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Behavioral safety compliance in an interdependent mining environment: supervisor communication, procedural justice and the mediating role of coworker communication

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Abstract

Objectives.—Although a focus on safety communication between managers and employees has been prevalent, research around coworker influence in this communication has been fragmented in the literature.

Methods.—To examine these issues, researchers gathered survey data from 1955 mine employees from surface stone, sand and gravel (SSG) and industrial mineral operations across the USA between 2016 and 2018, and studied the effects of relationships between justice perceptions, supervisor communication and coworker communication on behavioral safety compliance.

Results.—Using structural equation modeling, coworker communication partially mediated the direct effects of supervisor communication and justice perceptions on behavioral safety compliance – where the indirect effects were greater for justice perceptions.

Conclusion.—The results demonstrate the value in formal and informal communication paths to facilitate employee safety compliance; and that enhanced perceptions of job fairness and adaptability enhances coworker communication, further improving compliance in an interdependent environment.

Keywords

interdependent work environment; procedural justice; safety communication; structural equation modeling; supervisor–coworker relationships

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Disclosure statement

No potential conflict of interest was reported by the authors.

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1. Introduction

Mining is an occupation in which individual employees must collaborate with one another to accomplish their tasks. Because of the work itself and the specialization of jobs, mining is considered a highly interdependent work environment [1]. In interdependent environments, where separation between supervisors and employees is prevalent, it is important to determine the influences that coworkers may have on compliant safety behaviors on the job. Particularly, mine sites tend to have flat organizational structures where horizontal interactions are not only a critical component to work tasks but also to following the rules and procedures associated with those tasks. This study sought to examine how common situational factors established within an interdependent mining environment, such as communication and policies that promote fairness, may influence worker compliance.

Although safety compliance can be impacted by a variety of situational factors, this study sought to determine the relationships among supervisor communication, procedural justice and coworker communication on behavioral safety compliance. Besides determining the effects of these factors, researchers were particularly interested in understanding the potential mediating effect of coworker communication on behavioral compliance within the mining environment. Specifically, because coworkers are more likely to interact with each other during the day and are dependent on each other to complete work tasks, understanding the role that positive or negative coworker interactions may have on safety performance is critical to understand. Further, investigating the role and importance of these constructs in the context of the mining industry is increasingly important given the growing integration in mining automation and the accompanying reliance on clear and transparent communication [2]. Specifically, as job tasks are replaced and new job positions are developed, the frequency and importance of horizontal communication are likely to increase and aid the future organization of work. We start with a description of mining as an interdependent work environment, followed by a discussion of the situational predictors and mediators of safety compliance being studied.

1.1. Mining as a task-interdependent process

Since the beginning of the modern mining age, researchers have recognized mining as an interdependent occupation [3,4]. These studies found during the introduction of mechanized longwall mining methods that all three shifts making up the 24-h operations were highly interdependent; the cutting work of the first shift significantly affected the ripping work of the second shift, which then affected the third shift's ability to complete their filling tasks. Trist and Bamforth [3] went so far as saying 'So close is task interdependence that the [mining] system becomes vulnerable from its needs for 100% performance at each step' [3,p.18].

More recent research has continued to acknowledge the interdependency in mining. In discussing the management of surface mines, Sinclair [5] indicated that most work tasks must be done in an exact sequence, fostering high task interdependence. As another example, for a surface mining operation that requires blasting, occupational tasks may include boring holes, placing explosive materials inside the holes and then firing the shots. This makes the activities of one worker within a crew highly interdependent with the ability

of workers to successfully and safely complete subsequent blasting activities [5]. Relatedly, because work tasks in mining are interdependent, reward and penalty systems are often crew oriented, which makes coworkers even more dependent on one another for bonuses [6]. Therefore, the interdependent nature of work organizations and respective tasks in highly dynamic environments requires employees to communicate, collaborate and coordinate with each other to accomplish goals [7].

1.2. Situational predictors and mediators of compliance

1.2.1. Supervisor communication and behavioral compliance—Interventions to improve management styles have been discussed as a promising approach to improve employee safety compliance. Supervisory leadership has demonstrated predictive utility regarding organizational, worker and general health and safety outcomes [8–10]. Leadership and positive role modeling have also been correlated with worker perceptions of empowerment, engagement and feelings of job fairness [11]. These findings support why it is common for the managerial practices of senior leadership to serve as a frame of reference for guiding safe behaviors in the workplace [12,13].

Leadership communication has been established as a significant predictor of safety behaviors and workplace injuries [e.g., 14–17] and remains an important way to assess comfort and transparency within an organization. Safety communication is any formal or informal communication among project members regarding safety issues [18] that significantly impacts safety outcomes [19–22]. By improving leadership safety communication, individual perceptions of management and employees' subsequent safety outcomes are likely to improve [23,24]. Empirical research has even determined that open and frequent communication practices among supervisors and coworkers contribute to hazard identification, safety outcomes and reduced incident rates [20,21,25].

Relationships between supervisors and employees are perceived as positive when there is mutual respect, trust and obligation toward each other [26]. Research has also shown that the quality of relationships between supervisors and employees may have spillover effects on coworker communication [27,28]. Lau and Liden [6] found that leaders play a critical role in shaping coworker relationships, arguing that supervisor communication sets the tone for horizontal communication in the workplace as well as attitudes toward each other on the job. Research has also demonstrated that if a supervisor trusts two coworkers, those two coworkers are more likely to trust each other and have a positive relationship [29]. In other words, leaders' trust and support can be considered transmissible in that it enhances the same trustworthy and supportive perceptions among their employees [30].

1.2.2. Procedural justice and behavioral compliance—Fairness in the workplace is often referred to as procedural justice [31]. Fair treatment, as discussed by Tyler and Blader [32], conveys messages about individual value, contribution to the group and willingness to trust others. This construct also reflects employees' perceptions that the organizational leadership is willing to involve them in decision-making processes regarding the procedures that influence their work [17,33]. If employees perceive their involvement and evaluations to be fair, they are more likely to reciprocate by performing behavior to

benefit the organization that goes beyond the in-role performance of their jobs. Ashforth and Humphrey [34] argued that being equally engaged accounts for both workers' motivation on the job as well as their behavioral tendencies that influence performance. For these reasons, procedural justice perceptions have been found to be a consistent, significant predictor of safety outcomes [35,36].

Predictive relationships have been validated using procedural justice and organizational effectiveness [e.g., 37,38]. Procedural justice has also been heavily studied in terms of its impact on relational trust and communication in supervisor–subordinate relationships [e.g., 32,39,40]. Relatedly, Forret and Love [41] found that justice in the form of fair and equal behaviors by supervisors affects employees' relationships with each other. Some studies have even shown an association between justice perceptions and workplace friendships [42,43]. Specifically, these research findings found that if workers have a negative perception of justice or fair procedures at work, workplace friendships tend to be negatively impacted. Such findings show support for additional research in this area to appropriately determine the relationships between perceived fairness and peer communication. In the present study, coworker communication is hypothesized as a mediator of procedural justice and employee compliance. What makes this study more unique, however, is the examination of these interactions within an interdependent work environment where mineworkers are highly reliant on each other to maintain personal safety.

1.2.3. Coworker communication as a mediator in an interdependent work context—Although a focus on safety communication between managers and employees has been prevalent, Chiaburu and Harrison [44] argued that research around coworker influence has been fragmented in the literature. Focusing on managers' behaviors alone is inadequate for developing a proactive workforce [45]. Due to the high interdependency of the job tasks in mining, coworker communication may be a stronger factor in workers' compliant, or rule-following, activities. Specifically, hourly or front-line employees often work in closer proximity with one another, making peer-to-peer communication highly relevant. This is particularly the case in occupations such as mining, where managers are not able to be present at each job task to monitor employee activities [46]. Additionally, Carroll [47] suggested that, regarding safety, issues are more likely to be brought up and discussed among coworkers because of their closeness to the actual hazards. Research has shown that such communication with coworkers promotes cooperation and has been empirically shown to enhance occupational safety as well as lower injury rates [17].

Previous studies have made conclusions that position coworker communication as a mediator of interest. For example, Hirschman [48] suggested that horizontal communication can play a mediating role in mobilizing upward communication. Other research has positioned coworker support as a mediator between the employee safety voice and perceived organizational support for safety [49]. Particularly, because coworkers can be important conduits of safety information and safety rules, they can influence employee compliance [50]. For example, Westaby and Lowe [46] found that coworker presence and intervention reduces the risk-taking behaviors of their peers. Therefore, it is not surprising that some scholars believe that aspects of coworker communication, such as trust and overall

relationships, are an important but overlooked influence on safety-related communication [49].

When individuals within a work group must cooperate to accomplish something, they are considered interdependent [51]. More specific in these environments is task interdependence, the degree to which team members plan and help others through their own actions and resources [52]. Earlier research in worker compliance did not account for safety decisions when systems were interdependent [53,54]. However, there has been a push to focus on the interdependency of work systems as it relates to organizational safety outcomes [55]. For example, Griffin et al. [56] argued that interdependence in organizations must be studied and managed, not only to be more effective overall but also to limit employee work pressures. These researchers also contended that specific ways to function in an interdependent work environment to support safety behavior remain unexamined. Accordingly, this study focused on the mining industry as an interdependent work environment to better reveal critical predictors and potential mediators of employee safety compliance.

1.3. Research hypotheses and conceptual model

The current literature review highlighted the importance of understanding the potential mediating effect of coworker communication on behavioral compliance within an interdependent work environment. In the present study, we tested some of these derived gaps by examining the effects of relationships among supervisor communication, procedural justice and coworker safety communication on behavioral safety compliance. To that end, the following hypotheses were formed with the aim to identify where organizations can support soft skill development to improve future mining processes:

H_1 : increased supervisor communication will lead to increased behavioral compliance.

H_2 : increased justice perceptions will lead to increased behavioral compliance.

H_3 : coworker communication will mediate the relationship between supervisor communication and behavioral compliance in an interdependent work context.

H_4 : coworker communication will mediate the relationship between justice perceptions and behavioral compliance in an interdependent work context.

Collectively, the hypotheses suggest a theoretical model, as shown in Figure 1.

2. Method

Through an extensive literature review, we identified several perception-based situational and personal constructs that were presumed to be important in fostering compliant safety behavior. Because many emergent, perception-based constructs have both a theoretical and an empirical history, psychometrically tested items already existed for many constructs of interest. Using these previously developed, psychometrically tested items, we were able to test the associated theories and overall model within the mining industry and, in some cases, remove items from lengthy measures to adequately capture all desired constructs. Coworker

communication, procedural justice (i.e., engagement) and supervisor communication were three external factors identified and measured. For more information about the development of the survey and the individual and external constructs measured within the survey, refer to the full NIOSH report [57].

2.1. Survey instrument

Although the overall data collection assessed both situational and person-level factors, for the current analysis only three situational factors (i.e., supervisor communication, coworker communication and procedural justice) and behavioral safety compliance as the outcome variable were included in the current study. These four variables, detailed in the following, were measured at the worker level of analysis.

2.1.1. Compliance survey scale—Our safety compliance scale was adapted [17,58] to measure perceived adherence to safety procedures. The original scale had Cronbach's $\alpha = 0.94$. In our current survey, the scale was adapted to a four-item measure that workers were asked to complete using a 6-point Likert scale (1 = *strongly disagree* to 6 = *strongly agree*), with 6 indicating the highest perceived level of compliance. Our shortened, four-item version had Cronbach's $\alpha = 0.85$, demonstrating high internal reliability [59,60]. The four questions were verbalized as statements (rather than questions) prefaced with 'When I'm at work I ... ' and phrased as follows: (a) ' ... don't take risks that could result in an accident'; (b) ' ... use all necessary health and safety equipment to do my job'; (c) ' ... use the correct health and safety procedures for carrying out my job'; (d) ' ... always report all health/safety-related incidents'.

2.1.2. Supervisor communication—Supervisor communication was measured with six items that originated from Hofmann and Morgeson [61], who had Cronbach's α averaging 0.85. Other studies have adapted items from their scale to be shorter or context-specific [e.g., 62–64]. Cronbach's α for our adapted scale was 0.90. The six questions were verbalized as statements prefaced with 'My supervisor ... ' and phrased as follows: (a) ' ... reminds me to follow health and safety work rules'; (b) ' ... closely monitors my health and safety work practices'; (c) ' ... takes action if I don't follow health and safety work practices'; (d) ' ... clearly explains health and safety rules to me'; (e) ' ... regularly informs me of work hazards specific to my job'; (f) ' ... encourages communication about health and safety problems'.

2.1.3. Perceived procedural justice—Perceived justice was measured with four items adapted from a six-item scale [33] that studied justice as a mediator of the relationship between methods of monitoring and organizational citizenship behavior. This scale, originally based on Moorman [65], had Cronbach $\alpha = 0.90$. Our adapted scale had Cronbach's $\alpha = 0.79$. Items were phrased as statements and respondents were asked to rate the degree to which they agreed with items on a 6-point scale. The questions were prefaced with 'When it comes to the health and safety rules and procedures in place at this site ... ' and followed with: (a) ' ... the same rules apply to all employees'; (b) ' ... I can question the rules/procedures that influence my work'; (c) ' ... my supervisor makes sure that our

concerns are heard before making any new rules and procedures'; (d) '... I am involved in improving health and safety rules and procedures'.

2.1.4. Coworker communication—Coworker communication was measured with three items adapted from a six-item measure of interpersonal trust in peers [66]. Additional studies have gleaned items from their scale [e.g., 17,45] to study issues of coworker trust and communication as well. For Cook and Wall [66], Cronbach's $\alpha = 0.85$. In our shortened three-item scale, we also had Cronbach's $\alpha = 0.85$. Items were phrased as statements, and respondents were asked to rate the degree to which they agreed with each statement. The questions were prefaced with 'Everyone in my work crew ...' and followed with: (a) '... has confidence in each other to work safely'; (b) '... helps each other with health and safety problems at work'; (c) '... informs each other about potential workplace health and safety hazards'. Each item was related to one of a series of organizational constructs identified earlier, and responses were used to calculate a mean score for each construct.

2.2. Recruitment and data collection

Researchers received approval from the Institutional Review Board before this data collection. Prior to administering the survey to mine employees at each participating worksite, survey questions went through a face validity and internal reliability check through a small-scale pilot effort. Subsequently, recruitment and data collection occurred from February 2016 through February 2019. Once initial data collection with the first company was completed and pilot results were communicated during various mining trade and conference presentations, subsequent companies began to contact the researchers to participate in the study.

Researchers tried to coordinate data collection with any type of health and safety trainings being offered because everyone was together at one time and close to 100% participation could be obtained. Alternatively, researchers worked with the mines to distribute surveys as a part of pre-shift safety meetings. Mine management and hourly workers were briefed about the purpose of the survey and told that their responses would remain confidential and not be seen by their supervisors. Everyone was given the option to voluntarily participate and provided with the principal investigator's contact information. The survey took approximately 15 min to complete.

2.3. Participants

Participants consisted of 1955 mineworkers at 31 mine sites throughout the USA. The mines represented the mining subsectors of stone, sand and gravel (SSG) (53.6%, $n = 1048$) and industrial minerals (46.4%, $n = 907$). These specific commodities were chosen as the sample of interest due to the interdependence on workers to complete the extraction and production processes. SSG operations as well as industrial mineral operations are naturally, but also necessarily, dispersed worksites to accomplish production, maintenance and process-based tasks. Because these work tasks are spread across these large areas, supervisors have limited consistent and direct contact with employees. Due to fewer opportunities to communicate with supervisors, employees depend on each other for their own safety, for creating a safer work environment and for holding each other accountable. The breakdown of employee

experience is presented in Table 1 and other demographic characteristics of the overall sample are presented in Table 2.

Descriptive statistics for the data showed that each variable met the common rule-of-thumb test for normality in that the skewness was within the -2 to $+2$ range [67]. Applying the more stringent -1 to $+1$ criterion, the skew was close to these levels. Psychometric studies that include Likert measured responses typically contain skewed data. Bootstrapping has been identified as the leading method to correct bias associated with non-normally distributed variables [68–70]. Sophisticated bootstrapping techniques were used [71] and are detailed in the following sections.

3. Results

3.1. Factor analysis

Of the 1955 employees who completed the survey, 18 were found to be incomplete and were subsequently discarded. Using the completed surveys ($N = 1937$), researchers first ran an item-level factor analysis to examine the underlying structure in relation to the responses to the items categorized within the theoretical construct. The factor analysis was performed using principal components analysis with varimax rotation. Each of the four factors produced an eigenvalue greater than 1, and all items were adequately loaded on one construct with values greater than the recommended cutoff of 0.50 [72]. The loadings for each item on each construct are presented in Table 3.

3.2. H_1 and H_2

Bivariate correlations provide initial support for H_1 and H_2 . For each latent construct, the means, standard deviations, reliabilities and correlations are presented in Table 4. Each of the correlations is significant at the $p < 0.01$ level. The correlations show that the bivariate relationships are significant ($p < 0.01$) and in the expected direction between each of the key constructs shown in Figure 1. The correlation coefficient between supervisor communication and behavioral compliance is moderately positive and significant ($r = 0.37$, $p < 0.01$). The correlation coefficient between justice perceptions and behavioral compliance is also moderately positive and significant ($r = 0.34$, $p < 0.01$).

3.3. H_3 and H_4

Structural equation modeling (SEM) was used to answer H_3 and H_4 . Two structural models were initially examined. Model 1 was the conceptual model shown in Figure 1. This model included no direct pathways from perceived justice and supervisor communication to behavioral compliance. Model 2 included direct paths from each of the distal predictors (procedural justice and supervisor communication) to the outcome of interest (behavioral compliance). The inclusion of the direct paths allowed for the bootstrapped derivation of total, direct and indirect effects and, in turn, the computation of the percentage of mediation attributed to the hypothesized mediator [73]. Given an acceptable ratio of estimated parameters to the number of responses, full SEM models were utilized within SPSS version 25.0 [71]. This program allowed for the posterior, bootstrapped distributions to be observed; and for each variable in the model, the bootstrapped distributions appeared normal.

The bootstrapped standardized path coefficients derived from Model 2 are presented in Table 5 and shown in Figure 2. The estimated path coefficients provide partial support for *H3* and *H4*. The coefficients for prediction of coworker communication by supervisor communication and justice perceptions are both positive and significant ($\beta = 0.31, p < 0.001$ and $\beta = 0.25, p < 0.001$, respectively). Coworker communication also positively and significantly predicts behavioral compliance ($\beta = 0.41, p < 0.001$). There is also a significant path between supervisor communication and behavioral compliance ($\beta = 0.15, p < 0.001$). With regard to *H4*, there is a significant correlation between justice perceptions and behavioral compliance, combined with the non-significant path estimate in the model ($\beta = 0.05, p = 0.19$).

To fully examine the mediation of *H3* and *H4*, the total, direct and indirect effects were examined. Consistent with the estimated path coefficients presented in Table 5, the total, direct and indirect effects reported in Table 6 provide partial support for the mediation hypotheses. Each of the total, direct and indirect effects of supervisor communication on behavioral compliance were significant. This result suggests that in an interdependent context there is a direct effect of supervisor communication on individual behavioral compliance that cannot be explained through coworker communication. However, coworker communication did account for 45.68% of the total effect.

In contrast, the total and indirect effects were significant in the relationship between procedural justice perceptions and behavioral compliance. The indirect effect of this relationship – through coworker communication – accounted for nearly 81% of the total effect providing support for the mediation in *H4*. Given the non-significant pathway between justice perceptions and behavioral compliance (Table 3), along with the non-significant direct effect within this relationship (Table 6), a final model was examined. Although there was some level of misspecification ($\chi^2 = 581.39, p < 0.05, df = 114$), the fit statistics suggested an excellent fit (comparative fit index [CFI] = 0.973, goodness-of-fit index [GFI] = 0.966, root mean square error of approximation [rmsea] = 0.46). The final model also fit significantly better than the hypothetical model shown in Figure 1 ($\chi^2 = 52.16, df = 1, p < 0.001$).

4. Discussion

Individual mineworkers must collaborate with one another to accomplish their job tasks. The current results demonstrate that, in an interdependent work environment with separation between supervisors and employees, coworker influences need to be accounted for. This finding is important as, historically, there has been a lack of attention to the embeddedness of communication relationships within a larger organizational environment [74], despite arguments for the inclusion of how justice issues are related to perceptions of work relationships among employees [26]. In our study, even though supervisor communication demonstrated a significant path to predicting behavioral compliance, coworker safety communication significantly mediated the relationship from procedural justice to safety compliance – accounting for 81% of the mediation. This current finding is critical and can be considered in future initiatives, especially when it comes to developing safety interventions to equally target work crews who operate in a high-risk environment.

The current findings support the dyadic relationship between perceived justice and coworker communication, with a strong connection to compliance. Although safety communication may not explicitly be associated with procedural justice and fairness, features of safety communication include transparency and openness, so that any work level or group can participate and receive adequate safety feedback [75]. These features illustrate the importance of procedural justice and opportunities for employee participation within interactive work relationships, especially considering that perceptions of unfairness influence peer communication at work [76]. Based on the current study results, mine management practicing and executing fair processes and decisions as well as promoting informal communication mechanisms among coworkers may be beneficial endeavors in the work environment. Additionally, considering the barriers of an interdependent work environment may give greater attention and need toward creating autonomy where possible, including flexibility in work routines, to help facilitate positive communication on the job and provide some readiness for changes to the organization of work in the future.

4.1. Considerations for interdependent environments

First, these results support previous research findings in that regular, formal communication with managers is needed to facilitate trust and support safety outcomes as well as overall knowledge [e.g., 77]. Supervisor communication significantly predicted compliance with and without coworker communication as a mediator, making formal lines of communication critical to worker decision-making. This communication occurs through predefined channels such as hazard warnings, trainings, work orders, signage and toolbox talks [20,21,78]. Also, given the significance in the prediction model, the results suggest that mine management may have a greater effect on their employees in an interdependent setting in comparison to those employees who do not operate in this type of setting. It is worth considering how the context of an interdependent work environment may influence the need for additional communication mechanisms. For example, interdependent tasks often require extra coordination and interaction with management, particularly when trying to determine how work should be distributed among groups [79]. Therefore, additional feedback during trainings to identify the knowledge and skills that may be needed or small work group meetings to ensure that everyone receives the same messages could be valuable.

Additionally, any communication and implementation of management processes and practices must be explained to work crews to enhance perceived fairness and support trust in one another. Although it is not surprising that coworkers prefer equal and consistent treatment within their work unit, it is useful to know that this sentiment increases when members of the same unit or crew are highly interdependent with respect to task accomplishment [80]. Therefore, the more interdependent the work environment, the more important perceived fairness becomes. The current results show that perceived fairness is linked to perceptions of coworker communication and then compliance, adding to the literature in this area. More specifically, the findings show that it is important for supervisors to communicate with and build in procedures of fairness with work crews who are task interdependent to help maintain positive working relationships.

Other examples of how to effectively lead and communicate in an interdependent work environment include being a leader who ‘walks the talk’ to positively model and foster higher levels of communication on the job [61]. For example, Haas [81] found that mineworkers desire informational support in the form of task challenges and appreciation but also value personal assistance offered by their supervisors, such as role modeling of safe work practices and one-on-one communication to help build rapport on the job. These types of supportive roles were more impactful in decision-making; however, results also highlighted the need for consistency in the execution of these practices across the workforce.

4.1.1. Fostering autonomy in interdependent environments—Additionally, supervisors may benefit from granting employees decision-making authority to encourage participation in higher-level processes. Characterized as autonomy, enabling decision-making within these interdependent groups may provide a need to reciprocate and perform tasks in a safe way [82]. Previous research has already shown that mine employees who are members of autonomous organizations have significantly higher perceptions of supervisor support, procedural justice and coworker communication [83]. However, additional research has shown that workers who have jobs that are high in autonomy and task interdependence experience responsibility for both their own and others’ work outcomes [84]. Because mining is task interdependent, it may be worthwhile for organizational management to reexamine the autonomy available to individual workers and work crews and improve decision-making authority and, therefore, adaptability of certain operations.

Mining processes entail monotonous and routine tasks that are completed daily. However, these interdependent work tasks create challenges to organizational adaptability [85]. To that end, the current results have implications when forecasting potential changes within the mining industry. Specifically, the rise of automation and potential reorganization of work tasks has the possibility to temporarily disrupt routine processes that have been in place for decades. Prior research has posited that organizations with routinized operations are vulnerable in a changing environment; due to the interdependence of tasks within routine operations, adaptation becomes difficult [86]. Future changes to the organization of work in mining makes the need for communication even more apparent to foster a safe, smooth transition.

Specifically, as robotics and automation become more prevalent and the frequency of human to machine interfaces evolves, work peers must be able to effectively communicate to enhance decision-making around new processes and scenarios. Particularly, the job tasks may not change much – similar routines will likely be in place – but the completion of the task may be done or monitored differently. In response to ongoing technological innovations, mineworkers need to have better creative and social intelligence to maintain their resiliency on the job [2]. In other words, with automation being able to perform manual and routine work, individual mineworkers will have the ability to undertake more work that involves collaboration and engagement with other people, helping to develop a necessary skill for future work.

4.1.2. Improving coworker communication mechanisms in interdependent environments—Finally, if work tasks and processes are modified in response to

automation in the future, and the location and skills of individual workers change, communication becomes even more important to facilitate the safe completion of work. Therefore, it may be in the interest of mine management to foster various routes of communication on the job to build such interactions and skills for the future. Communication should consistently occur among members of a work crew or group [20,21,87] and can include a mentorship, general discussion or exchanges via social media [18]. Research has shown that these mediums of safety communication are effective tools that management can utilize to ensure a transfer of tacit knowledge and prevent safety incidents [88].

In response, research about the fairness embedded within certain communication mechanisms, not just between supervisor and employee, but among coworkers who are task interdependent in a work environment, is needed. For example, research has made calls for an increased use in social media to enable coworkers to share audio-visual feedback and resources [18], although these practices have not yet been tested. Such applications can be used outside of work hours to share safety-based information and training [89], which can help enhance the features of safety communication discussed earlier. Additionally, using mobile applications may allow for every individual worker to be treated in the same way, given the same information and consistent feedback, hopefully improving perceptions of fairness on the job that, based on the current results, will bolster coworker communication even more. However, future research should strive to develop and evaluate the impact of such safety-based applications among the mining workforce.

5. Study limitations

The limitations of the study design must be considered when interpreting the findings. Particularly, the subtle differences of mining environments may affect the level of interdependency involved with tasks, along with the autonomy provided and perceptions of mine employees. Researchers did not account for the other structural factors that may have affected perceptions among participants. Future research should include and examine how the spatial organization of work and those organizations with and without automation present impacts perceptions on fairness and communicative relationships. Additionally, factors such as unionization and size of the operating sites would be useful to continue developing the empirical research in this area. Similarly, in the current study, researchers limited the subsectors included in the sample to better identify trends within an operation. However, it is possible that different commodities have different processes that could result in varying execution of practices. If this is the case, interventions may need to be tailored differently to have the intended effect on positive coworker relationships. Finally, this study only looked at mines as an interdependent environment and did not focus on the differences between coworkers who were receiving or initiating task interdependence. Given that historical suggestions have been made to distinguish between these two groups [3,90], future research should aim to assess these two different roles, preferably for changes to the organization of work around automation.

6. Conclusions

Although coworker communication does not constitute a workplace friendship, having positive associations with coworkers can result in positive perceptions of the organization, greater job commitment and satisfaction, and perceived job significance [91–93]. To date, the quality and quantity of coworker exchanges has not received the same level of scrutiny as supervisor–employee relationships. Rather, the ways that communication and perceived fairness, based on equity or equality, may impact worker relationships and outcomes has been overlooked [94]. The results of the current study showed that interventions focused on implementing procedures and practices fairly and equally should receive more attention to support coworker relationships and compliant safety behaviors on the job. In other words, it is not just the intervention that is important but how the practices within them are executed to members of the workforce. To that end, future research should aim to enhance the types of communication practices that are used on mine sites.

This research sought to merge old and new literature about how a task interdependent environment, such as mining, may influence how and where to focus future health and safety intervention efforts in a new era of mining and production. Specifically, as task interdependence will likely remain high even as mining routines and processes technologically advance, the role of mineworker relationships and individual soft skills will be even more critical. Given the significant mediator role that coworker communication may have on safety outcomes, it is important for organizational management to support regular, formal interactions with their subordinates but also be aware of the equity and equality of how these interactions are executed, so a fair and just environment is fostered. Finally, mediums and methods to encourage communication among coworkers will be important to have in place moving forward so work crews can communicate if employees become more spatial or remote.

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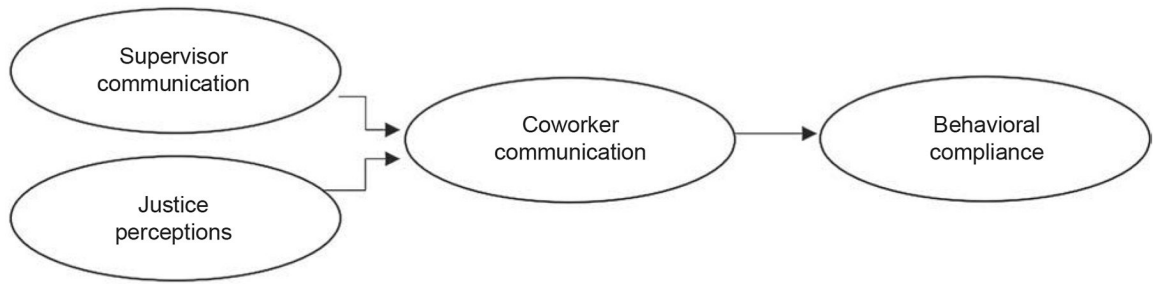


Figure 1.
Hypothesized mediation of coworker communication.

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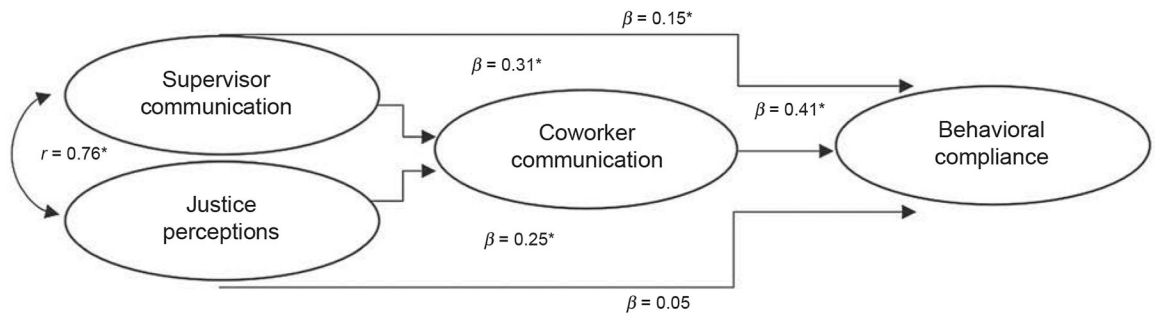


Figure 2. Bootstrapped standardized coefficients for the theoretical model. $*p < 0.01$.

Table 1.

Experience among participants.

Experience	Current job (60 missing)		Current company (134 missing)		Industry (93 missing)	
	<i>n</i>	%	<i>n</i>	%	<i>n</i>	%
Less than 1 year	235	12.4	240	13.1	192	10.4
1–5 years	526	27.8	433	23.8	351	18.9
6–10 years	310	16.4	281	15.4	289	15.5
11–15 years	249	13.1	262	14.4	280	15.0
16–20 years	157	8.3	156	8.6	182	9.8
More than 20 years	418	22.1	449	24.7	568	30.5

Table 2.Demographic characteristics of participants^a.

Demographic characteristic	Survey count	%
Gender (62 missing)		
Male	1741	92.0
Female	152	8.0
Job classification (81 missing)		
Salaried	470	25.0
Hourly	1404	75.0
Age range (61 missing)		
18–24 years	95	5.0
25–34 years	346	18.3
35–44 years	421	22.2
45–54 years	578	30.5
55–64 years	408	21.5
65+ years	46	2.4
Highest level of education (65 missing)		
Less than high school	54	2.9
High school	1024	54.2
Associate degree/trade certificate	544	28.8
Bachelor's degree	206	10.9
Master's degree or higher	62	3.3

^aResearchers did not aim to demonstrate equivalence in demographic distributions among the subsectors.

Table 3.

Factor loadings for items and constructs used in the analysis.

Item	Compliance	Supervisor communication	Organizational justice perceptions	Coworker communication
When I'm at work, I don't take risks that could result in an accident	0.779	-0.034	0.014	0.033
When I'm at work, I use all required health and safety equipment	0.861	-0.015	-0.028	-0.031
When I'm at work, I use the correct health and safety procedures	0.852	0.043	-0.037	-0.009
When I'm at work, I always report all health and safety incidents	0.726	0.052	0.098	0.031
My supervisor reminds me to follow health and safety work rules	0.123	0.763	0.158	0.103
My supervisor closely monitors my health and safety work practices	0.090	0.747	0.213	0.160
My supervisor takes action if I don't follow health and safety work practices	0.215	0.713	0.095	0.152
My supervisor clearly explains health and safety rules to me	0.138	0.806	0.199	0.148
My supervisor regularly informs me of work hazards specific to my job	0.080	0.803	0.213	0.122
My supervisor encourages communication about health and safety problems	0.125	0.765	0.309	0.155
When it comes to the health and safety rules and procedures in place at this site, the same rules apply to all employees	0.014	0.132	0.628	0.073
When it comes to the health and safety rules and procedures in place at this site, I can question the rules/procedures that influence my work	-0.042	-0.106	0.809	-0.009
When it comes to the health and safety rules and procedures in place at this site, my supervisor makes sure that our concerns are heard before making any new rules and procedures.	-0.005	0.252	0.671	-0.037
When it comes to the health and safety rules and procedures in place at this site, I am involved in improving health and safety rules and procedures	0.061	0.129	0.693	0.071
Everyone in my work crew has confidence in each other to work safely	0.183	0.129	0.157	0.824
Everyone in my work crew helps each other with health and safety problems at work	0.218	0.223	0.163	0.829
Everyone in my work crew informs each other about potential workplace health and safety hazards	0.204	0.222	0.111	0.802

Note: Numbers in bold show the factor the item loads most strongly.

Table 4.

Means, standard deviations and bivariate correlations among study variables.

	<i>M</i>	<i>SD</i>	1	2	3	4
1. Compliance	5.31	0.81 (0.85)	-	-	-	-
2. Supervisor communication	4.77	1.01	0.37*	(0.90)	-	-
3. Justice perceptions	4.61	1.12	0.34*	0.62*	(0.79)	-
4. Coworker cooperation	5.06	0.90	0.45*	0.44*	0.42*	(0.85)

* $p < 0.05$.

Note: $N = 1937$. Cronbach's α values in parentheses along the diagonal.

Table 5.

Parameter estimates for the model used to test mediation.

Path	<i>B</i>	β	<i>SE</i>	<i>p</i>	<i>R</i> ²
Coworker communication	-	-	-	-	0.279
Coworker communication ← supervisor communication	0.32	0.31	0.04	<0.001	-
Coworker communication ← justice perceptions	0.22	0.25	0.04	<0.001	-
Behavioral compliance	-	-	-	-	0.287
Behavioral compliance ← supervisor communication	0.13	0.15	0.04	<0.001	-
Behavioral compliance ← justice perceptions	0.04	0.05	0.03	0.19	-
Behavioral compliance ← coworker communication	0.34	0.41	0.03	<0.001	-

Note: Estimates derived through 1000 bootstraps. *B* = unstandardized regression coefficient; β = standardized regression coefficient; *SE* = standard error for unstandardized regression coefficient.

Table 6.

Total, direct and indirect effects on behavioral compliance.

Predictor	Standardized total effect	Standardized direct effect	Standardized indirect effect	% mediation
Supervisor communication	0.278* [0.182–0.378]	0.151* [0.058–0.245]	0.127* [0.075–0.184]	45.68
Procedural justice perceptions	0.157* [0.059–0.256]	0.030 [–0.065–0.124]	0.127* [0.056–0.150]	80.89

* $P < 0.05$.

Note: Standardized parameter estimates derived through 1000 bootstraps. 95% confidence interval for effects reported.