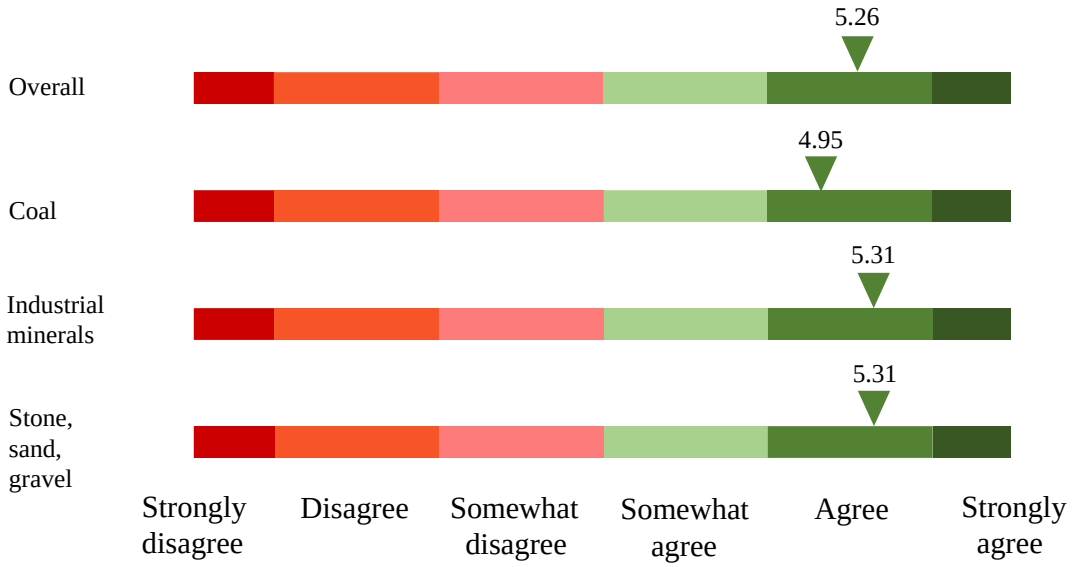

Figure 2. Compliance averages overall and by subsector.

Organizational Support for Health and Safety: Survey items 23–25

For organizational support for H&S, Figure 3 shows some deviation among the subsectors. The overall average was 4.36, trending lower but still in the positive range. The coal subsector produced an average of 4.05, barely over the "somewhat agree" response. The industrial minerals subsector reported the highest average at 4.53. The Kruskal-Wallis test ((2, n = 2,618) = 53.32, p < 0.001) indicates that these differences among the three subsectors are statistically significant. Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that each of the commodities were significantly different from one another at the p<0.001 level. As shown in Appendix B, the questions within this scale focused on ignoring H&S rules to get the job done and feelings of impossible production pressures.

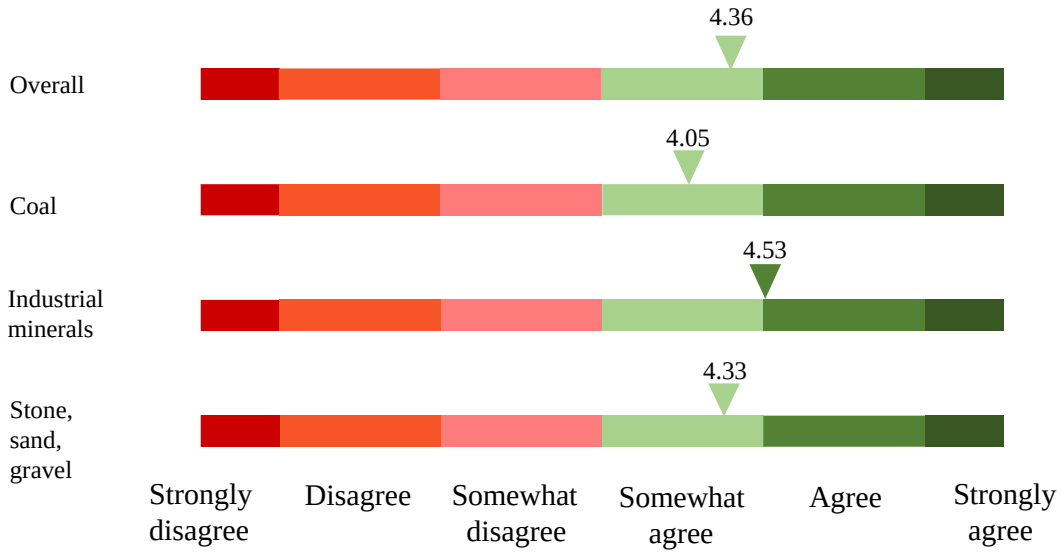

Figure 3. Organizational support for health and safety averages overall and by subsector.

Supervisor Support for Health and Safety: Survey items 29–31

Perceptions of supervisor support for H&S were consistent among subsectors, with the overall average being 4.85. Figure 4 shows that all three subsectors are within approximately one-tenth of each other. So, although the Kruskal-Wallis results are statistically significant ((2, n = 2,644) = 8.99, p < 0.011), with the minimal deviation in averages with the minimal deviation in averages, these differences may not be practically significant. Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that coal was not significantly different from SSG (p=0.65) or industrial minerals (p=0.02). SSG was significantly different from industrial minerals (p=0.006).

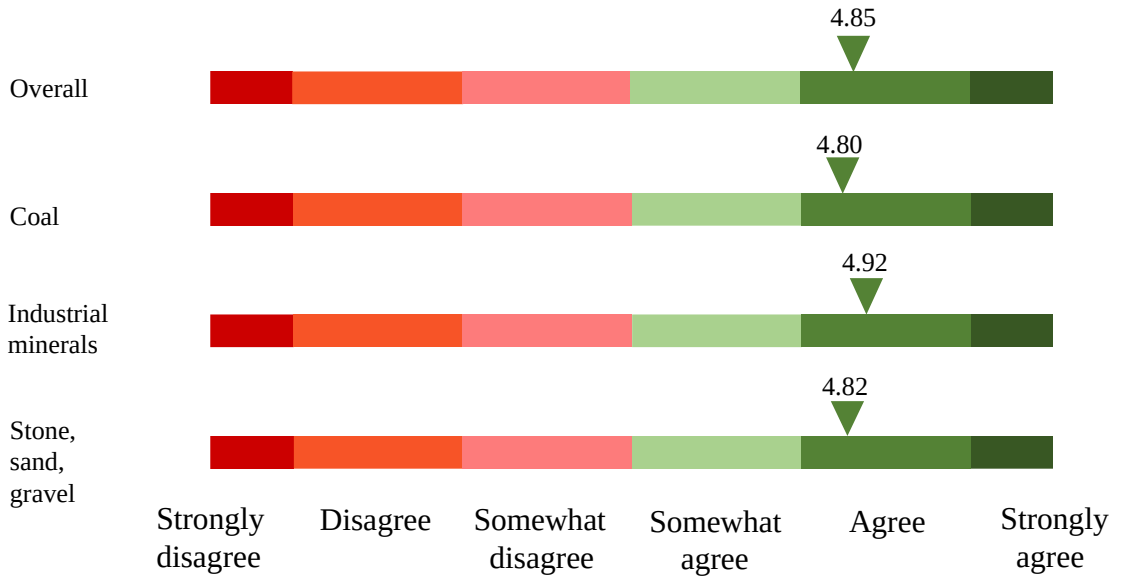

Figure 4. Supervisor support for health and safety averages overall and by subsector.

Supervisor Communication: Survey items 32–38

Perceptions of supervisor communication resulted in larger differences among subsectors. The SSG subsector revealed an almost identical average to the overall sample (4.76) whereas coal was lower (4.58) and industrial minerals was higher (4.80). Figure 5 shows these results, which were also significant ((2, n = 2,604) = 13.80, p < 0.001). Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that coal was significantly different from both SSG and industrial minerals (p<0.001) and industrial minerals and SSG were not significantly different from each other (p=0.24).

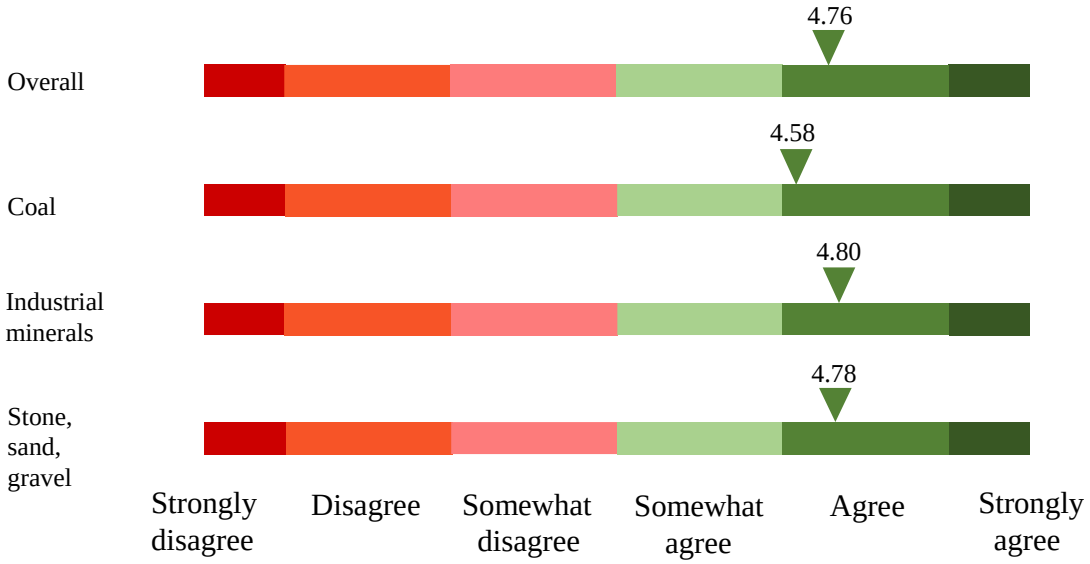

Figure 5. Supervisor communication about H&S averages overall and by subsector.

Coworker Communication: Survey items 26–28

The averages for coworker communication within each subsector were close to the overall average of 5.05. As shown in Figure 6, the industrial minerals subsector had the lowest average (4.90) whereas the coal and SSG subsectors were closer and even slightly above the average. These averages, all nearing 5 or "agree," indicate that workers perceive themselves to be communicative with each other about H&S on the job. It is possible that for the industrial minerals subsector, the nature of the work is sometimes more likely to involve the individual working alone and to be more scattered across an operation's surface. So, the opportunity to watch out for other coworkers or alert them about a potential hazard may not exist as often as in the other subsector. The Kruskal-Wallis test ((2, n = 2,658) = 10.27, $p < 0.006$) indicates that these differences among the three subsectors are statistically significant. Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that industrial minerals was not significantly different from coal or SSG (p=0.03 and p=0.24, respectively). Coal and SSG were significantly different at the p<0.001 level but, with the minimal deviation in averages, are likely not practically significant.

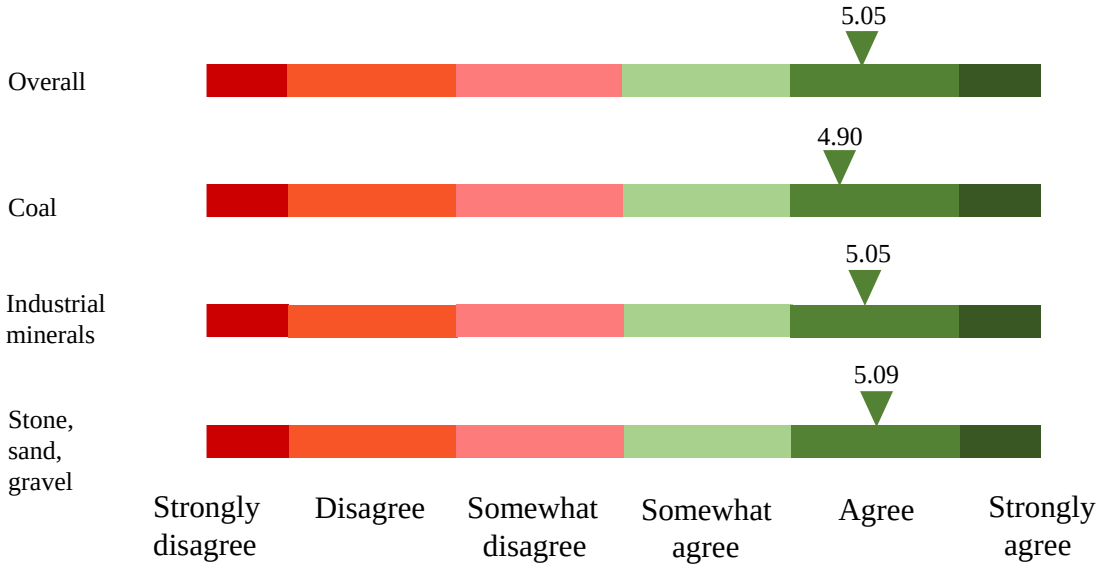

Figure 6. Coworker communication about H&S averages overall and by subsector.

Worker Engagement: Survey items 39–42

The overall average for worker engagement was 4.53. As shown in Figure 7, the industrial minerals sector had the highest average (4.64) with the SSG subsector not far behind (4.54). The coal subsector was almost half a point lower than these other averages. It is possible that for the coal subsector, more processes are regulated than for the other two, so participation in H&S rules may not always be an option. Depending on the relative weight of worker engagement on worker proactivity and compliance, it may be beneficial for coal practitioners to identify additional opportunities to involve workers in health and safety procedures and decision making on site. The Kruskal-Wallis test was (2, n = 2,640) = 43.69, $p < 0.001$), which indicates that these differences among the three subsectors are statistically significant. Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that coal was significantly different from both industrial minerals and SSG at the p<0.001 level. Industrial minerals and SSG, however, were not significantly different (p=0.07).

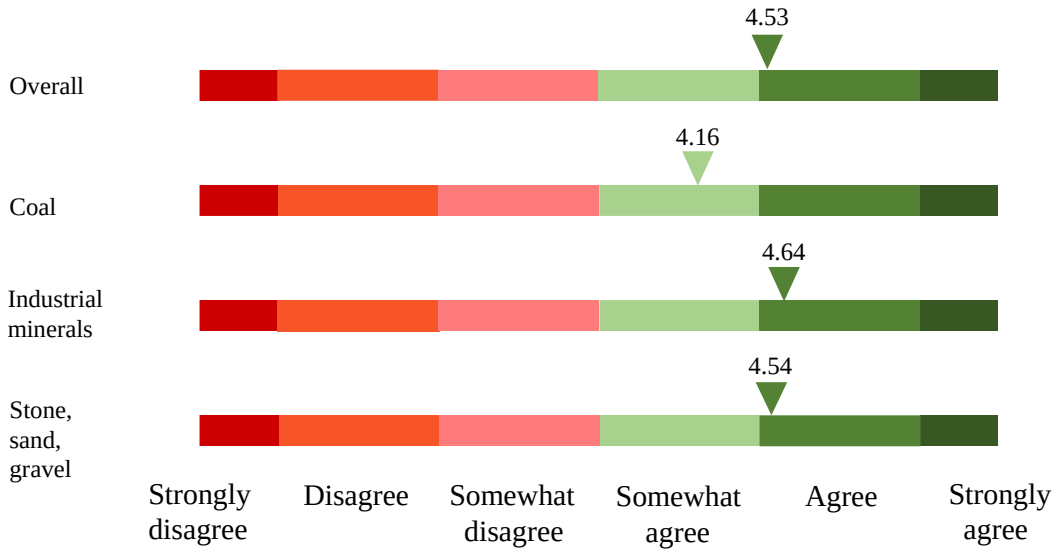

Figure 7. Worker engagement averages overall and by commodity overall and by subsector.

Health and Safety Training Adequacy: Survey items 49–51

The overall average for training adequacy was 5.15. As shown in Figure 8, the industrial minerals subsector had a visually higher average (5.32) with the SSG subsector following at 5.09 and then coal at 4.96. The Kruskal-Wallis test was (2, n = 2,625) = 53.55, p < 0.001), which indicates that these differences among the three commodities are statistically significant. However, all averages are high, indicating that most all workers have a positive view of current H&S training. Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that industrial minerals was different from both coal and SSG at the p<0.001 level. Coal and SSG were not significantly different from each other with the p value being right above the Bonferonni adjusted level of significance, p=0.017.

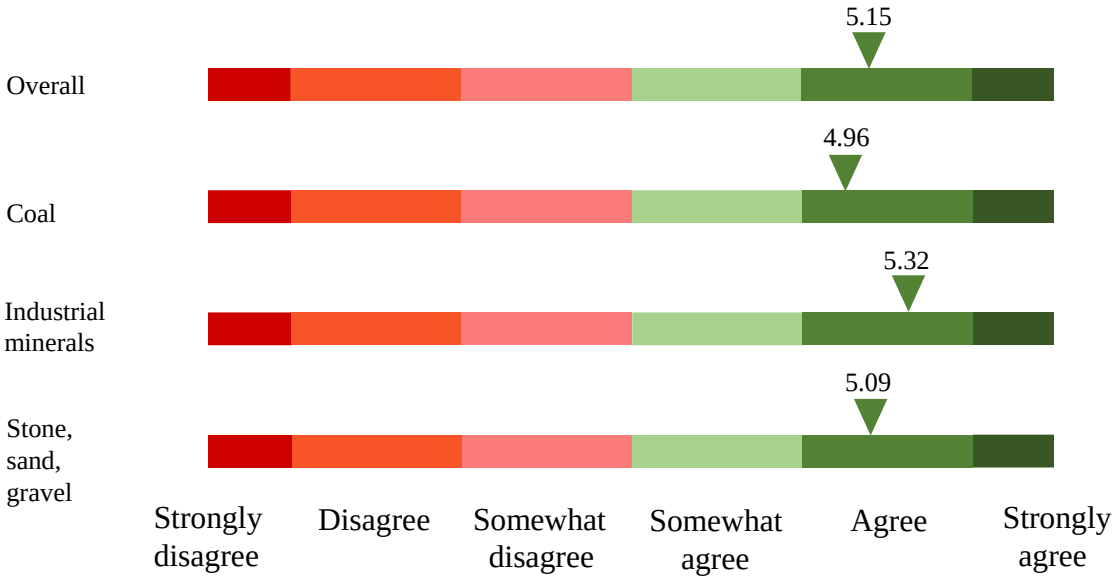

Figure 8. Health and safety training adequacy averages overall and by subsector.

Worker Adaptability: Survey items 52–54

Adaptability did not have much variance among the subsectors, all being in the average 4-point range. Figure 9 shows the similar averages for the mining sector and the three subsectors. The Kruskal-Wallis test was (2, n = 2,622) = 1.82, p =0.403), which indicates that these differences among the three commodities were not statistically significant. Follow-up, pairwise comparisons using the Mann-Whitney test confirmed the findings of the omnibus test. As RWA tests reveal later, adaptability also did not demonstrate significant differences for these groups.

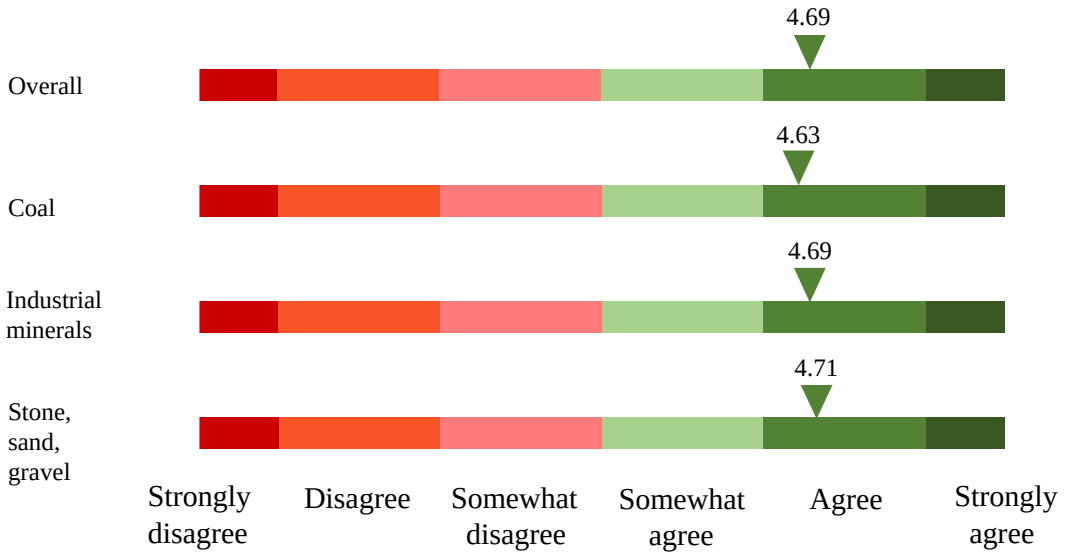

Figure 9. Worker adaptability averages overall and by subsector.

Risk Tolerance: Survey items 19–22

The results for risk tolerance (Figure 10) showed statistical differences among the subsectors ((2, n = 2,662) = 37.50, p < 0.000). The industrial minerals subsector (5.30) and SSG subsector (5.33) were both slightly above the average whereas the coal subsector was slightly below (5.06). Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that coal was significantly different from both industrial minerals and SSG at the p<0.001 level. Industrial minerals and SSG were not significantly different (p=0.39). However, all averages were high, indicating that a large percentage of the mining workforce does not regularly take risks on the job and has a low tolerance for risks on site. Of interest in this construct scale was often one question that asked workers if they took risks regularly. Within the overall sample, about 12% of participants reported taking risks on a regular basis. This prompted some companies to address risk tolerance, as highlighted in the Discussion section.

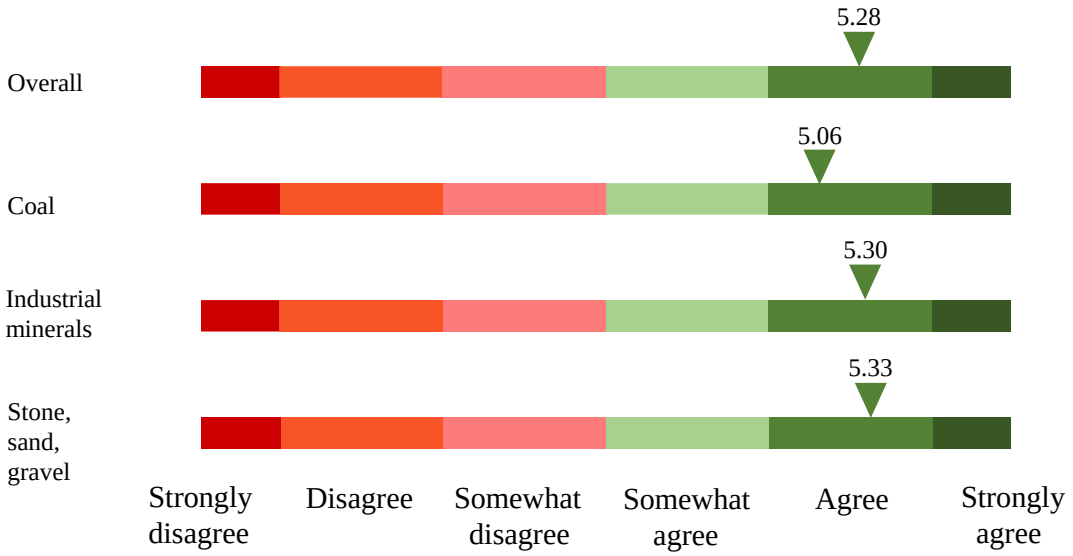

Figure 10. Worker risk tolerance averages overall and by subsector.

Worker Sense of Control: Survey items 10–13

The results for sense of control are shown in Figure 11. The results demonstrated statistical differences among the subsectors ((2, n = 2,642) = 7.11, p < 0.029). Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that only coal and industrial minerals were significantly different from each other (p=0.008). All of the averages were grouped close together, between 4.57 and 4.68. This construct resulted in the lowest average for the internal set of safety climate constructs, mainly due to workers' responses in that they do not have control over certain health and safety outcomes or work decisions on site. Specifically, almost 47% of participants reported most H&S problems not being within their control.

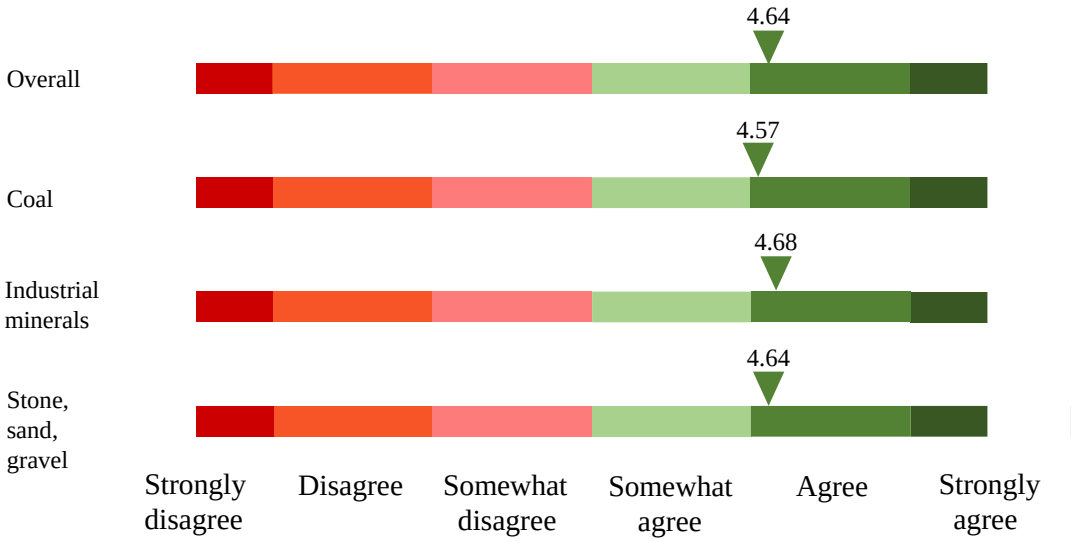

Figure 11. Worker sense of control averages overall and by subsector.

Worker Thoroughness: Survey items 14–18

Thoroughness averages (Figure 12) showed statistical differences among the subsectors ((2, n = 2,625) = 13.46, $p < 0.001$). Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that only coal and SSG were significantly different from each other ($p<0.001$). Again, the averages were grouped close together, between 5.11 and 5.25. This construct rendered higher averages than most internal safety climate constructs, indicating that workers feel confident in their precision and duty to complete their job tasks. This high self-assessment of thoroughness is assuring, as the RWA results reveal thoroughness as a heavily weighted predictor for worker H&S performance and outcomes.

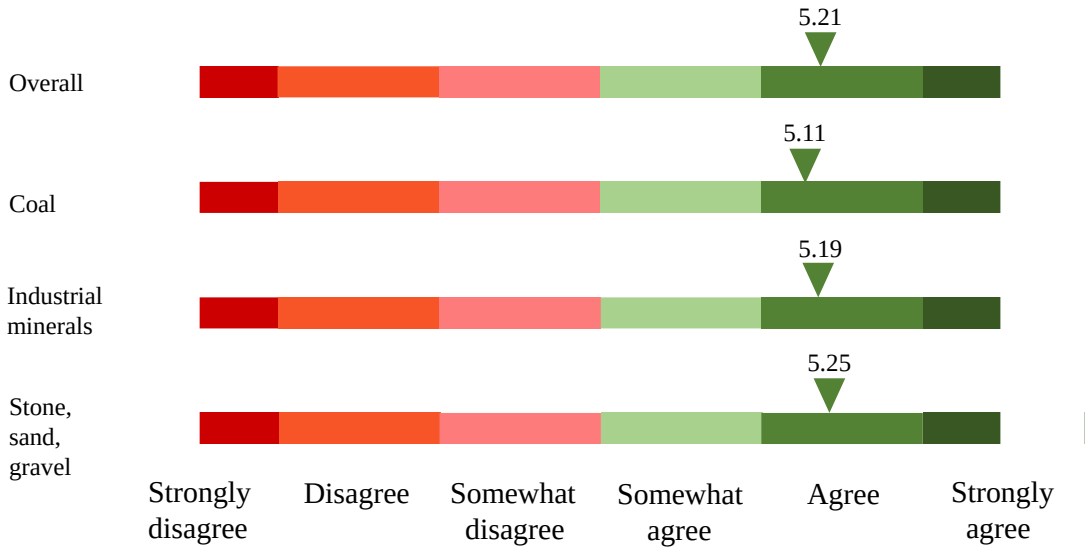

Figure 12. Worker thoroughness averages overall and by subsector.

Health and Safety Knowledge

Health and safety knowledge served as a proximal predictor to worker H&S performance and, therefore, was treated as a dependent variable in the subsequent RWAs. The benchmark results did show statistical differences among the subsectors ((2, n = 2,623) = 32.33, p < 0.001). Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that coal was significantly different from both industrial minerals and SSG at the p<0.001 level. Industrial minerals and SSG were not significantly different p=0.53.The lowest average was the coal subsector with 5.04. However, this average is still very high, being in the "agree" range and indicating that workers feel like they have a sense of how to use equipment and execute the procedures necessary on the job to stay safe. Figure 13 shows these averages.

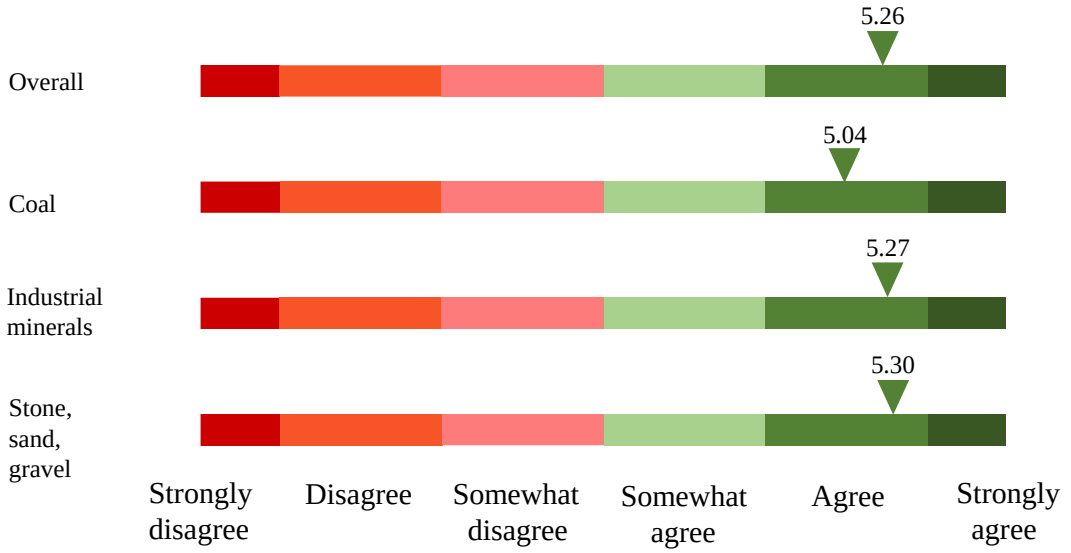

Figure 13. Health and safety knowledge averages overall and by subsector.

Health and Safety Motivation

Health and safety motivation was the other proximal predictor to worker H&S performance and, therefore, was treated as a dependent variable in the subsequent RWAs. The results are shown in Figure 14, revealing statistical differences among the commodities ((2, n = 2,638) = 12.05, p < 0.002). Follow-up, pairwise comparisons using the Mann-Whitney test and Bonferroni adjusted significant level suggested that coal was significantly different from both industrial minerals and SSG at the p<0.001 level and industrial minerals and SSG were not different from each other. However, with all the averages being extremely skewed to the right and close to the average, the practical difference is likely non-existent.

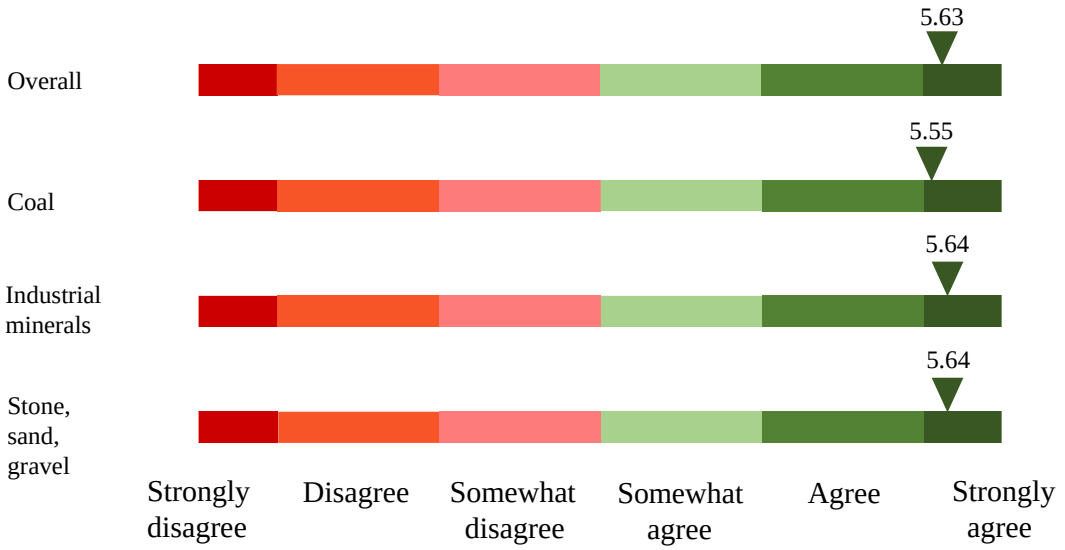

Figure 14. Health and safety motivation averages overall and by subsector.

Although these results provide a benchmark for each construct or factor represented within the survey, assumptions of benchmarking studies indicate that the "better" or "higher" performing workers more often contribute to current benchmarks [Healey et al. 2012]. Therefore, it is possible that the highest scores reported within the surveys could be slightly inflated and should be taken into consideration when interpreting these results.

Differences among Subsectors

As the above breakdown by subsector illustrated, coal workers often had lower perceptions than those workers in SSG or industrial minerals, although not all were statistically significant. For example, there was a mean difference of 0.48 when comparing perceptions of organizational support between coal miners and industrial minerals miners. It is important to note when interpreting these results that, in general, the averages for each scale among each subsector is relatively high. That is, even though the coal subsector experienced lower averages, the averages tended to still be in the "somewhat agree" to "agree" range. Even so, with this trend in the results, it is important to consider that even small differences on a perception scale can equate to meaningful differences at the organizational level as well as in individual-level outcomes.

This is the first study (to the authors' knowledge) in which a breakdown of mining subsector differences has been reported in the United States. In a recent systematic review of safety outcomes and H&S performance in high-risk industries, underground mining was not included because the commodity was said to represent highly specific risks [Cornelissen et al. 2017]. However, there is some overlap in results with a large safety culture initiative in the Australian mining industry surveyed coal and gold mine workers, where coal miners at the hourly/contractor level were significantly more negative [SAFEmap 1999].

Although it is difficult to speculate all the reasons why U.S. coal miners reported lower perceptions in the current study, underground coal mining has been reported as more complex and dynamic than other types of mining and specifically, has been encouraged—but not required—to go beyond the mandated rules and regulations, and adopt comprehensive occupational HSMS [Zhou et al. 2018]. However, research has argued that the diffusion of HSMS and specifically, risk-based processes, have been slow to take hold in the coal subsector [Yang 2012]. Therefore, when discussing the weighted results and takeaways in the subsequent sections, management and practitioners representing the coal mining industry may be able to glean more in the areas of worker empowerment and leadership.

Significant Predictors of Workers' H&S Performance

The relative weights regressions were used to determine which factors were the most influential in worker proactive and compliant H&S performance. This analysis includes the ranking of each factor based on its contribution to R^2. R^2 is the percentage of the variation in the dependent variable(s) that is explained by each factor when determining the overall contribution to worker proactivity and compliance. For easier interpretation, rather than present the raw relative weights that sum to the observed value of R^2, the rescaled relative weights (RS-RW) are presented. The RS-RW percentages for each predictor within the tables sum to 100 percent.

Predictors of Proactivity

This first model showed that all 10 safety climate constructs were significant predictors of worker proactivity. The overall model fit was $R^2 = .32$, or 32.24%. According to Cohen [1988], this R^2 indicates a large effect size and shows promising areas of inquiry within certain factors. Table 9 lists the RS-RW of each construct.

Table 9. Weighted impact of safety climate constructs on worker proactivity using overall sample. All 10 constructs are significant at the *p* = .05 level

Construct Rank	Proactivity RS-RW (%)
Thoroughness	20.76
Sense of control	17.06
Risk tolerance	13.16
Worker engagement	12.36
Coworker communication	8.88
Supervisor communication	7.36
Adaptability	7.14
Supervisor H&S support	6.07
H&S training	5.65
Organizational H&S support	1.57

For workers' proactivity, or their willingness to take initiative and report or fix H&S issues, a personal sense of thoroughness and control over their job tasks were the highest predictors at 21 and 17%, respectively. In addition, workers' personal levels of risk tolerance (13%) and their involvement or engagement in H&S activities on site (12%) were also greater predictors of proactivity.

Appendices G, H, and I show the ranking of the factors within each subsector. These models show that, although most if not all constructs are statistically significant, some had less of a weighted contribution to the subsector model. Thoroughness was either the first- or second-largest predictor for the three subsectors, while risk tolerance and sense of control also remained at the top. Of interest is that worker engagement was the most prevalent organizational factor that influenced workers' proactivity and was even the highest-weighted construct within the industrial minerals subsector (21%). Similarly to the overall model, coworker communication remained a steady contributor to worker proactivity across the industry subsectors, ranging from 8%–11%.

Predictors of Compliance

The compliance model showed that all 10 safety climate constructs were significant predictors of worker compliance. The overall model fit was $R^2 = .46$, or 46.70%. According to Cohen [1988], this R^2 indicates a large effect size and shows promising areas of inquiry within certain factors. Table 10 lists the RS-RW of each construct.

Table 10. Weighted impact of safety climate constructs on worker compliance using overall sample. All 10 constructs are significant at the *p* = .05 level

Construct rank	Compliance RS-RW (%)
Risk tolerance	30.60
Thoroughness	23.10
Coworker communication	10.50
Sense of control	8.70
Supervisor communication	5.50
Worker engagement	5.40
H&S training	5.30
Supervisor H&S support	4.60
Organizational H&S support	3.80
Adaptability	2.60

Looking at compliance, workers' risk tolerance was the predominant predictor at almost 31%. In addition, workers' thoroughness (23%) and then coworker communication (11%) were strong predictors of workers' compliant behaviors. H&S training, although a significant predictor, only contributed about 5% to the entire model. Additionally, organizational support for H&S only contributed about 4%. These areas typically receive ample attention on mine sites; however, the results indicate that a greater focus on workers' abilities to assess and communicate about risks during day-to-day operations may be more important in supporting workers' safety practices on the job.

Appendices G, H, and I show the ranking of the factors within each subsector. Of importance to the mining sector is that risk tolerance remained the largest predictor for all three subsectors, ranging from 26%–31%, showing that workers' risk tolerance or avoidance perceptions significantly contribute to their likelihood of following H&S rules on the job. Thoroughness was the second highest predictor for all three subsectors, ranging from 18%–26%. For compliance, coworker communication remained as a significant, noteworthy contributing variable ranging from 8%–13%. For the coal subsector, however, supervisor communication had a higher weight at 9%.

Predictors of H&S Knowledge and Motivation

Because knowledge and motivation are primary factors in precede-proceed models that lead to behavior change [Li et al. 2009; Noar and Zimmerman 2005], determining whether or not different factors emerged within these models was deemed important for mine practitioners to know. Tables 11 and 12 show the models for knowledge and motivation. The overall fit for the knowledge model was $R^2 = 0.5$ or 50.03%. The fit for the motivation model was $R^2 = 0.39$ or 39.74%. Tables 11 and 12 show the percentage of the variation that is explained by each factor when determining the overall contribution to workers' knowledge and motivation.

Table 11. Weighted impact of safety climate constructs on worker H&S knowledge. All 10 constructs are significant at the *p* = .05 level

Construct	Knowledge RS-RW (%)
Thoroughness	14.74
Worker engagement	13.15
H&S training	12.29
Coworker communication	12.17
Supervisor communication	11.30
Risk tolerance	10.57
Adaptability	9.65
Sense of control	7.99
Supervisor H&S support	5.97
Organizational H&S support	2.16

External constructs contributed more to the knowledge model than the previous H&S performance models. Particularly, in both the knowledge and motivation models, H&S training had a larger weight. Although training significantly and heavily contributed to workers' knowledge and motivation, the proactivity and compliance models show that it (training) does not necessarily translate to behavior change. The factors that consistently rendered high predictive utility throughout the models such as risk tolerance, thoroughness, worker engagement, and coworker communication can be considered factors that are critical to emphasize during site activities. Potential efforts to improve and maintain these predictive factors will be discussed later.

Table 12. Weighted impact of safety climate constructs on worker motivation. All 10 constructs are significant at the *p* = .05 level

Construct	Motivation RS-RW (%)
Thoroughness	18.35
Risk tolerance	17.52
H&S training	16.96
Adaptability	12.00
Sense of control	9.16
Coworker communication	8.77
Supervisor communication	5.75
Worker engagement	5.34
Supervisor H&S support	3.65
Organizational H&S support	2.50

Significant Predictors of Workers' H&S Outcomes

The final RWA models included the four types of incident occurrences that were measured. For these four items, frequencies were low, considering that most incidents, especially days lost, are not prevalent in the industry much less at individual participating mine sites. However, being able to compare the predictor utility of the safety climate constructs in incident outcomes has merit in terms of where an organization needs to focus HSMS efforts to prevent future accidents [Robson et al. 2007; Yorio et al. 2015]. Table 13 shows that together, the safety climate constructs predicted approximately 8% (R^2 = 8.26%) of near misses experienced; 6% (R^2 = 5.72%) of first aid incidents experienced; 7% (R^2 = 7.29%) of incidents experienced that required medical treatment; and 6% (R^2 = 6.13%) of days lost among participants. This model still produced several statistically significant results although not as many as the prior models. The significant predictors are marked with an asterisk.

Table 13. Impact of safety climate constructs on worker H&S outcomes

Construct	Near misses RS-RW (%)	First aid RS-RW (%)	Med. Treatment RS-RW (%)	Days Lost RS-RW (%)
Organizational H&S support	36.02*	34.59*	36.71*	36.99*
Supervisor H&S support	8.12*	3.82	3.53*	4.42*
Supervisor communication	2.84	1.97	2.68	3.73
Coworker communication	1.38	1.69	1.79	1.45
Worker engagement	4.30*	2.56	4.41*	4.59*
H&S training	14.45*	15.13*	12.56*	13.27*
Sense of control	2.31	3.05	2.94*	3.79
Thoroughness	11.16*	19.35*	20.36*	21.81*
Risk tolerance	18.96*	15.95*	11.19*	8.43*
Adaptability	0.46	1.86	3.80*	1.52

*Statistically significant at the p = .05 level.

Organizational support for H&S was the largest predictor (34%–36% of the variance) of each incident outcome. This construct was significant for the previous models but had the lowest weighted impact on H&S performance, knowledge, and motivation. The individual questions within the organizational support construct relate to going around safety rules to get the job done or feeling pressure to produce. The current results indicate that ignoring safety procedures and feeling pressured to cut corners can significantly influence a near miss or even an incident at some point in time.

Training, thoroughness, and risk tolerance remained as large and significant predictors of the four outcome variables. Also, supervisor support predicted 8% of the total variance of near misses, indicating that supervisors' attention to safety details on site may impact workers' willingness to acknowledge and potentially report a near miss. Subsector results are presented in Appendices G, H, and I and indicate the importance of the organizational constructs in preventing lagging indicators. Although there were fewer constructs that achieved statistical significance in these outcome models, the constructs that were significant contributed large weights, providing a clear path for practitioners to focus on.

Discussion—Improving Safety Management Practices

The results provide new insights in how to improve workers' H&S on the job while supporting what research has found. Although previous research has established the influence of both organizational and individual factors on H&S performance [e.g., Cox and Flin 1998; Guldenmund 2000; Hofmann et al. 1995; Mearns et al. 2003], research that shows the impact of these two areas together on worker H&S performance has not been done. The results provide the mining industry with additional areas of specific focus and the value of focusing on individual factors when trying to make improvements on the organizational level. For example, similar occupational H&S studies (not specific to mining) have shown that management support or management commitment is the strongest predictor of worker behaviors and injury outcomes compared to other safety climate constructs [Beus et al. 2010; Christian et al. 2009; DeJoy et al. 2010]. While management support and communication were found to be significant predictors as other studies have shown [e.g. Clarke 2010; Nahrgang et al. 2011], they were certainly not the strongest predictors for any of the outcomes measured. However, the current study did show that organizational support was the most significant predictor for near misses and incident outcomes.

Kirwan [1998] discusses safety management as the actual practices, roles, and functions associated with remaining safe on the job. These practices, which can be a sub-system of the HSMS, are meant to be integrated into the organization's overall procedures and strategies in an effort to control hazards and respond to risks [Labodova 2004; Vinodkumar and Bhasi 2010]. Further, safety management practices have been regarded as an antecedent, or predictor, of an organization's safety climate [Vinodkumar and Bhasi 2010]. As a result, gleaning ways to improve safety management practices, based on the current safety climate benchmarks and weighted analyses, can function to improve workers' perceptions of the safety climate later. Consequently, this section focuses on specific safety management practices that can be employed by organizations and site leadership to improve specific organizational and individual factors of interest.

Notably, the results showed that personal constructs were the most influential in predicting workers' H&S performance. Other research has shown consistent relationships between personal states and safety performance. For example, studies [Beus et al. 2015; Clarke and Robertson 2005] found that conscientiousness (also known as thoroughness), was negatively associated with unsafe work acts. These researchers also found that risk tolerance and specifically, sensation-seeking personalities, are more strongly related to unsafe behavior. However, uncovering the roles of person-based factors among workers, especially in relation to organizational factors, has not yet been achieved.

These results also show the value of organizations accounting for and responding to both the organizational and personal factors where possible. In most cases, addressing these two areas may occur simultaneously due to their interdependencies. To that end, the discussion provides examples of interventions that can be disseminated on an organizational level to influence workers' personality-based factors on the job. Examples provided stem from actual interventions developed and implemented at mine sites to improve constructs of their site-specific results and are provided as prompts to assist other H&S practitioners.

Going beyond Annual Refresher Training

A similar, primary way in which the mining industry prepares workers to work both proactively and reactively on the job are via standards developed by the Mine Safety and Health Administration (MSHA) that include provisions on who needs to be trained, how much training is needed, who can provide training, and subject areas to be covered. These requirements are included in the Code of Federal Regulations (30 CFR § 48) on training and retraining of underground coal workers. A similar regulation, Part 46, is in place for metal/nonmetal. Within the current results, it is safe to assume that most of this new employee, annual refresher, and other task training is adequate, considering the high benchmark as well as its significant contribution to worker knowledge within the study. Although H&S training emerged as a strong predictor of workers' knowledge on the job, it had a smaller weight on workers' actual H&S performance in terms of proactivity and subsequent decision making.

This is an important point to emphasize considering that in many cases organizations may assume that more safety training is an answer and can encourage safer work practices. For example, some argue that if training is required by an entity such as MSHA or OSHA, then it must be done and can be used as a quick solution to worker performance issues [Machles 2007]. However, more training does not necessarily account for the individual factors measured within the survey such as risk tolerance and, ultimately, safety decisions. Some even argue that using training to address H&S performance or compliance issues is an ineffective use of resources [Machles 2007]. Although a strong statement, limited research has found that the quality of safety training is more important than quantity [Burke et al. 2006] and, specific to mining, research has shown that increased hours of workplace safety training—in its generic and often-used form—does not impact workers' tolerance of risks and subsequent decision making on the job [Lehmann et al. 2006].

With the current results supporting that training is not a strong predictor of worker decision making, emphasizing other elements of an organization's HSMS remains critical for the mining industry. Specifically, management may need to focus on improving workers' opportunities and involvement to increase workers' sense of control, as well as actual control, and confidence. Additionally, enhanced communication with workers may be necessary in order to identify what the root causes of certain problems are, such as an equipment issue or even peer pressure [Machles 2007]. For instance, research has shown that the transfer of any training into practice will not occur if workers do not have adequate levels of self-efficacy and control as well as support from their management [Grossman and Salas 2011]. Therefore, rather than work to "provide more training," the focus should be on improving the level of follow-up and communication that starts when the training commences and continues thereafter. Dated research has argued that people often forget 90% of what they learned within 3–6 days, unless learning is

reinforced with multiple repetitions [Ebbinghaus 1913]. However, more recent research shows that this percentage of forgetfulness is highly variable based on workers' preexisting knowledge and their motivation [Thalheimer 2010].

Regardless of the percentage of content that workers remember, it is obvious that efforts need to be made within the organization to promote H&S practices and instill a sense of autonomy to motivate workers to make their own decisions [Haas et al. 2018b, NIOSH 2016]. This can be done by first, including training on the development of soft skills (i.e., communication) among the workforce as well as empowerment training to ensure that workers have the ability and support to take action prior to a supervisor's approval. Examples of how some companies have tried to address soft skills during trainings and subsequently on the job are discussed below.

Developing workers' soft skills

The transfer of any mandated training, such as MSHA's annual refresher courses, may be more useful if the training itself does a better job of improving workers' internal factors as a means to sustain their communication and motivation levels. A CRH company, Oldcastle Materials Group, made an effort to do just that; the company updated its ARTs to not only include the required MSHA topics, but also modules including types of communication, improving worker communication, leadership, teams, teambuilding, teamwork, and risk tolerance.

It appears that, for this small case group, participants appreciate when trainings go beyond the basic H&S content that has become the norm. For example, in an evaluation of the new soft-skills ART content outlined above, workers listed what they liked best about the training program. The most common responses aligned with the following topic areas:

- Learning about communication
- Leadership training
- The bar just got moved higher
- Kept the class interactive
- Interaction of all employees
- Good group discussion and participation from small groups
- Better than the same old safety stuff
- One more step upward in the improvement process

Although this is just one company case, this example shows that the content of these ARTs can and should be more carefully considered as a part of the overall HSMS on site. Specifically, incorporating more "soft skills" (i.e., not engineering) about communication, leadership, and how to intervene when risks are identified, could be something that all mine sites, as in the above case, are eager to learn. An example of the same company trying to incorporate some of these soft skills around listening and communicating is shown in Figure 15. The module within this workbook is situated within other modules around effective communication, teamwork, and leadership. Within this specific section, however, efforts were taken by the company to improve communication up and down the chain of command in order to more effectively achieve company goals. This topic speaks directly to common gaps that are heard when visiting mine sites and shows that targeted training efforts are possible within the mining sector.

05 LISTEN, WATCH AND TALK

"Nobody ever tells us what is going on!" "They never listen to us!" "Nobody asks our opinion!" "They treat everything like it is a big secret!" When at work, how often have we heard these comments or something similar to them being said? Who is "Nobody" or "They" employees are usually referring to in these cases? We have all heard these kinds of comments many times and "Nobody" or "They" generally refers to field, middle and senior managers.

The complete lack of communication or failure to communicate up and down the chain of command in the workplace is one of the biggest complaints voiced by employees. Both at work and in personal relationships, good communications are essential for success. In the workplace, employees who do not know what they are expected to do will not perform at their highest level. From the research we have learned most workplace issues related to unsatisfactory employee performance are frequently the result of poor communication.

1. Research shows inadequate or poor communication contributes to poor employee attendance, morale, performance and productivity.

a. ☐ *True*
b. ☐ *False*

2. Companies that communicate frequently and effectively with their employees find them be more engaged.

a. ☐ *True*
b. ☐ *False*

3. Companies which have effective communication with their employees:

a. ☐ *Have a higher employee turnover rate*
b. ☐ *Have a lower employee turnover rate*
c. ☐ *There is no difference in employee turnover rate*

Workplace communication is critical to companies because it contributes to improved production by increasing employee engagement and efficiency. Research indicates employees who have the freedom to communicate up and down the chain of command tend to have better attitudes, strive to be more productive and are more committed to achieving company goals. Employees, who have the freedom to communicate up the management chain; who are really listened to by managers and who are given timely feedback, experience greater job satisfaction. In turn, employees who are more satisfied with their jobs tend to come to work each day and stay with the company, thus reducing absenteeism and the turnover rates.

4. Good communication between workers and supervisors does not contribute to overall company performance.

a. ☐ *True*
b. ☐ *False*

7

Figure 15. Excerpt from CRH Oldcastle Materials Group ART [McGuire and Snead 2017].

Empowerment initiatives to develop an accountable workforce

Known as workers' rights under several MSHA regulations, including the Federal Mine Safety and Health Act of 1977, workers have the right to refuse to work in unsafe or unhealthy conditions—as long as the supervisor was notified and given time to correct the risky situation [MSHA 2010]. OSHA also includes training about workers' rights and encourages workers to initiate or request a temporary shutdown of work activities that are perceived to be unsafe [OSHA 2016].

This action has also been termed "empowerment training" and has been included in safety leadership development training and instruction in the construction industry by the Center for Construction Research and Training (CPWR) [2015] and may be useful for the mining industry. For example, within their foundations for a leadership safety development guide, one of the five skills or actions of an effective leader is to engage and empower team members. This can be done by encouraging workers to identify and act upon unsafe situations by reporting hazards, near misses, and other safety concerns, providing solutions, and stopping work if necessary [CPWR 2015; Schneider 2017].

Tasks discussed that leaders can do to engage and empower their workforce is to explain why safety is critical and engage workers in safe decision making—which was one question within the worker engagement section of the NIOSH survey. The CPWR training [2015] also discusses the importance of having pre-shift safety meetings as well as worker-manager discussions and walk-arounds throughout the day, also aspects that have been emphasized as a result of the current NIOSH survey [e.g., Haas 2019]. Finally, leadership can further empower workers to report site hazards or risks by developing and completing a list that shows when issues were raised and how they were addressed by the organization, which helps establish accountability on behalf of both management and the workforce [CPWR 2015; Haas and McGuire 2019]. Additional efforts to improve worker engagement and accountability are also discussed in a subsequent section of this report.

Intervening to Change Risk Tolerance

Research suggests that individuals make risk-based decisions based on their individualized concept of risk [Eklöf and Törner, 2002; Huang et al., 2007; Mearns et al. 2001b; Rundmo 2001; Slovic et al. 2005]. Therefore, one advantage *or* disadvantage, depending on the individual, is that risk tolerance is an emergent state that can change over time [Sitkin and Weingart 1995]. As a result, it may behoove organizations to improve any risk assessment processes or programs that occur onsite.

Individual risk assessment contains three steps, as outlined by Fennell [2017]: (1) hazard recognition; (2) perception; and (3) decision making. In general, most operations have mechanisms in place for hazard identification and subsequent risk perception such as job safety analyses [OSHA 2002]. However, the greatest threat is rarely missing a hazard but rather, failing to mitigate the hazard due to a high, inaccurate tolerance for risks [Fennell 2015; Jones 2015]. Fennell [2015] argued that, rather than conduct training about hazard recognition and risk perception, more attention should be given to this third step—the decision-making process [NIOSH 2006].

With the above context in mind, practitioners need to better understand what contributes to workers' high levels of risk tolerance in order to build an effective risk management program [Jones 2015]. Fennell [2017, 2015] proposed 10 risk tolerance factors that overlap with previous research [e.g., Eklöf and Törner 2002; Harrell 1990; Huang et al. 2007; Mearns et al. 2001b; Rundmo 2001]. These factors have been adopted by several high-risk industries and, in some cases, are displayed at mine sites to prompt specific conversations around this issue. The following 10 risk tolerance factors are often addressed in additional ways with the workforce:

1. Overestimating capability or experience
2. Familiarity with the task
3. Severity of the outcome
4. Voluntary actions and being in control
5. Personal experience with an outcome
6. Cost of non-compliance
7. Confidence with the equipment or task
8. Confidence in protection and response
9. Potential profit or gain from risky actions
10. Role models accepting risk

These 10 risk tolerance factors can be addressed in additional ways with the workforce. Mainly, it is important for the organization and management to address these 10 factors via communication and support to the workforce. One method commonly used has been organizations utilizing employees to be advocates for messages around risk-taking and risk tolerance. As one example, a large aggregates company created a series of risk tolerance videos that featured members of its safety teams that focused on each one of these 10 factors. These videos are publicly available on YouTube and referenced by other companies [e.g., Callanan Industries 2019] in an effort to guide workers' safe decision making when confronted with a risky situation as well as advocate support for taking action to quickly prevent or mitigate an incident if necessary. Other companies have created similar videos that, although not shown on YouTube, are distributed company-wide to promote workers' assessment of risks and appropriate response to those risks.

Organizations do not have to undergo large social media efforts; however, being aware that this survey has shown that approximately 10% of a workforce is likely to engage in risky behaviors on a regular basis and knowing some of the contributing reasons can be helpful when trying to intervene. It is also important to note that workers often accept both health and safety risks to get their job done [Haas et al. 2019; Schneider 2017]. However, one advantage is that risk tolerance or avoidance are emergent traits that can change over time [Sitkin and Weingart 1995]. Because numerous situations combine and interact over time to define the way that risk is holistically evaluated for each individual worker [Reason 1997], it is particularly important for management to reinforce safety communication and support on site and be aware of the 10 factors that contribute to risk tolerance and seek to prevent a sense of complacency or pressure among the workforce. Follow-up results with a handful of companies did show a substantial reduction in the number of employees who noted regular participation in risky behaviors, showing that working on decision-making efforts with workers rather than recognition efforts can be useful in sustaining safety. This is a significant, yet unreferenced area to date, except for some narrative-based research in health behavior and injury prevention [Cole 1997].

Improving Engagement Efforts

Engagement, although measured as an organizational construct in the current survey, has both organizational and individual roots. Kahn [1990] discussed engagement being made up of workers' value congruence, perceived organizational support, and core self-evaluations. Additionally, Ashforth and Humphrey [1995] argued that engagement accounts for both workers' motivation on the job as well as their behavioral tendencies that influence safety performance. Studies have shown that engagement significantly accounts for the relationships between several organizational and individual antecedents and worker performance outcomes [Rich et al. 2010]. For example, in Rich and colleagues' [2010] case study research with firefighters, they found that those who were more engaged at work not only invested significantly more energy on the job but also were more helpful and involved in ways to improve organizational outcomes. One hypothesis could be that those who feel more engaged at work could consider their job to have more "roles" in the organization that they affiliate with in addition to just their specific job-related tasks. In turn, they may contribute to more efforts and initiatives at work.

Although engagement as a construct in the current research effort scored as one of the lowest perceived organizational factors, it is important to note that engagement is made up of quickly changing moments and occurs in more of an ebb and flow [Kahn 1990]. For example, if recent initiatives occur on site that involve workers in some type of decision-making activity that positively affects them, it is likely that scores would be higher. Below is a list of examples that were discussed as employee-involvement initiatives that seemed to "work" in terms of being recognized by employees.

- Letting employees choose a new type of personal protective equipment (PPE) based on a variety of approved options. Examples of this sort of collaborative effort have been done previously, such as knee pad design research with NIOSH, MSHA, and participating mine companies. For examples of these sorts of collaborations on a research level, refer to Moore et al. 2011 and Moore et al. 2008. However, the current research has shown that maintaining daily activities and decision point in which everyone can be involved is critical to workers feeling involved in worksite processes.
- Creating and involving employees on different health and safety committees, including participation in walk-throughs and debriefs on site. Additionally, targeting specific groups who appear to have lower perceptions or perceived morale on site (e.g., specific age group, experience group) has demonstrated success.
- Improving, through documentation and management by walking around and communication quantity and quality throughout the workday.

These examples pick up on an important distinction between training the workforce and involving the workforce. Although training the mining community is critical, a more futuristic option, as discussed by Kohler [2015], is that, in comparison to traditional training, workers "should be empowered with knowledge, skills, and abilities, rather than 'trained,' to recognize and mitigate hazards" [p. 331]. Kohler [2015] goes on to discuss HSMS as a powerful framework to ensure worker and manager accountability in the successful implementation and measurement of health and safety efforts.

The challenge among the current sample was finding activities in which first, workers would readily participate and second, that they would perceive as activities in which their efforts were valued and used to improve health and safety initiatives. Research has shown that in order to foster value congruence for site safety, positive and consistent leadership is needed along with consistent opportunities for developed, shared perceptions of safety [Schwatka et al. 2016]. Within the current safety climate study, several mine sites noted that they have suggestion boxes, open door policies, or safety committees in which all opinions are considered and valued. However, as other worker participation efforts have shown in the construction industry, workers may be reluctant to give health and safety input at first due to a historic culture of blame [Schneider 2017].

As illustrated in the above intervention examples, finding ways for workers to participate in daily decisions on the job is critical to improving perceptions and workplace norms, ultimately affecting worker H&S performance. Schneider [2017], through the American Industrial Hygiene Association, offered several examples of how construction workers can participate in jobsite safety. Many of these examples are applicable to the mining industry such as workers participating in safety orientation sessions to learn how they can be involved in safety and even present aspects of the site orientation; help develop and present toolbox talks; help train or task train workers in hazard recognition and mitigation; be trained in and conduct safety audits on site; participate in worksite safety inspections and incident investigations; and be part of problem solving and planning teams in any health or safety area being addressed on site (paraphrased from p. 8).

Finally, by participating in NIOSH's safety climate surveys, companies were able to better determine which groups, if any, had more negative perceptions of safety and support on site. This allowed organizations and management to better target and involve certain groups of workers in future interventions. At one underground coal mine, for example, the group of workers who were between 35 and 44 with 11–20 years of experience had the lowest perceptions of safety climate in almost all areas of the survey measured. So, the company made specific efforts to further engage with this subgroup of employees and solicit involvement in the safety committee on site. In follow-up assessments, although their perceptions were still lower than other subgroups on site, their perceptions of management support and communication had improved.

Maintaining Thoroughness and Improving Sense of Control

The safety climate results showed that personal factors have a larger impact on worker H&S performance than those external factors measured in the survey. Therefore, being aware of how any changes to the HSMS processes or policies may impact aspects such as workers' thoroughness and perceived sense of control, is important. Specifically, the sense of control construct often received a low score across mine sites. Research has shown that individuals who have a higher, internal locus of control can more objectively deal with situations that occur on the job, have a better perception of their work environment, and are more motivated on the job [Erez and Judge 2001]. More specifically, workers with a higher internal locus of control have demonstrated better social skills [Ringer and Boss 2000] as well as more proactive qualities, and they tend to engage in problem-focused activities such as mitigating a hazard [Gianakos 2002; Ng and Butts 2009; Ng et al. 2006].

Although these are personal factors, these states can be influenced by organizational characteristics such as decision-making authority bestowed onto an individual (e.g., giving workers "stop work" authority if necessary), opportunities provided to use knowledge and skills, the option and ability to participate in site-wide initiatives [Karasek and Theorell 1990], and rewarding such decisions and actions that result in a safer workplace. It can be suggested, then, that the root cause, and perhaps a potential longer-lasting solution of organizational conflicts regarding workplace safety, may reside in understanding the processes undertaken by organizations to communicate with individuals. Specifically, short-term interventions and communication efforts can prompt changes to work practices but seldom maintain them [Mullan et al. 2015]. Rather, management and organizations determining ways to communicate with their workforce in ways that help appease or further develop intrinsic motivations rather than extrinsic motivations, has been deemed highly effective in high-risk industries [Laitinen and Päivärinta 2010; Lingard and Rowlinson 1997]. As an example, determining if a safety initiative is not endorsed as it should be can be useful in determining a misaligned communication between managers and hourly workers. In other instances, supervisors being visible on site and engaging in positive monitoring and feedback on the job have been shown to be effective in enhancing worker perceptions and behavior [Mullan et al. 2015]. Through greater understanding, communication, and involvement, practitioners can continually determine new ways to facilitate alignment between management and hourly workers.

Accountable Communication through Performance Assessments

Safety communication has been continuously encouraged in high-risk industries as an effective mechanism to enhance workers' awareness of safety and appropriate response to risks [Clarke 2003; Griffin and Neal 2000; Mearns et al. 2003; Probst 2004]. HSMS programs, such as the CoreSafety Program developed by the National Mining Association (NMA), includes responsibility, accountability, communication, and collaboration as core elements [NMA 2014]. A common theme within several of the CoreSafety Program modules that detail specific elements are to "Lead by Example," and indicates that management must ensure that workers understand their roles and responsibilities, provide resources to fulfill those responsibilities, and use appropriate tools to measure and review for continuous improvement.

Communication that works well has been shown to contribute to financial gains of a company and can also enhance the organization's reputation [Kaplan and Norton 2004]. A specific gap identified in the current research is the lack of accountable communication between managers and workers in the workplace [Haas 2019]. This gap was likely identified because there is little research being done in this area [Van Ruler 2000; Fleisher and Mahaffy 1997]. Historically, it has been difficult to identify a relationship between communication efforts and results. However, HSMS intervention research has been able to show gaps and best practices [Haas 2019; Haas et al. 2018b; Haas et al. 2016; Haas and Yorio 2016] and that there is room for improvement. In response, NIOSH developed communication accountability scorecards to help organizations make communication management more transparent in a way that conforms to ideas behind organizational policies, practices, and processes within most HSMSs (Appendices J, K, L).

These communication scorecards were developed using previous research about performance measurement in HSMS [Haas and Yorio 2016] as well as results gleaned about communication indicators and measurement. Specifically, results from these safety climate surveys as well as

qualitative data collected from managers and workers about communication practices on site [e.g., see Haas 2019] informed the quality indicators identified. These scorecards were piloted with eight members of H&S management from three companies to ensure that the objectives, measures, and indicators were accurate ways to assess communication quantity and quality. These communication cards were pilot-tested with eight H&S managers from three mine companies. The pilot companies were able to verify that the intervention measures listed were common and that the communication quality indicators aligned with their overall HSMS implementation goals. Additionally, they were able to provide feedback about ways in which they could adapt and use these communication scorecards daily to assess and measure messages that were being exchanged on site about health and safety. Using such a tool also helps make communication as a management effort more tangible.

After minor tweaks were made for consistency, three cards aim to improve critical gaps identified between managers and hourly workers (i.e., visibility, consistency, and fairness) [Haas 2019]. The final scorecards (Appendices J, K, and L) were developed in response to the current research efforts to help improve communication and, consequently, the perceived safety climate. Similar gaps such as clarity, effectiveness, responsiveness, and consistency have been identified in research on other industries [Vos and Schoemaker 2004]. Additionally, others have touted such communication scorecards as an "ideal communication method" [Olve et al. 2003, p. 199], making this method a viable approach to assess and improve aspects of accountable communication. In response to these tools focusing on communication assessment, companies are able to adapt these cards to be more specific to a health or safety issue being addressed on site to ensure communication in this area. For example, one company has taken these cards and created a set for workers and set for managers that was integrated into a powered haulage management plan [Haas and McGuire 2019; McGuire et al. 2019]. They labeled these cards "*Plan to Eliminate and Manage Powered Haulage Accidents, Injuries and Fatalities"* and included performance indicators around barriers to mobile haulage safety (e.g., inadequate berms, using conveyors to move materials, visibility out of large vehicles, etc.), which then included communication indicators for workers and managers to discuss and mitigate.

Conclusion

This study contributes valuable knowledge to the mining sector. Considering that meta-analytic studies have found that the effect size of safety climate exceeds that of hazards and other unknown risks [Nahrgang et al. 2011], understanding sector, subsector, and site-specific trends in safety climate constructs is critical to managing H&S performance. Besides establishing current benchmarks of safety climate in the mining industry, these results show the impact that organizational and personal safety climate factors can have on safety performance. Because other studies have already conveyed the significant, positive relationship between safety climate and safety performance [e.g., Guldenmund 2000; Wiegmann et al. 2002; Smith and DeJoy 2014; Zohar 1980], it was important for NIOSH to further characterize the impact of these indicators to provide support to mine organizations in tailoring their HSMS implementation efforts.

This report addressed aspects of both organizational and personal factors that play a significant role in worker perceptions and performance. The analysis rendered several statistically significant results and accounted for a large proportion of variance (approximately 50%) in

workers' performance. Although a large R^2 value was determined, it is also worth mentioning that future research should assess where the other 50% can be accounted for to help prevent future incidents. It is possible that some of the unaccounted variance can be attributed to random error or short-term motivating factors that come and go both on behalf of the organization and the workforce.

Additionally, it remains important that companies continually assess their safety climate to establish benchmarks that provide a more holistic view of the overall culture. Several participating companies did request follow-up assessments after significant changes to company programs and processes were made. For example, one company participated in this effort in February 2016 and again in February 2017 to find that worker perceptions had significantly improved, especially in areas related to risk tolerance, communication, and perceived support [Haas et al. 2017]. However, future research should build in the time and capacity for formal longitudinal assessments to establish HSMS indicators that are effective in improving the safety culture at mine sites. Along these lines, it is possible that more collaboration with MSHA's technical support division can be used to obtain and maintain worker involvement in mine organization's safety culture efforts.

Eventually, it is possible that more short-term constructs can be accounted for and measured to better understand what factors are likely to come and go more quickly than others and could account for H&S incidents. In the meantime, this report provides some guidance for mine organizations to use to improve organizational factors to help enhance the overall culture while supporting workers' personal factors. It is believed that organizations can start to address a select number of HSMS practices and, over time, scale their system to include additional indicators.

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References

Ahmed PK, Rafiq M [1998]. Integrated benchmarking: a holistic examination of select techniques for benchmarking analysis. Bench Qual Man Tech *5*(3):225–42.

American Productivity & Quality Centre [1993]. The benchmarking management guide. Portland, OR: Productivity Press.

ANSI/AIHA Z-10 [2005]. American National Standard for Occupational Health and Safety Management Systems. American Industrial Hygiene Association.

Ashforth BE, Humphrey RH [1995]. Emotion in the workplace: A reappraisal. Human Relations *48*:97–125.

Barrick MR, Mount MK [1991]. The big five personality dimensions and job performance: a meta-analysis. Personnel Psychology *44*(1):1–26.

Beus JM, Payne SC, Bergman ME, Arthur W [2010]. Safety climate and injuries: An examination of theoretical and empirical relationships. J Appl Psych *95:*713–727.

Beus JM, Dhanani LY, McCord MA [2015]. A meta-analysis of personality and workplace safety: Addressing unanswered questions. J Appl Psych *100:*481–498.

Bland JM, Altman DG [1997]. Statistics notes: Cronbach's alpha. BMJ: British Medical Journal *314*(7080):572.

Bogg T, Roberts BW [2004]. Conscientiousness and health-related behaviors: A meta-analysis of the leading behavioral contributors to mortality. Psych Bulletin *130*(6):887–919.

Brondino M, Silva S, Pasini M [2012]. Multilevel approach to organizational and group safety climate and safety performance: Co-workers as the missing link. Safety Science *50*(9):1847–1856.

Bronkhorst B [2015]. Behaving safely under pressure: The effects of job demands, resources, and safety climate on employee physical and psychosocial safety behavior. J Safety Res *55*:63–72.

Burke MJ, Sarpy SA, Smith-Crowe K, Chan-Serafin S, Salvador RO, Islam G. [2006]. Relative effectiveness of worker safety and health training methods. Am J Public Health *96*(2):315–24.

Burt CD, Chmiel N, Hayes P [2009]. Implications of turnover and trust for safety attitudes and behaviour in work teams. Safety Science *47*(7):1002–1006.

Bushnell S [1992]. Implementing plan, do, check and act. J Qual Part *15*(5):58.

Callanan Industries [2019]. Safety. Risk tolerance. http://www.callanan.com/safety. January 31, 2019.

Campbell JP, McCloy RA, Oppler SH, Sager CE [1993]. A theory of performance. In: Schmitt N, Borman W, eds. Personnel selection in organizations (pp. 35–69). San Francisco, CA: Jossey-Bass.

Carmeli A, Reiter-Palmon R, Ziv E [2010]. Inclusive leadership and employee involvement in creative tasks in the workplace: The mediating role of psychological safety. Creat Res J *22*(3):250–260.

Casey TW, Krauss AD [2013]. The role of effective error management practices in increasing miners' safety performance. Safety Science *60*:131–41.

Christian MS, Bradley JC, Wallace JC, Burke MJ [2009]. Workplace safety: a meta-analysis of the roles of person and situation factors. J Appl Psych *94*(5):1103–1127.

Cigularov KP, Chen PY, Rosecrance J [2010]. The effects of error management climate and safety communication on safety: A multi-level study. Acc Anal Prev *42*(5):1498–1506.

Clarke S [2003]. The contemporary workforce: Implications for organisational safety culture. Personnel Review *32*(1):40–57.

Clarke S [2010]. An integrative model of safety climate: Linking psychological climate and work attitudes to individual safety outcomes using meta-analysis. J Occup Org Psych *83*(3):553–578.

Clarke S, Robertson IT [2005]. A meta-analytic review of the Big Five personality factors and accident involvement in occupational and non-occupational settings. J Occup Org Psych *78:*355–376.

Clarke S, Ward K [2006]. The role of leader influence tactics and safety climate in engaging employees' safety participation. Risk Anal *26*(5):1175–1185.

Code of Federal Regulations (30 CFR § 48.5). Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Cohen J [1988]. Statistical power analysis for the behavioral sciences. 2nd ed. Hillsdale, NJ: Erlbaum.

Cole HP [1997]. Stories to live by: A narrative approach to health behavior research and injury prevention. In: Gochman, D.S., ed. Handbook of health behavior research IV: Relevance for professionals and issues for the future. New York, NY: Plenum Press., pp. 325–349.

Conchie SM, Donald IJ, Taylor PJ [2006]. Trust: Missing piece(s) in the safety puzzle. Risk Anal *26*(5):1097–1104.

Cornelissen PA, Van Hoof JJ, De Jong MD [2017]. Determinants of safety outcomes and performance: A systematic literature review of research in four high-risk industries. J Safety Res *62*:127–141.

Cousins R, MacKay CJ, Clarke SD, Kelly C, Kelly PJ, McCaig RH [2004]. Management standards work-related stress in the UK: Practical development. Work & Stress *18*(2):113–136.

Cox S, Flin R [1998]. Safety culture: philosopher's stone or man of straw? Work & Stress *12*(3):189–201.

CPWR [2015]. The foundations for safety leadership (FSL) instructor teaching guide. Center for Construction Research and Training. https://www.cpwr.com/sites/default/files/research/FSL-Instructor-Guide-FINAL.pdf.

Crant JM [1995]. The proactive personality scale and objective job performance among real estate agents. J Appl Psych *80:*532–537.

Crant JM [2000]. Proactive behavior in organizations. J Man *26:*435–462.

Curcuruto M, Griffin MA [2018]. Prosocial and proactive "safety citizenship behaviour" (SCB): The mediating role of affective commitment and psychological ownership. Safety Science *104*:29–38.

Curcuruto M, Mearns KJ, Mariani MG [2016]. Proactive role-orientation toward workplace safety: Psychological dimensions, nomological network and external validity. Safety Science *87*:144–155.

Dahl Ø, Kongsvik T [2018]. Safety climate and mindful safety practices in the oil and gas industry. J Safety Res *64:*29–36.

DeJoy DM [2005]. Behavior change versus culture change: Divergent approaches to managing workplace safety. Safety Science *43*(2):105–129.

DeJoy DM, Wilson MG, Vandenberg RJ, McGrath-Higgins AL, Griffin-Blake CS [2010]. Assessing the impact of healthy work organization intervention. J Occup Org Psych *83*(1):139–65.

Deming EW [1986]. Out of the crisis. Cambridge, MA: Massachusetts Institute of Technology.

DeVellis RF [2012]. Scale development: Theory and applications (Vol. 26). Thousand Oaks, CA: Sage Publications.

Ebbinghaus H [1913]. Memory: A contribution to experimental psychology. Columbia University, MA: Teachers College Press.

Eisenberger R, Stinglhamber F, Vandenberghe C, Sucharski IL, Rhoades L [2002]. Perceived supervisor support: Contributions to perceived organizational support and employee retention. J Appl Psych *87*(3):565–573.

Eklöf M, Törner M [2002]. Perception and control of occupational injury risks in fishery—a pilot study. Work and Stress *16*(1):58–69.

Erez A, Judge TA [2001]. Relationship of core self-evaluations to goal setting, motivation, and performance. J Appl Psych *86*(6):1270–1279.

Evans WR, Davis WD [2005]. High-performance work systems and organizational performance: The mediating role of internal social structure. J Man *31*(5):758–775.

Fang DP, Chen Y, Louisa W [2006]. Safety climate in construction industry: a case study in Hong Kong. J Const Engin Man *132*(6):573–584.

Fennell D [2015]. Strategies for understanding and addressing risk tolerance. Presentation provided at the C-NLOPB Safety Forum. October 2015. St. John's Newfoundland. https://www.cnlopb.ca/wp-content/uploads/safetyforum/davef.pdf.

Fennell D [2017]. Understanding and influencing risk tolerance. Presentation at the Canadian Radiation Protection Association in June 2017. Saskatoon. http://crpa-acrp.org/home/wp-content/uploads/2018/06/P1-Wed-AM-main-Fennel.pdf.

Fleisher CS, Mahaffy D [1997]. A balanced scorecard approach to public relations management assessment. Public Rel Rev *23*(2):117–142.

Flin R, Mearns K, O'Connor P, Bryden R [2000]. Measuring safety climate: identifying the common features. Safety Sci *34*(1-3):177–192.

Frederikson N [1966]. Some effects of organizational climates on administrative performance (Research Memorandum RM-66-21). Princeton, NJ: Educational Testing Service.

Frese M, Kring W, Soose A, Zempel J [1996]. Personal initiative at work: Differences between East and West Germany. Acad Man J *39:*37–63.

Frese M, Plüddemann K [1993]. Umstellungsbereitschaft im Osten und Westen Deutschlands [Readiness to change at work in East and West Germany]. Zeitschrift fuer Sozialpsychologie. *24:*198–210.

Frick K, Jensen PL, Quinlan M, Wilthagen T [2000]. Systematic Occupational Health and Safety Management—An Introduction to a New Strategy for Occupational Safety, Health and Well-Being. Systematic occupational health and safety management: perspectives and international development (pp. 17–42). Amsterdam: Pergamon.

Friedlander F, Margulies M [1969]. Multiple impacts of organizational climate and individual value systems upon job satisfaction. Pers Psych *22*:171–183.

Gardner DG, Pierce JL [2010]. The core self-evaluation scale: Further construct validation evidence. Ed Psych Meas *70*(2):291–304.

Gianakos I [2002]. Predictors of coping with work stress: The influences of sex, gender role, social desirability, and locus of control. Sex Roles *46*(5):149–158.

Gillen M, Goldenhar LM, Hecker S, Schneider S [2014]. Safety culture and climate in construction: Bridging the gap between research and practice. Report of the workshop, June 11-12, 2013, sponsored by NIOSH and CPWR—The Center for Construction Research and Training. https://www.cpwr.com/sites/default/files/publications/CPWR_Safety_Culture_Final_Report_0.pdf.

Grant AM, Parker SK, Collins CG [2009]. Getting credit for proactive behavior: Supervisor reactions depend on what you value and how you feel. Pers Psych *62:*31–55.

Grayson LR et al. [2006]. Improving mine safety technology and training: Establishing U.S. global leadership. National Mining Association and Mine Safety and Training Commission. http://www.coalminingsafety.org.

Griffin MA, Neal A [2000]. Perceptions of safety at work: a framework for linking safety climate to safety performance, knowledge, and motivation. J Occup Health Psych *5*(3):347–358.

Griffin MA, Curcuruto M [2016]. Safety climate in organizations. Annual Rev Org Psych Org Behav *21*(3):191–212.

Grossman R, Salas E [2011]. The transfer of training: What really matters. Int J Train Dev *15*(2):103–120.

Guldenmund FW [2000]. The nature of safety culture: a review of theory and research. Safety Science *34*:215–257.

Guldenmund FW [2007]. The use of questionnaires in safety culture research–an evaluation. Safety Science *45*(6):723–743.

Guldenmund FW [2010]. (Mis) understanding safety culture and its relationship to safety management. Risk Anal *30*(10):1466–80.

Haas EJ, Yorio P [2016]. Exploring the state of health and safety management system performance measurement in mining organizations. Safety Science *83*:48–58.

Haas EJ, Cecala AC, Hoebbel CL [2016]. Using dust assessment technology to leverage mine site manager-worker communication and health behavior: A longitudinal case study. J Prog Res in Soc Sci *3*(1):154–167.

Haas EJ, McGuire J, Hoebbel CL [2017]. Workplace perceptions of safety: What do your workers think about health and safety, why does it matter, and what can you do about it? Rock Prod pp. 26–27, 30, 32.

Haas EJ, Connor B, Heiser R, Vendetti J [2018]. A case study exploring field level risk assessments as a leading safety indicator. Transactions of the Society for Mining, Metallurgy & Exploration *342*:22–28.

Haas EJ, Ryan M, Hoebbel CL [2018]. Job autonomy and safety climate: Examining associations in the mining industry. Prof Safety December Issue:30–34.

Haas EJ, Yorio PL [2019]. The role of risk avoidance and locus of control in workers' near miss experiences: Implications for safety management systems. J Loss Prev Proc Ind *59*:91–99.

Haas EJ [2019]. The role of supervisory support on workers' health and safety performance. Health Comm, https://dx.doi.org/10.1080/10410236.2018.1563033. Advance online publication.

Haas EJ, Eiter B, Hoebbel C, Ryan ME [2019]. The impact of job, site, and industry experience on worker health and safety. Safety *5*(16) 21 p. https://www.mdpi.com/2313-576X/5/1/16.

Haas EJ, McGuire J [2019]. Tracking communication as a performance measure: The industry's health and safety requirements are evolving and new tools are needed. Rock Prod August Issue:132–134.

Harrell WA [1990]. Perceived risk of occupational injury: Control over pace of work and blue-collar versus white-collar work. Percep Motor Skills *70*:1351–1359.

Hatfield J, Fernandes R [2009]. The role of risk-propensity in the risky driving of younger drivers. Acc Anal Prev *41*(1):25–35.

Healey N, Sugden C, Binch S, Lekka C, Bottomley D [2012]. Developing a benchmarking service for the HSL safety climate tool. Symposium Series *158*(XXIII):222–229.

Health and Safety Executive [1991]. Successful Health and Safety Management, HMSO, London.

Hoebbel CL, Haas EJ, Ryan M [2019]. Examining trends in individual risk factors: Organizational approaches to emergency management. SME Pre-print 19-059. SME Annual Meeting, February 24–27, 2018, Denver, CO.

Hofmann DA, Jacobs R, Landy F [1995]. High reliability process industries: Individual, micro, and macro organizational influences on safety performance. J Safety Res *26*(3):131–49.

Hofmann DA, Stetzer A [1998]. The role of safety climate and communication in accident interpretation: Implications for learning from negative events. Acad Man J *41*(6):644–657.

Hofmann DA, Morgeson FP, Gerras SJ [2003]. Climate as a moderator of the relationship between leader-member exchange and content specific citizenship: safety climate as an exemplar. J Appl Psych *88*(1):170–178.

Hofmann DA, Burke MJ, Zohar D [2017]. 100 years of occupational safety research: From basic protections and work analysis to a multilevel view of workplace safety and risk. J Appl Psych *102*(3):375–388.

Huang YH, Chen JC, DeArmond S, Cigularov K, Chen PY [2007]. Roles of safety climate and shift work on perceived injury risk: A multi-level analysis. Acc Anal Prev *39*(6):1088–1096.

Hystad SW, Mearns KJ, Eid J [2014]. Moral disengagement as a mechanism between perceptions of organisational injustice and deviant work behaviours. Safety Science *68:*138–145.

International Council on Mining & Metals [2015]. Health and safety critical control management: Good practice guide. http://www.icmm.com/website/publications/pdfs/health-and-safety/8570.pdf.

Johnson JW [2000]. A heuristic method for estimating the relative weight of predictor variables in multiple regression. Multi Beh Res *35*(1):1–9.

Jones G [2015]. Risk tolerance affects workplace safety. Canadian Occupational Safety, October/November Issue, p. 9. http://digital.carswellmedia.com/i/585162-oct-nov-2015.

Judge TA, Erez A, Bono JE, Thoresen CJ [2003]. The core self-evaluations scale: Development of a measure. Pers Psych *56*(2):303–331.

Juglaret F, Rallo JM, Textoris R, Guarnieri F, Garbolino E [2011]. New Balanced Scorecard leading indicators to monitor performance variability in OHS management systems. In: Fourth resilience engineering symposium, pp. 121–127.

Kahn WA [1990]. Psychological conditions of personal engagement and disengagement at work. Acad Man J *33*:692–724.

Kaplan RS, Norton DP [2004]. Measuring the strategic readiness of intangible assets. Harvard Bus Rev *82*(2):52–63.

Karasek RT, Theorell TT [1990]. Healthy work: Stress, productivity and the reconstruction of working life. Library of Congress: Basic Books, Perseus Books Group.

Katz-Navon TA, Naveh E, Stern Z [2005]. Safety climate in health care organizations: A multidimensional approach. Acad Man J *48*(6):1075–1089.

Kirwan B [1998]. Safety management assessment and task analysis—a missing link? In: Baram M, Hale A, eds. Safety Management: The Challenge of Change, pp. 67–92. Oxford, UK: Pergamon.

Kohler JL [2015]. Looking ahead to significant improvements in mining safety and health through innovative research and effective diffusion into the industry. Inter J Min Sci Tech *25*:325–332.

Kottke JL, Sharafinski CE [1998]. Measuring perceived supervisory and organizational support. Ed Psych Meas *48*:1075–1079.

Labodova A [2004]. Implementing integrated management systems using a risk analysis based approach. J Clean Prod *12*:571–580.

Laitinen H, Päivärinta K [2010]. A new generation safety contest in the construction industry—a long-term evaluation of a real-life intervention. Safety Science *48*:680–686.

Lee TR [1981]. The public's perception of risk and the question of irrationality. Proceedings of the Royal Society of London *376*(1764):5–16.

Lefcourt HM [1976]. Locus of control and the response to aversive events. Canadian Psychological Review *17*(3):202–209.

Lehmann CC, Haight JM, Judd MH [2006] Effects of safety training on risk tolerance: An examination of male workers in the surface mining industry. J Safety Health Env Res *4*(3):1–22.

Li Y, Cao J, Lin H, Li D, Wang Y, He J [2009]. Community health needs assessment with precede-proceed model: A mixed methods study. BMC Health Services Research *9*:181–195.

Lingard H, Rowlinson S [1997]. Behavior-based safety management in Hong Kong's construction industry. J Safety Res *28*:243–256.

Lord D, Washington SP, Ivan JN [2005]. Poisson, Poisson-gamma and zero-inflated regression models of motor vehicle crashes: balancing statistical fit and theory. Acc Anal Prev *37*(1):35–46.

Luria G, Zohar D, Erev I [2008]. The effect of workers' visibility on effectiveness of intervention programs: Supervisory-based safety interventions. J Safety Res *39*(3):273–280.

Machles D [2007]. Why safety training may not be the answer. Occ Health Safety Mag. https://ohsonline.com/Articles/2007/03/Why-Safety-Training-May-Not-Be-the-Answer.aspx.

McGuire J, Snead B [2017]. MSHA eight-hour refresher education (Volume 5).

McGuire J, Haas EJ, Ferguson C [2019]. This is not your father's MSHA safety training: Reaching a higher level of involvement in an effort to attain new levels of safety on the job. Rock Prod *122*(8):127–131.

Mearns K, Whitaker SM, Flin R [2003]. Safety climate, safety management practice and safety performance in offshore environments. Safety Science *41*(8):641–680.

Mearns K, Whitaker SM, Flin R [2001a]. Benchmarking safety climate in hazardous environments: a longitudinal, interorganizational approach. Risk Analysis *21*(4):771–786.

Mearns K, Flin R, Gordon R, Fleming M [2001b]. Human and organizational factors in offshore safety. Work & Stress *15*(2):144–60.

Meertens RM, Lion R [2008]. Measuring an Individual's Tendency to Take Risks: The Risk Propensity Scale 1. J Appl Psych *38*(6):1506–1520.

Michael JH, Guo ZG, Wiedenbeck JK, Ray CD [2006]. Production supervisor impacts on subordinates' safety outcomes: An investigation of leader-member exchange and safety communication. J Safety Res *37*(5):469–477.

Miller I, Cox SJ [1997]. Benchmarking for loss control. J Inst Occ Safety Health *1*(2):39–47.

Moore SM, Pollard JP, Porter WL, Gallagher S, Mayton AG [2011]. "Demands on the Knee during Kneeling and Squatting Activities Common to Low-seam Mining," DHHS (NIOSH) Publication No. 2011-176; RI-9681: 1-47.

Moore SM, Steiner LJ, Nelson ME, Fitzgerald K, Huber J, Mayton AG [2008]. Keeping knees healthy in restricted work spaces: A look at low-seam mining. DHHS (NIOSH) Publications No. 2008-130; IC-9504.

Morrison EW, Phelps CC [1999]. Taking charge at work: Extrarole efforts to initiate workplace change. Acad Man J *42*(4):403–419.

Morrison DL, Upton DM, Cordery J [1997]. Organizational climate and skill utilization. Paper presented to the 12th Annual Conference of the Society for Industrial and Organizational Psychology, St. Louis, MO.

MSHA [2010]. A guide to miners' rights and responsibilities under the Federal Mine Safety and Health Act of 1977. U.S. Department of Labor, MSHA 3116 (OT 2) https://arlweb.msha.gov/readroom/coal%20handbook/Miners%20Rights.pdf

Mullan B, Smith L, Sainsbury K, Allom V, Paterson H, Lopez A [2015]. Active behavior change safety interventions in the construction industry: A systematic review. Safety Science *79*:139–148.

Nahrgang JD, Morgeson FP, Hofmann DA [2011]. Safety at work: a meta-analytic investigation of the link between job demands, job resources, burnout, engagement, and safety outcomes. J Appl Psych *96*(1):71–94.

National Research Council [2013]. Improving self-escape from underground coal mines. Committee on mine safety: Essential components of self-escape. Board on Human-Systems Integration, Division of Behavioral and Social Sciences and Education. Washington, DC: The National Academies Press.

Naveh E, Katz-Navon T, Stern Z 2011]. The effect of safety management systems on continuous improvement of patient safety: The moderating role of safety climate and autonomy. Qual Man J *18*(1):54–67.

Neal A, Griffin MA, Hart PM [2000]. The impact of organizational climate on safety climate and individual behavior. Safety Science *34*(1-3):99–109.

Neal A, Griffin MA [2006]. A study of the lagged relationships among safety climate, safety motivation, safety behavior, and accidents at the individual and group levels. J Appl Psych *91*(4):946–953.

Ng TW, Butts MM [2009]. Effectiveness of organizational efforts to lower turnover intentions: The moderating role of employee locus of control. Human Res Man *48*(2):289–310.

Ng TW, Sorensen KL, Eby LT [2006]. Locus of control at work: a meta-analysis. J Org Beh *27*(8):1057–1087.

Niehoff BP, Moorman RH [1993]. Justice as a mediator of the relationship between methods of monitoring and organizational citizenship behavior. Acad Man J *36*(3):527–556.

NIOSH [2006]. Information Circular 9490: Job training analysis: a process for quickly developing a roadmap for teaching and evaluating job skills. By Wiehagen, W.J., Conrad, D.W., Baugher, J.M. Pittsburgh, PA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, DHHS (NIOSH) Publication No. 2006–139. http://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/2006-139.pdf.

NMA [2014]. Handbook about CORESafety and Health Management System. Washington, DC: National Mining Association. https://coresafety.org/wp-content/uploads/2014/11/workbook-complete.pdf.

Noar SM, Zimmerman RS [2005]. Health behavior theory and cumulative knowledge regarding health behaviors: Are we moving in the right direction? Health Ed Res *20*(3):275–290.

Nowrouzi-Kia B, Sharma B, Dignar C, Kerekes Z, Dumond J, Li A, Lariviere M [2017]. Systematic review: Lost-time injuries in the US mining industry. Occup Med *67*(6):442–447.

NSC [2013]. Near miss reporting systems. National Safety Council. https://www.nsc.org/work-safety/tools-resources/near-miss-reporting.

Nunnally JC, Bernstein IH [1994]. Psychometric Theory (McGraw-Hill Series in Psychology). New York, NY: McGraw-Hill.

OHSAS 18001 [2007]. Occupational Health and Safety Management (OHS).

OSHA [2002]. Job hazard analysis. U.S. Department of Labor Occupational Safety and Health Administration, OSHA 3071. https://www.osha.gov/Publications/osha3071.pdf.

OSHA [2016]. Recommended practices for safety and health programs. OSHA3885. https://www.osha.gov/shpguidelines/docs/OSHA_SHP_Recommended_Practices.pdf.

Olve N, Petri C, Roy J, Roy S [2003]. Making scorecards actionable: Balancing strategy and control. Chichester: Wiley.

Parker SK, Williams HM, Turner N [2006]. Modeling the antecedents of proactive behavior at work. J Appl Psych *91*(3):636–652.

Parker SK, Bindl UK, Strauss K [2010]. Making things happen: A model of proactive motivation. J Man *36:*827–856.

Payne SC, Bergman ME, Beus JM, Rodríguez JM, Henning JB [2009]. Safety climate: Leading or lagging indicator of safety outcomes? J Loss Prev Proc Ind *22*(6):735–739.

Poropat AE [2009]. A meta-analysis of the five-factor model of personality and academic performance. Psychological Bulletin *135*(2):322–338.

Probst TM [2004]. Safety and insecurity: exploring the moderating effect of organizational safety climate. J Occup Health Psych *9*(1):3.

Reason J, Parker D, Lawton R [1998]. Organizational controls and safety: The varieties of rule-related behavior. J Occup and Org Psych *71:*289–304.

Reason J [2016]. Managing the risks of organizational accidents (Eds.). London: Routledge.

Reason J [2008]. The human contribution: Unsafe acts, accidents, and heroic recoveries (Eds.). New York, NY: Ashgate Publishing.

Rhoades L, Eisenberger R, Ameli S [2001]. Affective commitment to the organization: The contribution of perceived organizational support. J Appl Psych *86*:825–836.

Rich BL, Lepine JA, Crawford ER [2010]. Job engagement: Antecedents and effects on job performance. Academy of Management Journal *53*(3):617–635.

Richter A, Koch C [2004]. Integration, differentiation and ambiguity in safety cultures. Safety Science *42*(8):703–722.

Ringer RC, Boss RW [2000]. Hospital professionals' use of upward influence tactics. J Man Iss *12*(1):92–108.

Robson LS, Clarke JA, Cullen K, Bielecky A, Severin C, Bigelow PL, ... Mahood Q [2007]. The effectiveness of occupational health and safety management system interventions: a systematic review. Safety Science *45*(3):329–353.

Rotter JB [1966]. Generalized expectancies for internal versus external control of reinforcement. Psychological Monographs *80*(1):1–28.

Rundmo T [2001]. Employee images of risk. J Risk Res *4*(4), 393–404.

SAFEmap [1999]. Safety culture survey report of the Australian minerals industry. Minerals Council of Australia, 54 p. http://158.132.155.107/posh97/private/culture/safety_survey_report_jul99.pdf.

Schein EH [1990]. Organizational culture. American Psychologist *45*(2):109–119.

Schein EH [1999]. The corporate culture survival guide: Sense and nonsense about cultural change. San Francisco: Jossey-Bass.

Schneider B, Hall DT [1972]. Toward specifying the concept of work climate: A study of Roman Catholic diocesan priests. J Appl Psych *56*(6):447–455.

Schneider B, Barbera KM [2014]. The Oxford Handbook of organizational climate and culture. New York, NY: Oxford University Press.

Schneider S [2017]. How to improve safety climate on your construction site. American Industrial Hygiene Association, Falls Church, VA.

Schwatka NV, Hecker S, Goldenhar LM [2016]. Defining and measuring safety climate: a review of the construction industry literature. Ann Occup Hyg *60*(5):537–550.

Sitkin SB, Weingart LR [1995]. Determinants of risky decision-making behavior: A test of the mediating role of risk perceptions and propensity. Acad Man J *38*(6):1573–1592.

Slovic P, Peters E, Finucane ML, MacGregor DG [2005]. Affect, risk, and decision making. Health Psych *24*(4S):S35–S40.

Smith T, DeJoy D [2014]. Safety climate, safety behaviors and line-of-duty injuries in the fire service. Int J Emer Serv *3*(1):49–64.

Spector PE [1988]. Development of the work locus of control scale. J Occup Org Psych *61*(4):335–340.

Stapenhurst T [2009]. The benchmarking book. Oxford: Routledge.

Tagiuri R, Litwin GH [1968]. Organizational culture: A key to financial performance. Organizational climate and culture. San Francisco, CA: Jossey-Bass.

Thalheimer W [2010]. How Much Do People Forget? Work-Learning Research, Inc. 2010. https://www.worklearning.com/wp-content/uploads/2017/10/How-much-do-people-forget-v12-14-2010.pdf.

Thompson JA [2005]. Personality and information seeking: Understanding how traits influence information-seeking behaviors. J Bus Comm *42:*51–77.

Tonidandel S, LeBreton JM, Johnson JW [2009]. Determining the statistical significance of relative weights. Psych Meth *14*(4):387–399.

Tonidandel S, LeBreton JM [2011]. Relative importance analysis: A useful supplement to regression analysis. J Bus Psych *26*(1):1–9.

Tonidandel S, LeBreton JM [2015]. RWA web: A free, comprehensive, web-based, and user-friendly tool for relative weight analyses. J Bus Psych *30*(2):207–216.

Tucker S, Turner N [2015]. Sometimes it hurts when supervisors don't listen: The antecedents and consequences of safety voice among young workers. J Occup Health Psych *20*(1):72–81.

Tyler TR, Blader SL [2005]. Can businesses effectively regulate employee conduct? The antecedents of rule following in work settings. Acad Man J *48*(6):1143–58.

Van Ruler, B [2000]. Communication management in the Netherlands. Pub Rel Rev *26*(4):403–423.

Veazie MA, Landen DD, Bender TR, Amandus HE [1994]. Epidemiologic research on the etiology of injuries at work. Ann Rev Pub Health *15:*203–221.

Vinodkumar MN, Bhasi M [2010]. Safety management practices and safety behavior: Assessing the mediating role of safety knowledge and motivation. Acc Anal Prev *42*(6):2082–93.

Vos M, Schoemaker H [2004]. Accountability of communication management: A balanced scored for communication quality. Utrecht, Netherlands: LEMMA Publishers.

Weigold MF, Schlenker BR [1991]. Accountability and risk taking. Pers Soc Psych Bull *17*(1):25–29.

Wiegmann DA, Zhang H, von Thaden T, Sharma G, Mitchell A [2002]. A synthesis of safety culture and safety climate research. Savoy, Illinois: University of Illinois at Urbana-Champaign.

Yang B [2012]. Regulatory governance and risk management: Occupational health and safety in the coal mining industry. New York, NY: Routledge.

Yorio PL, Willmer DR, Moore SM [2015]. Health and safety management systems through a multilevel and strategic management perspective: Theoretical and empirical considerations. Safety Science *72*:221–228.

Zacharatos A, Barling J, Iverson RD [2005]. High-performance work systems and occupational safety. J Appl Psych *90*(1):77–93.

Zhou L, Cao Q, Yu K, Wang L, Wang H [2018]. Research on occupational safety, health management and risk control technology in coal mines. Int J Env Res Public Health *15*:686.

Zohar D [1980]. Safety climate in industrial organizations: theoretical and applied implications. J Appl Psych *65*(1):96–102.

Zohar D [2000]. A group-level model of safety climate: Testing the effect of group climate on micro accidents in manufacturing jobs. J Appl Psych *85*(4):587–96.

Zohar D [2002]. Modifying supervisory practices to improve sub-unit safety: A leadership-based intervention model. J Appl Psych *87*:156–63.

Zohar D, Luria G [2003]. The use of supervisory practices as leverage to improve safety behavior: A cross-level intervention model. J Safety Res *34*(5):567–77.

Zohar D [2010]. Thirty years of safety climate research: Reflections and future directions. Acc Anal Prev *42*(5):1517–1522.

Appendix A: Safety Climate Antecedents in Worker Performance

A lengthy literature review of safety climate, safety culture, and organizational values in high-risk occupations rendered a list of organizational and personal antecedents to workers' performance (hereafter referred to as worker proactivity and worker compliance) on the job. Regarding the organizational antecedents to worker performance, the following were identified: supervisor support; supervisor communication; organizational H&S support; adequacy of safety training; employee involvement/engagement; and coworker communication. Important distal, person-related factors identified in the literature search included adaptability, sense of control, thoroughness, and risk tolerance. A review of these antecedents and the development or adoption of scales to measure their presence in the mining industry is discussed below.

Organizational Predictors of Worker Performance

Much research including meta-analyses has identified organizational elements that support a strong safety climate and predict worker performance [see Brondino et al. 2012; Flin et al. 2000; Griffin and Curcuruto 2016; Nahrgang et al. 2011; Neal et al. 2000].

Organizational Support: Survey items 23–25

This scale measures the degree of priority assigned to safety within the organization. Priority of safety refers to employee expectations and daily behaviors regarding the balance maintained among work pace, workload, and pressure for productivity and safety [Zohar 2000]. This positive reinforcement of safety behavior often entails supporting work at a slower pace and investing in extra resources, including staff and equipment. The priority of safety in the organization has been the subject of many research investigations (including numerous meta-analyses) and has consistently been found to be a strong predictor of worker safety knowledge, motivation, and behavior (see the meta-analyses conducted by Clarke 2006 and Christian et al. 2009). The construct has also been found to moderate the relationship between health and safety management systems and safety performance [Naveh et al. 2011] as well as leadership and safety performance [Hofmann et al. 2003].

Coworker Communication: Survey items 26–28

Communication with coworkers and trust in coworkers imply that coworkers will accept mistakes as learning experiences, which is more likely to encourage individuals to try things beyond core tasks and enhance their own self-efficacy. If individuals have trust in coworkers' abilities and believe other coworkers will support them, then they are likely to feel more open to change and to feel in control. Also, if individuals believe that their relationship with coworkers is characterized by trust, they are likely to gain confidence in their own abilities. This also promotes sharing of safety ideas and physical cooperation and has been empirically shown to enhance occupational safety/lower injury rates [Zacharatos et al. 2005]. The importance of horizontal communications and coworker trust has steadily risen to the forefront of interest among organizational safety scholars [see Conchie et al. 2006; Burt et al. 2009].

Supervisor Support: Survey items 29–31

Supervisors act as agents of the organization who have responsibility for directing and evaluating worker performance. Workers often view their supervisor's favorable or unfavorable orientation toward them as indicative of the organization's posture toward them. Supervisor support captures a worker's perception regarding the degree to which supervisors value his or her contribution to the organization and care about the individual's personal well-being. Parker et al. [2006] empirically tested and found that supervisory support has been shown to stimulate proactive behaviors. This construct has been found to be a strong predictor of important organizational and worker-related outcomes [Eisenberger et al. 2002; Kottke and Sharafinski 1998; Rhoades et al. 2001], including safety- and health-related outcomes [Cousins et al. 2004].

Supervisor Communication: Survey items 32–38

Supervisors who care about safe work and the health and safety of their workers should emphasize safe work among their employees. One way for supervisors to emphasize and foster safety and health behaviors is to monitor worker behaviors and provide feedback when their behaviors are unsafe or do not conform to company safety procedures [Zohar 2002; Zohar and Luria 2003; Luria et al. 2008]. Tyler and Blader [2005] developed and tested a construct that succinctly measures workers' perceptions of their immediate supervisors monitoring and detection of behaviors in an occupational setting. This construct is designed to assess employee expectations about the likelihood of their behavior being detected and their judgments about expectancies of behavior being observed. Detection of behavior has also been found to be an important predictor of whether employees report following organizational rules. Finally, vertical safety communication has been established as a significant predictor of employee safety behaviors and workplace injuries [e.g., Hofmann and Stetzer 1998; Michael et al. 2006; Cigularov et al. 2010; Zacharatos et al. 2005]. This construct captures both downward sharing of safety information (related to specific workplace hazards and safety procedures) as well as the ease with which workers can communicate with their supervisors and managers about workplace H&S issues.

Worker Involvement/Engagement: Survey items 39–42

This construct reflects workers' perceptions that the organization is willing to involve them in decision-making processes about the procedures that influence their work. This is consistent with the construct of procedural justice commonly researched in the organizational and industrial psychology literatures. If employees perceive the outcomes of their evaluations to be fair or perceive the process by which outcome allocation decisions are made to be fair, they will be more likely to reciprocate by performing behaviors to benefit the organization that go beyond the in-role performance of their jobs. Employee involvement, as well as the related procedural justice construct, has been found to be a predictor of safety-related outcomes [Hystad et al. 2014; Carmeli et al. 2010].

Perception of Adequate Safety Training: Survey items 49–51

Zacharatos and colleagues [2005] noted that occupational safety training is heavily researched and that most studies suggest that workers who receive safety training are less likely to get injured than those who have not been trained. In general, safety training is designed to increase worker knowledge and awareness of hazards and risks and the types of behaviors needed to avoid injury and illness in general and specific contexts. Evans and Davis [2005] noted that the

benefits of training go beyond safety knowledge and awareness when they suggested that as worker behavior becomes more reliably safe through effective safety training, trust among the collective workforce is also enhanced. This, in turn, can lead to increased cooperation and information sharing around safety issues and lead to an overall decrease in safety incidents.

Personal Predictors of Performance

Sense of Control: Survey items 10–13

Locus of control represents the extent to which people believe that the rewards they receive in life can be controlled by their own personal actions [Lefcourt 1976; Rotter 1966]. A meta-analysis by Ng and colleagues [2006] provides a recent review of research examining the role of locus of control in the workplace. Work locus of control represents the extent to which people attribute rewards at work to their own behavior (example work locus of control items include "People who perform their jobs well generally get rewarded" and "Most people are capable of doing their jobs well if they make the effort" [Spector 1988]). Locus of control often is a significant predictor of job stress as well. The locus of control construct was adapted from previous constructs that measured core self-evaluations [Judge et al. 2003; Parker et al. 2006].

Thoroughness: Survey items 14–18

An individual who is conscientious is orderly, dependable, and responsible. The conscientiousness factor is one of the "big five" personality traits and has appeared under the names dependability, task interest, will to achieve, impulse control, and work. Other facets used to describe this variable include competence, order, dutifulness, achievement striving, self-discipline, and deliberation. Conscientiousness is used in the current study because research has shown that this is the personality trait with the most predictive utility [e.g., Barrick and Mount 1991; Bogg and Roberts 2004; Poropat 2009].

Risk Tolerance/Avoidance: Survey items 19–22

The risk propensity scale was developed to measure an individual's general tendency to take risks [Weigold and Schlenker 1991; Meertens and Lion 2008]. An individual's level of risk propensity may determine the types of health and safety behaviors they are willing to engage in high-risk occupations and risky situations [Hatfield and Fernandes 2009]. Measuring risk avoidance can help predict the types of at-risk behaviors in which workers are willing to participate [Hatfield and Fernandes 2009]. Thus, a risk avoidance scale was adapted and used to measure an individual's general tendency to take risks and general avoidance of risks on site [Weigold and Schlenker 1991; Meertens and Lion 2008). A scale was adapted from the Meertens and Lion [2008] risk propensity scale.

Adaptability: Survey items 52–54

Given that the proactive safety behaviors involve changing the work environment, individuals with an active orientation toward change may be more prone to behave proactively in the workplace. An active-change orientation is similar to "felt responsibility for change," or "an individual's belief that he or she is personally obligated to bring about constructive change" [Morrison and Phelps 1999, p. 407]. Morrison and Phelps argued that those with high felt responsibility for change will perceive taking charge positively because it provides a sense of personal satisfaction and accomplishment. Both active-change orientation and felt responsibility

for change have been shown to predict proactive behavior [Frese and Pluddemann 1993]. Parker and colleagues [2006] indeed found that individuals with a strong adaptability and change orientation are more likely to engage in proactive behaviors at work.

Appendix B: NIOSH Safety Climate Survey

National Institute for Occupational Safety and Health
NIOSH

Organizational Health and Safety Survey

The purpose of this survey is to understand what may have the biggest impact on the health and safety of employees at this mine operation. Please think about your work experiences and behaviors during a typical week when responding.

- Mark your answers directly on the survey by filling in, circling, or checking the box.
- Return your survey answer sheet to us when you are done.

To protect your identity:

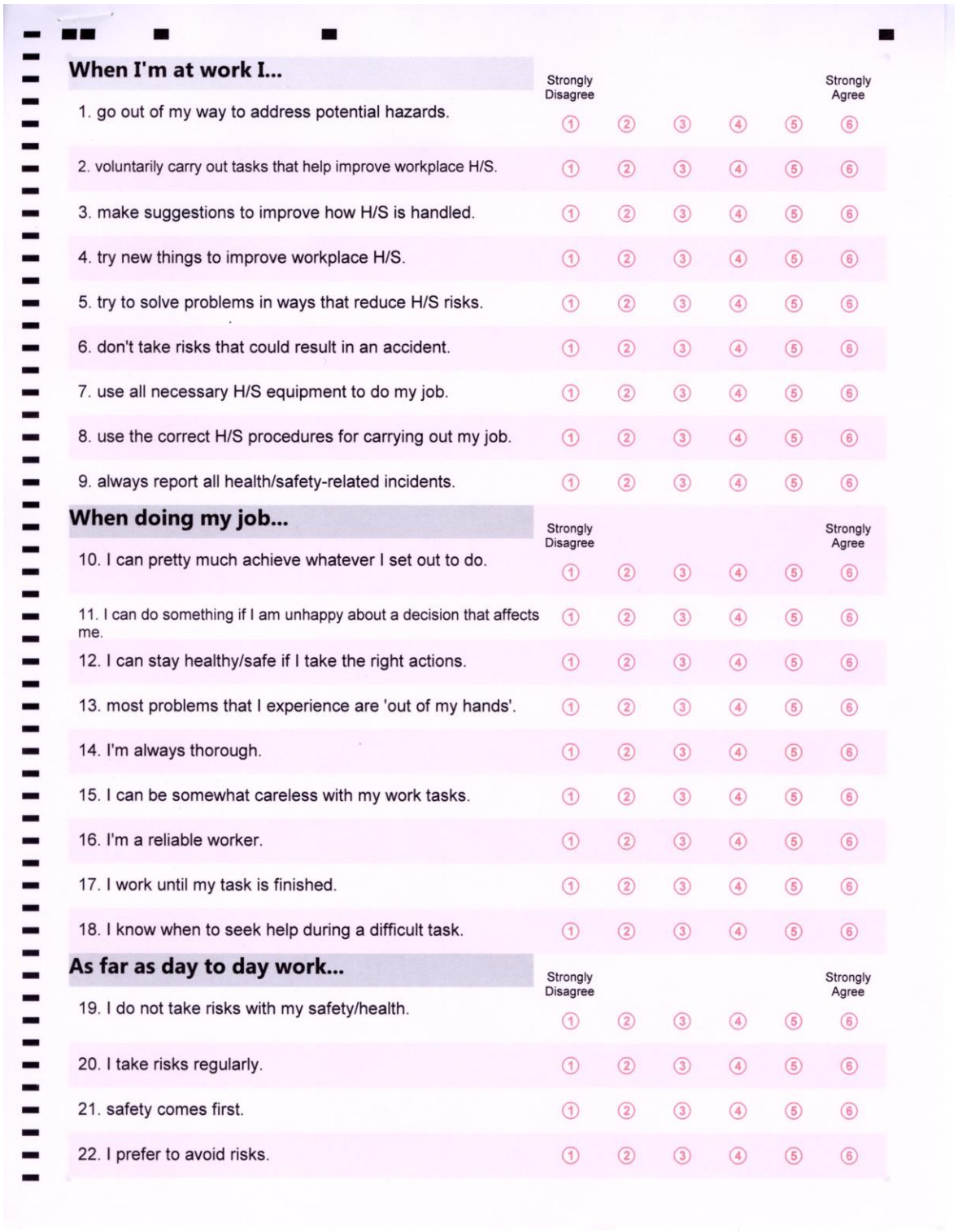
- Your supervisors will not see your individual responses.
- These forms will not be made available to any management personnel.
- We will combine the data from everyone into one large group to summarize the results.

Please mark the number below each statement or question that best describes your opinion using the following scale.

Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree
1	2	3	4	5	6

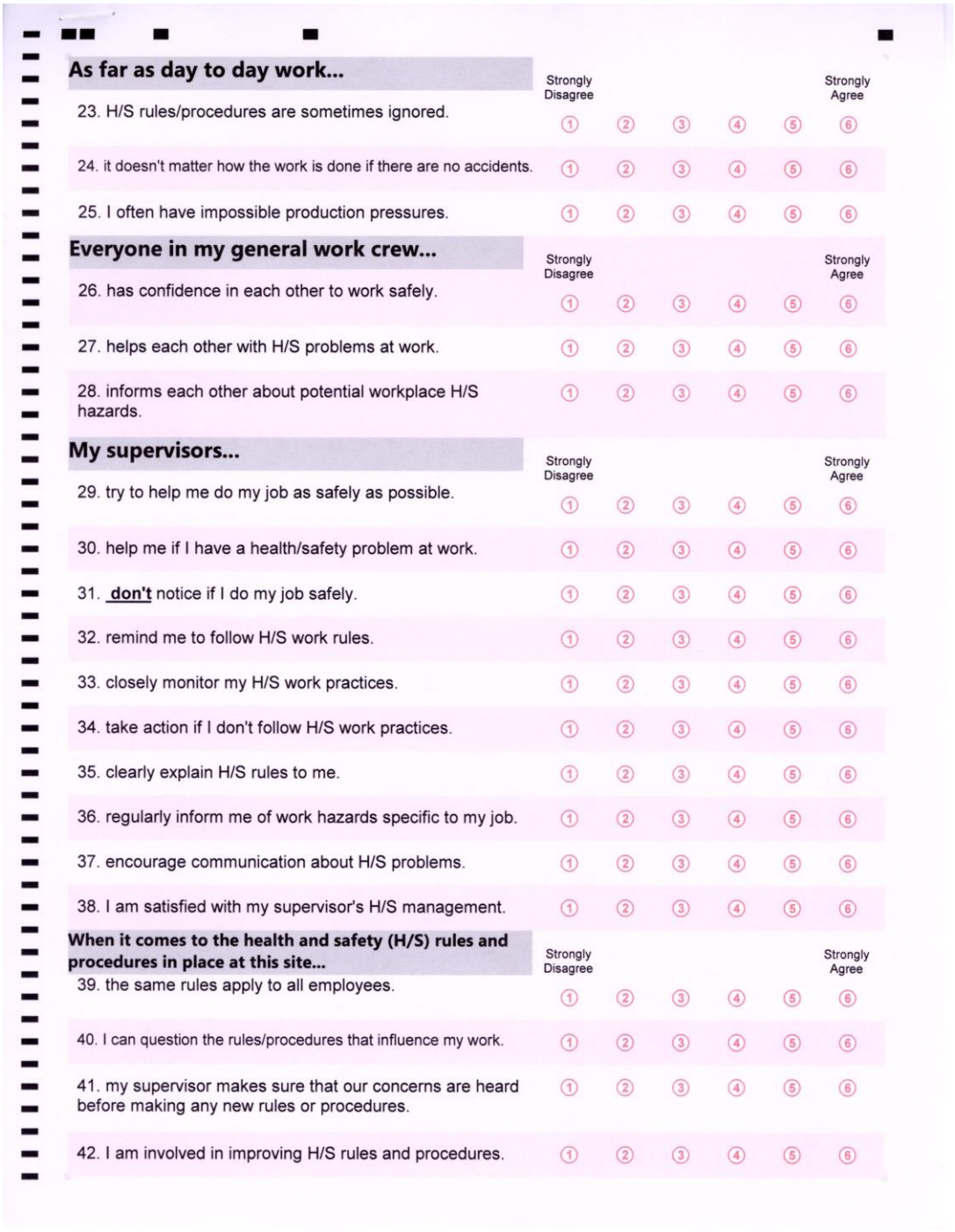
Thank you in advance, for your participation!

Figure 16. NIOSH safety climate survey cover sheet.



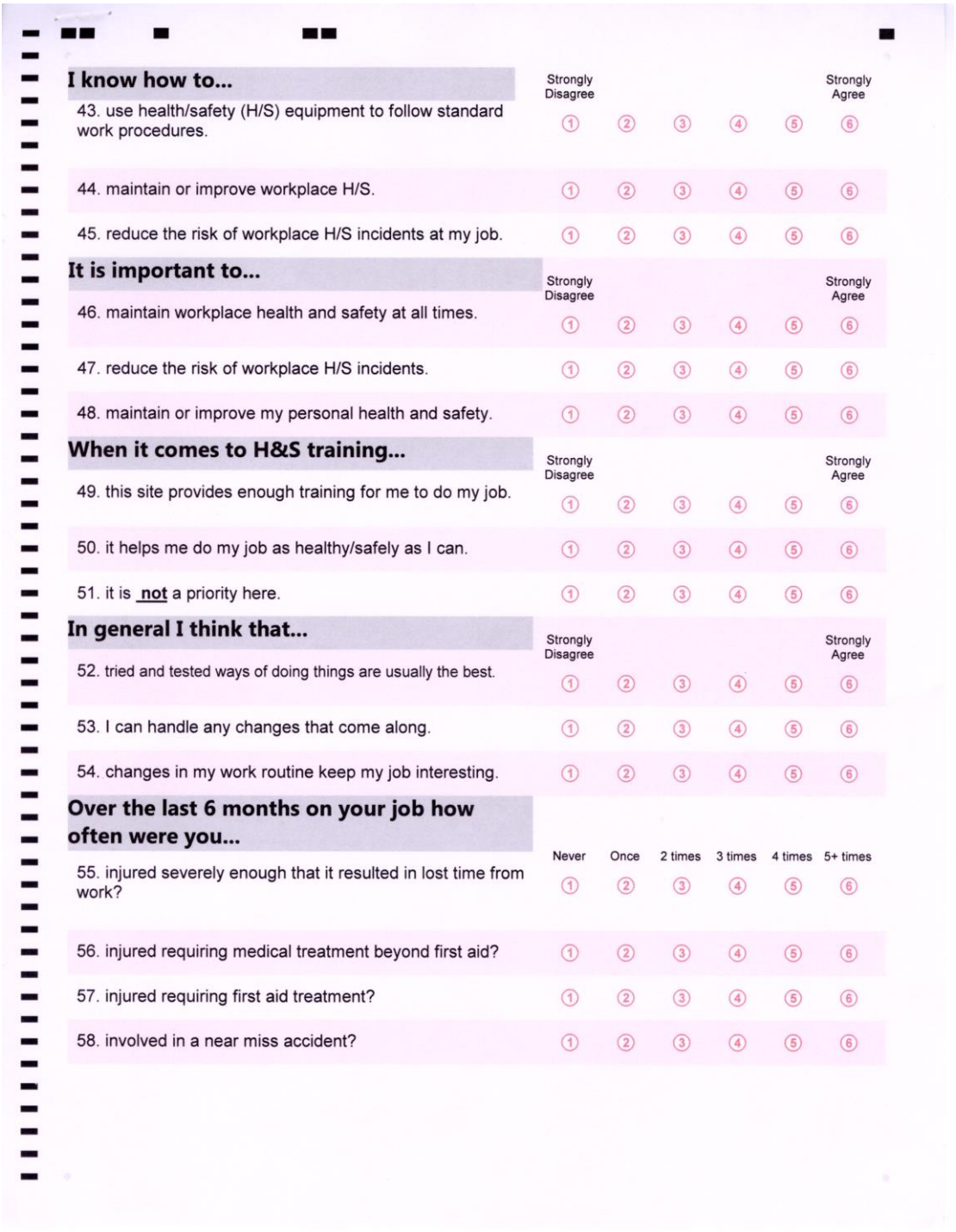
When I'm at work I...	Strongly Disagree					Strongly Agree
1. go out of my way to address potential hazards.	①	②	③	④	⑤	⑥
2. voluntarily carry out tasks that help improve workplace H/S.	①	②	③	④	⑤	⑥
3. make suggestions to improve how H/S is handled.	①	②	③	④	⑤	⑥
4. try new things to improve workplace H/S.	①	②	③	④	⑤	⑥
5. try to solve problems in ways that reduce H/S risks.	①	②	③	④	⑤	⑥
6. don't take risks that could result in an accident.	①	②	③	④	⑤	⑥
7. use all necessary H/S equipment to do my job.	①	②	③	④	⑤	⑥
8. use the correct H/S procedures for carrying out my job.	①	②	③	④	⑤	⑥
9. always report all health/safety-related incidents.	①	②	③	④	⑤	⑥
When doing my job...	Strongly Disagree					Strongly Agree
10. I can pretty much achieve whatever I set out to do.	①	②	③	④	⑤	⑥
11. I can do something if I am unhappy about a decision that affects me.	①	②	③	④	⑤	⑥
12. I can stay healthy/safe if I take the right actions.	①	②	③	④	⑤	⑥
13. most problems that I experience are 'out of my hands'.	①	②	③	④	⑤	⑥
14. I'm always thorough.	①	②	③	④	⑤	⑥
15. I can be somewhat careless with my work tasks.	①	②	③	④	⑤	⑥
16. I'm a reliable worker.	①	②	③	④	⑤	⑥
17. I work until my task is finished.	①	②	③	④	⑤	⑥
18. I know when to seek help during a difficult task.	①	②	③	④	⑤	⑥
As far as day to day work...	Strongly Disagree					Strongly Agree
19. I do not take risks with my safety/health.	①	②	③	④	⑤	⑥
20. I take risks regularly.	①	②	③	④	⑤	⑥
21. safety comes first.	①	②	③	④	⑤	⑥
22. I prefer to avoid risks.	①	②	③	④	⑤	⑥

Figure 17. Page 1 of the NIOSH safety climate survey with questions assessing perceived proactivity, compliance, sense of control, thoroughness, and risk tolerance.



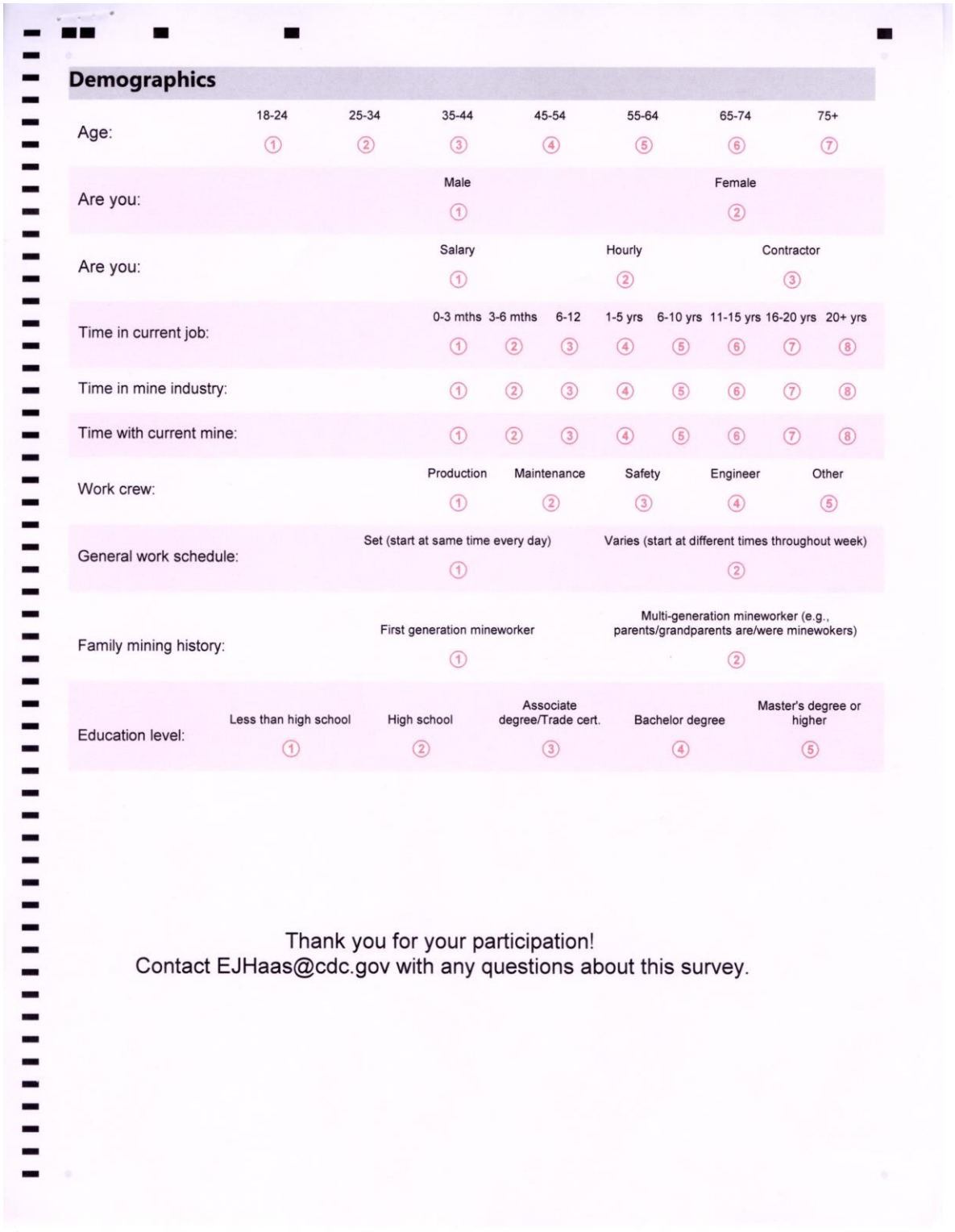
As far as day to day work...	Strongly Disagree					Strongly Agree
23. H/S rules/procedures are sometimes ignored.	①	②	③	④	⑤	⑥
24. it doesn't matter how the work is done if there are no accidents.	①	②	③	④	⑤	⑥
25. I often have impossible production pressures.	①	②	③	④	⑤	⑥
Everyone in my general work crew...	Strongly Disagree					Strongly Agree
26. has confidence in each other to work safely.	①	②	③	④	⑤	⑥
27. helps each other with H/S problems at work.	①	②	③	④	⑤	⑥
28. informs each other about potential workplace H/S hazards.	①	②	③	④	⑤	⑥
My supervisors...	Strongly Disagree					Strongly Agree
29. try to help me do my job as safely as possible.	①	②	③	④	⑤	⑥
30. help me if I have a health/safety problem at work.	①	②	③	④	⑤	⑥
31. **don't** notice if I do my job safely.	①	②	③	④	⑤	⑥
32. remind me to follow H/S work rules.	①	②	③	④	⑤	⑥
33. closely monitor my H/S work practices.	①	②	③	④	⑤	⑥
34. take action if I don't follow H/S work practices.	①	②	③	④	⑤	⑥
35. clearly explain H/S rules to me.	①	②	③	④	⑤	⑥
36. regularly inform me of work hazards specific to my job.	①	②	③	④	⑤	⑥
37. encourage communication about H/S problems.	①	②	③	④	⑤	⑥
38. I am satisfied with my supervisor's H/S management.	①	②	③	④	⑤	⑥
When it comes to the health and safety (H/S) rules and procedures in place at this site...	Strongly Disagree					Strongly Agree
39. the same rules apply to all employees.	①	②	③	④	⑤	⑥
40. I can question the rules/procedures that influence my work.	①	②	③	④	⑤	⑥
41. my supervisor makes sure that our concerns are heard before making any new rules or procedures.	①	②	③	④	⑤	⑥
42. I am involved in improving H/S rules and procedures.	①	②	③	④	⑤	⑥

Figure 18. Page 2 of the NIOSH safety climate survey with questions assessing perceived organizational support for H&S, coworker communication, supervisor support for H&S, supervisor communication, and worker engagement.



I know how to...	Strongly Disagree					Strongly Agree
43. use health/safety (H/S) equipment to follow standard work procedures.	①	②	③	④	⑤	⑥
44. maintain or improve workplace H/S.	①	②	③	④	⑤	⑥
45. reduce the risk of workplace H/S incidents at my job.	①	②	③	④	⑤	⑥
It is important to...	Strongly Disagree					Strongly Agree
46. maintain workplace health and safety at all times.	①	②	③	④	⑤	⑥
47. reduce the risk of workplace H/S incidents.	①	②	③	④	⑤	⑥
48. maintain or improve my personal health and safety.	①	②	③	④	⑤	⑥
When it comes to H&S training...	Strongly Disagree					Strongly Agree
49. this site provides enough training for me to do my job.	①	②	③	④	⑤	⑥
50. it helps me do my job as healthy/safely as I can.	①	②	③	④	⑤	⑥
51. it is **not** a priority here.	①	②	③	④	⑤	⑥
In general I think that...	Strongly Disagree					Strongly Agree
52. tried and tested ways of doing things are usually the best.	①	②	③	④	⑤	⑥
53. I can handle any changes that come along.	①	②	③	④	⑤	⑥
54. changes in my work routine keep my job interesting.	①	②	③	④	⑤	⑥
Over the last 6 months on your job how often were you...	Never	Once	2 times	3 times	4 times	5+ times
55. injured severely enough that it resulted in lost time from work?	①	②	③	④	⑤	⑥
56. injured requiring medical treatment beyond first aid?	①	②	③	④	⑤	⑥
57. injured requiring first aid treatment?	①	②	③	④	⑤	⑥
58. involved in a near miss accident?	①	②	③	④	⑤	⑥

Figure 19. Page 3 of the NIOSH safety climate survey with questions assessing perceived H&S knowledge, H&S motivation, H&S training adequacy, worker adaptability, and frequency of near misses and incidents experienced in the last 6 months.



Demographics

Age:	18-24 ①	25-34 ②	35-44 ③	45-54 ④	55-64 ⑤	65-74 ⑥	75+ ⑦
Are you:			Male ①			Female ②	
Are you:			Salary ①		Hourly ②		Contractor ③
Time in current job:	0-3 mths ①	3-6 mths ②	6-12 ③	1-5 yrs ④	6-10 yrs ⑤	11-15 yrs ⑥	16-20 yrs ⑦	20+ yrs ⑧
Time in mine industry:	①	②	③	④	⑤	⑥	⑦	⑧
Time with current mine:	①	②	③	④	⑤	⑥	⑦	⑧
Work crew:		Production ①	Maintenance ②	Safety ③	Engineer ④	Other ⑤		
General work schedule:			Set (start at same time every day) ①		Varies (start at different times throughout week) ②		
Family mining history:			First generation mineworker ①		Multi-generation mineworker (e.g., parents/grandparents are/were minewokers) ②		
Education level:	Less than high school ①	High school ②	Associate degree/Trade cert. ③	Bachelor degree ④	Master's degree or higher ⑤		

Thank you for your participation!
Contact EJHaas@cdc.gov with any questions about this survey.

Figure 20. Demographic page of the NIOSH safety climate survey.

Appendix C: Overall Benchmarking Results/Averages

Table 14. Results for proactivity items overall for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
go out of my way to address potential hazards	0.9	1.9	5.7	15.6	34.4	41.4	5.05
voluntarily carry out tasks that help improve H&S	0.7	1.3	5.0	16.8	40.1	36.1	5.03
make suggestions to improve how H&S is handled	1.1	3.0	8.6	22.4	37.0	27.8	4.75
try new things to improve workplace H&S	1.4	2.7	9.3	23.5	36.4	26.7	4.71
try to solve problems in ways that reduce H&S risks	0.8	1.4	4.8	16.5	39.2	37.3	5.04

Table 15. Results for compliance items overall for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
don't take risks that could result in an accident	1.1	1.5	4.5	10.4	25.7	56.8	5.28
use all necessary H&S equipment to do my job	0.7	1.0	3.6	10.7	30.5	53.5	5.30
use the correct H&S procedures for carrying out my job	0.6	0.5	3.1	10.7	34.1	50.9	5.30
always report all H&S-related incidents	1.1	1.8	6.4	12.9	26.9	50.9	5.15

Table 16. Sense of control overall for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I can pretty much achieve whatever I set out to do	0.9	0.7	4.0	14.6	41.7	38.0	5.10
I can do something if I am unhappy about a decision	4.7	5.3	10.6	24.1	35.2	20.1	4.40
I can stay healthy/safe if I take the right actions	0.8	0.7	1.6	7.4	32.2	57.2	5.41
most problems that I experience are "out of my hands"	13.7	20.2	19.5	20.3	16.2	10.1	3.65

Table 17. Thoroughness overall for each response option (%) and item average (on a 6-point scale)

When doing my job…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I am always thorough	0.6	1.5	5.5	23.4	45.0	23.9	4.82
I can be somewhat careless with my work tasks	42.8	29.5	10.4	7.7	6.3	3.3	4.85
I'm a reliable worker	1.2	0.1	0.5	2.1	26.6	69.5	5.61
I work until my task is finished	0.7	0.7	1.2	8.2	34.7	54.5	5.39
I know when to seek help during a difficult task	0.8	0.9	2.6	7.8	34.8	53.1	5.34

Table 18. Risk tolerance overall for each response option (%) and item average (on a 6-point scale)

As far as day to day work…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I do not take risks with my safety/health	1.4	1.9	4.6	11.2	30.1	50.7	5.19
I take risks regularly	51.6	27.8	8.6	4.8	4.0	3.1	5.09
safety comes first	1.0	0.6	2.2	6.0	23.4	66.9	5.51
I prefer to avoid risks	2.0	1.5	2.7	6.9	27.0	59.9	5.35

Table 19. Organizational support for H&S overall for each response option (%) and item average (on a 6-point scale)

As far as day to day work…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
H&S rules and procedures are sometimes ignored	26.0	23.1	13.6	17.9	13.6	5.8	4.13
it doesn't matter how the work is done if there are no accidents	47.9	24.5	9.5	7.4	5.9	4.7	4.87
I often have impossible production pressures	21.6	23.6	18.2	19.1	11.8	5.7	4.07

Table 20. Coworker communication overall for each response option (%) and item average (on a 6-point scale)

Everyone in my crew…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
has confidence in each other to work safely	1.6	2.4	5.9	15.0	39.0	36.0	4.95
helps each other with H&S problems at work	0.9	2.0	4.6	14.2	42.2	36.1	5.03
informs each other about potential workplace H&S hazards	0.8	1.4	4.1	12.0	37.8	43.9	5.16

Table 21. Supervisor support overall for each response option (%) and item average (on a 6-point scale)

My supervisors…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
try to help me do my job as safely as possible	1.7	2.9	4.9	13.0	31.9	45.6	5.07
help me if I have a H&S problem at work	1.5	2.3	5.3	11.9	35.9	43.2	5.08
don’t notice if I do my job safely	32.9	27.2	11.4	11.4	10.7	6.4	4.41

Table 22. Supervisor communication overall for each response option (%) and item average (on a 6-point scale)

My supervisors…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
remind me to follow H&S work rules	1.9	3.2	6.0	14.2	37.5	37.4	4.94
closely monitor my H&S work practices	3.3	6.1	12.3	24.3	32.7	21.2	4.41
take action if I don't follow H&S work practices	2.4	3.6	7.6	17.2	37.1	32.2	4.80
clearly explain H&S rules to me	2.2	3.8	7.9	15.9	35.8	34.5	4.83
regularly inform me of work hazards specific to my job	3.4	5.4	9.8	18.8	31.9	30.7	4.63
encourage communication about H&S problems	2.8	3.3	7.4	15.6	33.4	37.4	4.86
I am satisfied with my supervisor's H&S management	4.5	4.1	6.2	13.6	32.5	39.1	4.83

Table 23. Worker engagement overall for each response option (%) and item average (on a 6-point scale)

When it comes to the H&S rules…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
the same rules apply to all employees	6.6	4.6	6.2	9.6	24.8	48.3	4.86
I can question the rules/procedures that influence my work	5.0	6.5	7.5	15.8	33.0	32.2	4.62
concerns are heard before making new rules or procedures	6.0	6.9	10.5	19.2	31.4	26.0	4.41
I am involved in improving H&S rules and procedures	6.2	8.9	13.6	21.9	27.4	22.0	4.21

Table 24. H&S knowledge overall for each response option (%) and item average (on a 6-point scale)

I know how to…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
use H&S equipment to follow standard work procedures	0.3	0.4	2.3	8.9	38.3	49.7	5.34
maintain or improve workplace H&S	0.5	0.9	2.9	12.1	41.8	41.8	5.19
reduce the risk of workplace H&S incidents at my job	0.4	0.9	2.4	11.4	40.1	44.8	5.24

Table 25. H&S motivation overall for each response option (%) and item average (on a 6-point scale)

It is important to…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
maintain workplace health and safety at all times	0.4	0.3	1.1	4.3	22.2	71.8	5.63
reduce the risk of workplace H&S incidents at my job	0.4	0.3	0.9	4.7	22.3	71.4	5.62
maintain or improve my personal H&S	0.5	0.3	0.9	4.3	21.4	72.5	5.63

Table 26. H&S training adequacy overall for each response option (%) and item average (on a 6-point scale)

When it comes to H&S training…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
this site provides enough training for me to do my job	1.6	2.2	4.6	11.4	34.4	45.7	5.12
it helps me do my job as healthy/safely as I can	1.0	1.6	3.7	10.7	36.5	46.4	5.19
it is not a priority here	61.2	18.2	5.7	6.0	5.1	3.7	5.13

Table 27. Adaptability overall for each response option (%) and item average (on a 6-point scale)

In general I think that…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
tried and tested ways of doing things are usually the best	3.0	5.4	11.3	25.0	33.7	21.5	4.45
I can handle any changes that come along	0.7	1.1	4.6	17.6	46.1	29.9	4.97
changes in my work routine keep my job interesting	3.3	4.1	8.6	19.6	37.9	26.4	4.64

Appendix D: Overall Results/Averages for the Coal Industry (n = 358)

Table 28. Proactivity in coal for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
go out of my way to address potential hazards	2.0	1.7	4.5	16.5	38.3	37.2	4.99
voluntarily carry out tasks that help improve H&S	0.6	1.1	5.3	19.3	41.9	31.8	4.96
make suggestions to improve how H&S is handled	1.1	4.8	10.7	25.3	34.0	24.2	4.59
try new things to improve workplace H&S	0.8	2.8	8.7	25.8	38.9	23.0	4.68
try to solve problems in ways that reduce H&S risks	0.8	1.4	4.2	16.8	39.9	36.9	5.04

Table 29. Compliance in coal for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
don't take risks that could result in an accident	1.4	2.0	6.7	12.6	29.7	47.6	5.10
use all necessary H&S equipment to do my job	1.1	1.7	9.2	14.8	33.8	39.4	4.97
use the correct H&S procedures for carrying out my job	1.1	0.6	5.0	17.3	37.4	38.5	5.05
always report all H&S-related incidents	1.7	2.5	15.5	20.6	26.5	33.2	4.67

Table 30. Sense of control in coal for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I can pretty much achieve whatever I set out to do	0.6	1.4	3.9	16.8	41.2	36.1	5.05
I can do something if I am unhappy about a decision	5.3	5.0	16.2	25.5	30.8	17.1	4.23
I can stay healthy/safe if I take the right actions	0.8	1.1	2.2	10.4	34.5	51.0	5.29
most problems that I experience are "out of my hands"	10.5	21.8	24.9	20.9	15.8	6.2	3.71

Table 31. Thoroughness in coal for each response option (%) and item average (on a 6-point scale)

When doing my job…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I am always thorough	0.3	3.1	6.4	24.6	46.6	19.0	4.71
I can be somewhat careless with my work tasks	35.8	35.5	10.6	8.9	7.0	2.2	4.77
I'm a reliable worker	1.7	0.0	0.0	3.1	31.6	63.7	5.54
I work until my task is finished	0.3	0.6	2.2	9.2	35.6	52.1	5.36
I know when to seek help during a difficult task	0.8	2.5	4.5	9.5	37.7	45.0	5.16

Table 32. Risk tolerance in coal for each response option (%) and item average (on a 6-point scale)

As far as day to day work…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I do not take risks with my safety/health	0.3	3.1	8.7	19.7	32.3	36.0	4.88
I take risks regularly	38.6	32.7	11.8	7.6	7.0	2.3	4.81
safety comes first	1.7	0.8	2.5	7.9	27.0	60.1	5.38
I prefer to avoid risks	2.2	2.5	3.6	9.2	31.4	51.0	5.18

Table 33. Organizational support for H&S in coal for each response option (%) and item average (on a 6-point scale)

As far as day to day work…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
H&S rules and procedures are sometimes ignored	15.5	20.9	18.9	22.6	15.5	6.5	3.79
it doesn't matter how the work is done if there are no accidents	28.9	28.6	17.3	14.2	6.2	4.8	4.45
I often have impossible production pressures	16.3	23.8	19.8	19.2	14.3	6.6	3.89

Table 34. Coworker communication in coal for each response option (%) and item average (on a 6-point scale)

Everyone in my crew…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
has confidence in each other to work safely	1.7	2.5	6.8	17.2	40.0	31.8	4.87
helps each other with H&S problems at work	0.8	2.8	6.8	16.4	44.5	28.6	4.87
informs each other about potential workplace H&S hazards	0.8	2.8	7.1	12.4	39.8	37.0	4.99

Table 35. Supervisor support in coal for each response option (%) and item average (on a 6-point scale)

My supervisors…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
try to help me do my job as safely as possible	0.6	3.9	5.9	14.4	32.1	43.1	5.03
help me if I have a H&S problem at work	0.6	3.1	6.5	13.9	35.1	40.8	5.02
don’t notice if I do my job safely	30.3	28.6	10.2	12.5	13.3	5.1	4.35

Table 36. Supervisor communication in coal for each response option (%) and item average (on a 6-point scale)

My supervisors…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
remind me to follow H&S work rules	1.4	5.1	8.5	19.5	35.6	29.9	4.73
closely monitor my H&S work practices	2.8	7.1	19.0	22.9	31.4	16.7	4.23
take action if I don't follow H&S work practices	2.0	7.3	11.9	21.8	31.6	25.4	4.50
clearly explain H&S rules to me	2.5	5.9	10.7	20.6	30.5	29.7	4.60
regularly inform me of work hazards specific to my job	2.3	7.7	9.4	19.7	33.3	27.6	4.57
encourage communication about H&S problems	2.8	5.1	8.8	17.8	34.3	31.2	4.69
I am satisfied with my supervisor's H&S management	5.1	5.1	8.2	14.1	30.1	37.5	4.72

Table 37. Worker engagement in coal for each response option (%) and item average (on a 6-point scale)

When it comes to the H&S rules…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
the same rules apply to all employees	9.0	7.0	8.7	8.5	26.2	40.6	4.57
I can question the rules/procedures that influence my work	6.8	12.2	10.8	17.3	30.6	22.4	4.20
concerns are heard before making new rules or procedures	7.6	12.4	13.2	19.4	29.6	17.7	4.04
I am involved in improving H&S rules and procedures	8.2	13.8	17.5	22.9	23.2	14.4	3.82

Table 38. H&S knowledge in coal for each response option (%) and item average (on a 6-point scale)

I know how to…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
use H&S equipment to follow standard work procedures	0.3	0.6	2.0	17.4	45.1	34.6	5.10
maintain or improve workplace H&S	0.8	2.0	4.6	16.6	45.3	30.7	4.95
reduce the risk of workplace H&S incidents at my job	1.2	1.2	2.9	13.5	45.8	35.4	5.08

Table 39. H&S motivation in coal for each response option (%) and item average (on a 6-point scale)

It is important to…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
maintain workplace health and safety at all times	0.3	0.3	0.3	6.3	28.0	64.9	5.56
reduce the risk of workplace H&S incidents at my job	0.6	0.6	0.6	7.4	25.1	65.7	5.53
maintain or improve my personal H&S	0.6	0.6	0.9	5.7	26.6	65.6	5.54

Table 40. H&S training adequacy in coal for each response option (%) and item average (on a 6-point scale)

When it comes to H&S training…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
this site provides enough training for me to do my job	2.3	4.3	5.4	16.0	35.6	36.5	4.88
it helps me do my job as healthy/safely as I can	1.7	2.3	5.1	16.5	37.0	37.3	4.97
it is not a priority here	53.6	22.9	8.3	7.7	2.9	4.6	5.03

Table 41. Adaptability in coal for each response option (%) and item average (on a 6-point scale)

In general I think that…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
tried and tested ways of doing things are usually the best	2.0	5.1	11.4	21.4	41.6	18.5	4.51
I can handle any changes that come along	0.9	1.1	7.1	23.1	42.5	25.4	4.81
changes in my work routine keep my job interesting	3.7	5.4	11.4	17.1	34.9	27.4	4.56

Appendix E: Overall Results/Averages for Stone, Sand, and Gravel Industry (n = 1,418)

Table 42. Proactivity in SSG for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
go out of my way to address potential hazards	0.6	2.3	5.7	13.3	33.9	44.2	5.10
voluntarily carry out tasks that help improve H&S	0.7	1.4	5.0	14.6	40.6	37.6	5.06
make suggestions to improve how H&S is handled	1.2	2.7	7.0	20.3	38.0	30.8	4.84
try new things to improve workplace H&S	1.6	2.7	8.4	21.1	37.7	28.6	4.76
try to solve problems in ways that reduce H&S risks	0.7	1.3	3.8	14.8	41.0	38.4	5.09

Table 43. Compliance in SSG for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
don't take risks that could result in an accident	1.3	1.3	4.1	9.7	24.3	59.1	5.32
use all necessary H&S equipment to do my job	0.5	0.6	2.8	9.1	30.9	56.0	5.37
use the correct H&S procedures for carrying out my job	0.4	0.4	2.6	9.7	34.7	52.1	5.34
always report all H&S-related incidents	0.9	2.1	5.0	12.1	27.7	52.1	5.20

Table 44. Sense of control in SSG for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I can pretty much achieve whatever I set out to do	0.8	0.7	4.0	14.8	42.3	37.4	5.09
I can do something if I am unhappy about a decision	4.6	6.0	9.8	24.8	35.2	19.7	4.39
I can stay healthy/safe if I take the right actions	0.7	0.6	1.4	6.9	32.4	58.0	5.44
most problems that I experience are "out of my hands"	14.3	19.3	18.6	19.6	17.1	11.0	3.61

Table 45. Thoroughness in SSG for each response option (%) and item average (on a 6-point scale)

When doing my job…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I am always thorough	0.4	1.1	5.1	22.4	44.5	26.6	4.90
I can be somewhat careless with my work tasks	45.9	27.7	10.1	6.5	5.9	4.0	4.89
I'm a reliable worker	1.0	0.1	0.4	1.6	26.1	70.7	5.64
I work until my task is finished	0.7	0.6	1.0	7.5	35.4	54.7	5.40
I know when to seek help during a difficult task	0.8	0.6	2.1	7.6	35.3	53.7	5.37

Table 46. Risk tolerance in SSG for each response option (%) and item average (on a 6-point scale)

As far as day to day work…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I do not take risks with my safety/health	1.1	1.8	4.2	9.0	29.8	54.1	5.27
I take risks regularly	53.2	26.7	8.7	4.5	3.6	3.4	5.11
safety comes first	0.8	0.6	2.3	5.2	21.8	69.3	5.55
I prefer to avoid risks	2.3	1.3	3.0	5.4	25.2	62.7	5.38

Table 47. Organizational support for H&S in SSG for each response option (%) and item average (on a 6-point scale)

As far as day to day work…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
H&S rules and procedures are sometimes ignored	25.9	22.5	13.3	18.1	14.1	6.0	4.10
it doesn't matter how the work is done if there are no accidents	48.6	23.8	8.8	7.0	6.9	4.9	4.86
I often have impossible production pressures	20.4	22.1	18.9	21.0	12.5	5.1	4.02

Table 48. Coworker communication in SSG for each response option (%) and item average (on a 6-point scale)

Everyone in my crew…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
has confidence in each other to work safely	1.4	2.6	6.0	14.0	38.5	37.5	4.98
helps each other with H&S problems at work	0.8	2.1	3.8	13.6	42.2	37.6	5.07
informs each other about potential workplace H&S hazards	0.8	1.3	3.1	11.6	37.5	45.7	5.21

Table 49. Supervisor support for H&S in SSG for each response option (%) and item average (on a 6-point scale)

My supervisors…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
try to help me do my job as safely as possible	1.6	3.2	4.7	14.0	32.6	43.8	5.04
help me if I have a H&S problem at work	1.4	2.5	5.4	13.0	37.1	40.6	5.04
don’t notice if I do my job safely	32.9	25.3	12.5	12.2	10.9	6.2	4.39

Table 50. Supervisor communication in SSG for each response option (%) and item average (on a 6-point scale)

My supervisors…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
remind me to follow H&S work rules	1.9	2.7	5.8	13.9	39.7	36.1	4.95
closely monitor my H&S work practices	3.3	5.5	10.9	24.9	33.6	21.8	4.45
take action if I don't follow H&S work practices	2.4	2.9	7.0	16.4	37.5	33.8	4.85
clearly explain H&S rules to me	1.9	3.0	7.9	15.4	37.5	34.3	4.86
regularly inform me of work hazards specific to my job	3.7	5.1	9.5	19.2	32.2	30.3	4.62
encourage communication about H&S problems	2.6	2.9	7.5	16.3	33.0	37.5	4.87
I am satisfied with my supervisor's H&S management	4.6	4.1	6.3	14.3	33.1	37.6	4.80

Table 51. Worker engagement in SSG for each response option (%) and item average (on a 6-point scale)

When it comes to the H&S rules…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
the same rules apply to all employees	6.6	4.7	5.6	11.0	24.3	47.8	4.85
I can question the rules/procedures that influence my work	4.5	5.6	7.7	16.1	33.9	32.2	4.66
concerns are heard before making new rules or procedures	6.6	7.0	10.1	19.2	31.4	25.8	4.39
I am involved in improving H&S rules and procedures	5.7	8.8	13.0	20.4	28.2	23.9	4.28

Table 52. H&S knowledge in SSG for each response option (%) and item average (on a 6-point scale)

I know how to…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
use H&S equipment to follow standard work procedures	0.3	0.4	2.4	7.6	38.1	51.3	5.37
maintain or improve workplace H&S	0.4	0.6	2.3	10.6	43.3	42.8	5.24
reduce the risk of workplace H&S incidents at my job	0.1	1.1	1.9	9.9	39.8	47.2	5.30

Table 53. H&S motivation in SSG for each response option (%) and item average (on a 6-point scale)

It is important to…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
maintain workplace health and safety at all times	0.6	0.3	1.0	3.3	22.1	72.7	5.64
reduce the risk of workplace H&S incidents at my job	0.4	0.4	0.9	3.4	22.2	72.6	5.64
maintain or improve my personal H&S	0.6	0.4	0.6	4.0	21.0	73.5	5.65

Table 54. H&S training adequacy in SSG for each response option (%) and item average (on a 6-point scale)

When it comes to H&S training…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
this site provides enough training for me to do my job	1.9	2.6	4.7	12.3	35.7	42.8	5.06
it helps me do my job as healthy/safely as I can	1.1	1.5	3.9	11.2	38.0	44.3	5.16
it is not a priority here	57.7	19.6	6.2	6.2	6.5	3.8	5.05

Table 55. Adaptability in SSG for each response option (%) and item average (on a 6-point scale)

In general I think that…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
tried and tested ways of doing things are usually the best	3.2	5.3	10.6	25.3	32.9	22.7	4.47
I can handle any changes that come along	0.6	1.1	4.0	17.4	46.7	30.2	4.99
changes in my work routine keep my job interesting	3.3	4.2	7.6	19.1	39.4	26.3	4.66

Appendix F: Overall Results/Averages for Industrial Minerals Industry (n = 907)

Table 56. Proactivity in industrial minerals for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
go out of my way to address potential hazards	1.1	1.3	6.2	18.9	33.7	38.7	4.99
voluntarily carry out tasks that help improve H&S	0.7	1.3	4.8	19.1	38.7	35.4	5.00
make suggestions to improve how H&S is handled	1.0	2.9	10.3	24.7	36.5	24.6	4.67
try new things to improve workplace H&S	1.3	2.8	11.0	26.5	33.3	25.2	4.63
try to solve problems in ways that reduce H&S risks	0.9	1.6	6.5	19.3	36.2	35.5	4.95

Table 57. Compliance in industrial minerals for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
don't take risks that could result in an accident	0.6	1.7	4.3	10.5	26.1	56.9	5.31
use all necessary H&S equipment to do my job	0.8	1.2	2.7	11.6	28.5	55.3	5.32
use the correct H&S procedures for carrying out my job	0.8	0.6	3.1	9.5	32.0	54.0	5.33
always report all H&S-related incidents	1.1	1.1	5.0	11.0	25.9	55.9	5.27

Table 58. Sense of control in industrial minerals for each response option (%) and item average (on a 6-point scale)

When I'm at work I…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I can pretty much achieve whatever I set out to do	1.1	0.4	4.2	13.5	40.9	39.8	5.12
I can do something if I am unhappy about a decision	4.8	4.4	9.7	22.3	36.9	21.8	4.48
I can stay healthy/safe if I take the right actions	0.9	0.7	1.8	7.1	31.2	58.4	5.42
most problems that I experience are "out of my hands"	14.1	21.0	18.8	21.2	14.9	10.1	3.68

Table 59. Thoroughness in industrial minerals for each response option (%) and item average (on a 6-point scale)

When doing my job…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I am always thorough	1.2	1.7	5.9	24.5	45.0	21.7	4.76
I can be somewhat careless with my work tasks	40.7	30.1	10.8	9.1	6.5	2.8	4.81
I'm a reliable worker	1.4	0.2	0.9	2.3	25.2	69.9	5.59
I work until my task is finished	1.0	0.8	1.2	8.7	33.2	55.0	5.38
I know when to seek help during a difficult task	0.8	0.7	2.8	7.3	32.8	55.5	5.37

Table 60. Risk tolerance in industrial minerals for each response option (%) and item average (on a 6-point scale)

As far as day to day work…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
I do not take risks with my safety/health	2.2	1.7	3.7	11.4	29.8	51.2	5.19
I take risks regularly	54.2	27.8	7.3	4.3	3.3	3.1	5.16
safety comes first	0.9	0.4	1.9	6.5	24.5	65.7	5.50
I prefer to avoid risks	1.4	1.4	1.7	8.3	28.1	59.0	5.37

Table 61. Organizational support for H&S in industrial minerals for each response (%) and item average (on a 6-point scale)

As far as day to day work…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
H&S rules and procedures are sometimes ignored	30.2	24.9	12.1	15.6	12.1	5.1	4.30
it doesn't matter how the work is done if there are no accidents	54.3	24.0	7.5	5.4	4.2	4.6	5.05
I often have impossible production pressures	25.6	25.8	16.6	16.0	9.8	6.2	4.23

Table 62. Coworker communication in industrial minerals for each response (%) and item average (on a 6-point scale)

Everyone in my crew…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
has confidence in each other to work safely	1.9	2.0	5.4	15.8	39.4	35.5	4.95
helps each other with H&S problems at work	1.2	1.7	5.1	14.2	41.2	36.6	5.02
informs each other about potential workplace H&S hazards	0.9	1.0	4.4	12.5	37.4	43.8	5.16

Table 63. Supervisor support for H&S in industrial minerals for each response (%) and item average (on a 6-point scale)

My supervisors…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
try to help me do my job as safely as possible	2.2	2.1	4.7	10.9	30.5	49.1	5.14
help me if I have a H&S problem at work	2.1	1.7	4.5	9.3	34.4	48.0	5.16
don’t notice if I do my job safely	34.0	29.5	10.1	9.8	9.4	7.2	4.47

Table 64. Supervisor communication in industrial minerals for each response (%) and item average (on a 6-point scale)

My supervisors…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
remind me to follow H&S work rules	2.1	3.1	5.3	12.5	34.7	42.3	5.01
closely monitor my H&S work practices	3.5	6.8	11.9	23.8	31.9	22.1	4.40
take action if I don't follow H&S work practices	2.6	3.1	6.9	16.6	38.6	32.3	4.82
clearly explain H&S rules to me	2.4	4.1	6.7	15.0	35.1	36.7	4.86
regularly inform me of work hazards specific to my job	3.4	4.9	10.4	17.7	30.9	32.6	4.66
encourage communication about H&S problems	2.9	3.2	6.8	13.7	33.7	39.7	4.91
I am satisfied with my supervisor's H&S management	4.0	3.8	5.3	12.3	32.4	42.1	4.92

Table 65. Worker engagement in industrial minerals for each response (%) and item average (on a 6-point scale)

When it comes to the H&S rules…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
the same rules apply to all employees	5.5	3.4	6.2	7.8	24.9	52.1	4.99
I can question the rules/procedures that influence my work	5.0	5.7	6.0	14.8	32.4	36.1	4.72
concerns are heard before making new rules or procedures	4.4	4.7	10.2	19.1	32.2	29.4	4.58
I am involved in improving H&S rules and procedures	6.2	7.1	13.0	23.9	27.8	22.0	4.26

Table 66. H&S knowledge in industrial minerals for each response (%) and item average (on a 6-point scale)

I know how to…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
use H&S equipment to follow standard work procedures	0.4	0.3	2.3	7.5	36.1	53.2	5.38
maintain or improve workplace H&S	0.4	0.8	3.2	12.8	38.2	44.6	5.21
reduce the risk of workplace H&S incidents at my job	0.6	0.4	3.0	12.8	38.5	44.6	5.22

Table 67. H&S motivation in industrial minerals for each response (%) and item average (on a 6-point scale)

It is important to…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
maintain workplace health and safety at all times	0.2	0.2	1.4	4.9	20.1	73.1	5.64
reduce the risk of workplace H&S incidents at my job	0.2	0.0	1.1	5.6	21.5	71.6	5.63
maintain or improve my personal H&S	0.3	0.2	1.6	4.2	20.0	73.7	5.64

Table 68. H&S training adequacy in industrial minerals for each response (%) and item average (on a 6-point scale)

When it comes to H&S training…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
this site provides enough training for me to do my job	0.9	0.9	4.0	8.3	32.0	53.9	5.31
it helps me do my job as healthy/safely as I can	0.6	1.6	2.9	7.7	34.1	53.2	5.33
it is not a priority here	69.6	14.2	3.9	5.2	3.8	3.3	5.31

Table 69. Adaptability in industrial minerals for each response option (%) and item average (on a 6-point scale)

In general I think that…	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Average
tried and tested ways of doing things are usually the best	3.2	5.7	12.3	26.0	32.0	20.8	4.40
I can handle any changes that come along	0.7	1.0	4.5	15.8	46.8	31.3	5.01
changes in my work routine keep my job interesting	3.1	3.6	9.0	21.2	36.9	26.3	4.64

Appendix G: Relative Weights Results by Coal Mining Subsector

Table 70. Impact of safety climate constructs on worker performance (proactivity and compliance), knowledge, and motivation in the coal mining industry

Construct	Proactivity R^2 = 37.06%	Compliance R^2 = 49.17%	Motivation R^2 = 38.15%	Knowledge R^2 = 57.97%
	RS-RW (%)	RS-RW (%)	RS-RW (%)	RS-RW (%)
Organizational H&S support	4.10*	5.96*	6.64*	3.22
Supervisor H&S support	5.59*	4.46*	3.37	5.04
Supervisor communication	10.55*	9.08*	7.09*	17.19
Coworker communication	10.94*	6.87*	15.16*	9.39
Worker engagement	7.74*	8.47*	5.28*	17.56
H&S training	8.48*	8.54*	16.39*	13.60
Sense of control	11.69*	8.16*	6.28*	4.59
Thoroughness	21.48*	17.88*	13.94*	13.29
Risk tolerance	12.98*	26.36*	14.81*	8.89
Adaptability	6.45*	4.21*	11.04*	7.22

*Statistically significant at the p = .05 level.

Table 71. Impact of safety climate constructs on H&S outcomes in the coal mining industry

Construct	Near misses R^2 = 10.89%	First aid R^2 = 8.22%	Med. treatment R^2 = 7.95%	Days lost R^2 = 8.55%
	RS-RW (%)	RS-RW (%)	RS-RW (%)	RS-RW (%)
Organizational H&S support	23.70*	44.31*	26.75*	21.15
Supervisor H&S support	11.42	4.07	4.40	5.30
Supervisor communication	4.03	3.21	3.49	3.14
Coworker communication	4.76	1.66	3.49	2.81
Worker engagement	11.11	15.91	18.03	17.17
H&S training	5.06	8.29	11.26	6.18
Sense of control	2.42	8.71	8.50	5.91
Thoroughness	17.36	7.90	20.24	31.87*
Risk tolerance	14.75	2.11	3.03	3.29
Adaptability	5.42	3.80	0.90	3.16

*Statistically significant at the p = .05 level.

Appendix H: Relative Weights Results by SSG Mining Subsector

Table 72. Impact of safety climate constructs on worker performance (proactivity and compliance), knowledge, and motivation in the stone, sand, and gravel industry

Construct	Proactivity R^2 = 31.81%	Compliance R^2 = 44.40%	Motivation R^2 = 43.16%	Knowledge R^2 = 49.29%
	RS-RW (%)	RS-RW (%)	RS-RW (%)	RS-RW (%)
Organizational H&S support	4.18*	2.04*	1.48*	4.18*
Supervisor H&S support	6.36*	2.77*	4.88*	6.36*
Supervisor communication	5.46*	4.88*	9.62*	5.46*
Coworker communication	9.54*	7.20*	13.34*	9.54*
Worker engagement	9.69*	4.21*	4.44*	9.67*
H&S training	5.68*	4.34*	13.87*	9.34*
Sense of control	21.76*	9.29*	9.89*	8.50*
Thoroughness	18.47*	23.41*	22.42*	17.67*
Risk tolerance	12.20*	31.41*	20.52*	14.19*
Adaptability	6.30*	1.77*	11.92*	11.18*

*Statistically significant at the $p = .05$ level.

Table 73. Impact of safety climate constructs on H&S outcomes in the stone, sand, and gravel industry

Construct	Near misses R^2 = 7.3%	First aid R^2 = 5.97%	Med. treatment R^2 = 7.92%	Days lost R^2 = 6.54%
	RS-RW (%)	RS-RW (%)	RS-RW (%)	RS-RW (%)
Organizational H&S support	29.47*	30.08*	33.79*	39.49*
Supervisor H&S support	6.46*	5.10	3.69	5.95*
Supervisor communication	2.20	1.67	2.01	2.64
Coworker communication	1.49	1.58	1.57	1.47
Worker engagement	4.29	0.92	1.15	1.17
H&S training	6.16*	4.47	3.93*	2.33
Sense of control	1.91	1.78	1.74	1.99
Thoroughness	20.29*	21.60*	19.81*	18.21*
Risk tolerance	26.54*	31.66*	25.81*	17.71*
Adaptability	1.16	1.11	6.47*	9.00*

*Statistically significant at the p = .05 level.

Appendix I: Relative Weights Results by Industrial Minerals Subsector

Table 74. Impact of safety climate constructs on worker performance (proactivity and compliance), knowledge, and motivation in the industrial minerals industry

Construct	Proactivity R^2 = 34.63%	Compliance R^2 = 49.08%	Motivation R^2 = 37.53%	Knowledge R^2 = 52.29%
	RS-RW (%)	RS-RW (%)	RS-RW (%)	RS-RW (%)
Organizational H&S support	1.10*	1.88*	2.26*	2.88*
Supervisor H&S support	3.99*	3.47*	5.81*	9.05*
Supervisor communication	4.63*	4.04*	6.28*	10.83*
Coworker communication	9.68*	13.33*	8.78*	10.46*
Worker engagement	20.91*	4.75*	6.68*	14.97*
H&S training	5.94*	5.55*	23.55*	17.85*
Sense of control	12.01*	8.53*	8.78*	9.13*
Thoroughness	20.58*	25.67*	13.01*	10.52*
Risk tolerance	13.28*	29.28*	13.24*	5.99*
Adaptability	7.85*	3.49*	11.57*	8.30*

*Statistically significant at the p = .05 level.

Table 75. Impact of safety climate constructs on H&S outcomes in the industrial minerals industry

Construct	Near misses R^2 = 11.66%	First aid R^2 = 8.56%	Med. treatment R^2 = 9.81%	Days lost R^2 = 9.83%
	RS-RW (%)	RS-RW (%)	RS-RW (%)	RS-RW (%)
Organizational H&S support	36.39*	21.92*	30.09*	22.11*
Supervisor H&S support	6.62*	2.68	3.49	3.73
Supervisor communication	3.67	2.18	3.41	4.37
Coworker communication	2.34	2.02	2.85	2.12
Worker engagement	2.44	2.62	5.96	4.87
H&S training	25.11*	32.24*	25.35*	36.81*
Sense of control	5.05	4.96	5.11	4.39
Thoroughness	4.43	19.49*	18.45*	16.37*
Risk tolerance	13.38*	10.04*	3.65	4.20
Adaptability	0.52	1.82	1.62	0.99

*Statistically significant at the p = .05 level.

Appendix J: Management Communication Scorecard for Establishing and Maintaining Visibility

Communication strategy		Scorecard		Evaluation and action plan	
	Management Objectives	Measurement	Target	Communication quality indicators	Ways to improve
Establish and maintain management visibility	Support worker H&S initiatives	• # workers talk to about risks on the job (pre/mid/post shift)		• List proactive discussions with workers about risk management	• Leave conversations on a positive note • Balance listening and action • Focus on specific hazards and warnings • Discuss individual sampling results with workers • Explain rules and the reason(s) behind their implementation
	Follow through and do what you say you will do	• # workers follow up with pre/mid/post shift		• List discussion topics had with workers about hazards, risks and mitigation efforts	
	Focus on quality over of quantity of interactions	• # work orders put in based on risk assessment discussions		• List work orders fixed, what determined priority and average time it takes to address these issues	
	Actively listen to worker concerns	• # medium to high-risk hazards workers identify to you		• List of common hazards identified, when, and where	
		• # hazards mitigated with the help of workers		• List of hazards mitigated and how, who took the lead, and how long it took to address	
		• # one-on-one interactions/ reminders with workers		• Common one-on-one topics discussed	
		• # of positive H&S things found/ observed that workers are doing		• Best practices identified with workers	
		• # risk assessments turned in		• Types of incidents prevented through RAs	
		• # risk assessments mitigated		• New methods/tools used to assess risk	

Document indicators currently being improved:

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Appendix K: Management Communication Scorecard for Establishing and Maintaining Consensus among the Workforce

Communication strategy		Scorecard		Evaluation and action plan	
Management objectives		Measurement	Target	Communication quality indicators	Ways to improve
Establish and maintain consensus among the workforce	Obtain trust and buy-in from the workforce	• # workers involved in a new process		• List methods/tools used to empower and involve workers	• Establish a balance of hourly and salaried workers on all decision-making committees • Establish a safety team that has primarily hourly representatives • Develop new programs for self and peer evaluation, provide feedback on all assessments
	Support worker execution of H&S practices	• # of tours or observations performed by H&S committee		• List hazards and risks commonly found and reported by hourly employees	
	Engage workers in H&S decision making	• # risks or hazards found during H&S observations/tours		• Trends in reported hazards and mitigation strategies	
	Enhance workers' responsibility and accountability on the job	• # of leadership development opportunities for workers		• Leadership development opportunities identified for workers, including frequency	
		• # of peer-to-peer interventions performed/facilitated		• How peers evaluate each other, common hazards identified, and corrective actions taken	

Document indicators currently being improved:

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Appendix L: Management Communication Scorecard for Establishing Consistent Communication with the Workforce

Communication strategy		Scorecard		Evaluation and action plan	
	Management objectives	Measurement	Target	Communication quality indicators	Ways to improve
Establish and maintain consistency of the H&S management system	Balance proactive and reactive communication	• # basic observations (positive or negative) used to give feedback		• Develop safety standards, new task training, and feedback in response to observations	• Ask employees what is/is not working on the job • Establish a value-based reward program grounded in communicative support • Establish a script for pre-shift meetings so the same messages are communicated across shifts • Have daily management meetings to ensure consistent communication with the workforce throughout the day
	Sustain proactive and reactive communication	• Discretionary system used to reward safety values		• Methods and types of recognition programs for workers	
	Balance positive and negative reinforcements	• # of crew-based meetings throughout the week		• Types of messages communicated in pre-shift meetings and hazard noted across shifts	
	Balance positive and negative consequences	• # of risk assessment, near miss, or other forms completed		• List of risks identified within an RA matrix	
	Establish high-quality communication mediums	• # of reported issues that were discussed with workforce		• List of issues reported and how they were resolved, including how long it took to follow up	
		• # of corrective action reports		• List corrective actions made	
		• # of targeted injuries reduced or prevented		• Specific scenarios where injuries have been prevented based of changes made	

Document indicators currently being improved:

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