tions and guidance may be developed to ensure proximity detection systems work properly in the presence of trailing cables. It is anticipated that the results and findings in the paper will be applicable to all magnetic PDSs that operate in a frequency close to 70 kHz. ■

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the National Institute for Occupational Safety and Health. Reference to specific brand names does not imply endorsement by NIOSH.

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Comparing the implementation of two dust control technologies from a sociotechnical systems perspective

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To read the full text of this paper (free for SME members), see the beginning of this section for step-by-step instructions.

Special Extended Abstract

Researchers from the U.S. National Institute for Occupational Health and Safety (NIOSH) studied the impact of an unregulated dust control technology (the Helmet-CAM) and a regulated dust control technology (the continuous personal dust monitor) within a sociotechnical system (STS) framework to mitigate respirable dust sources. The results address how to best incorporate the overarching principles of meta-design STS during the technology integration process. Specifically, quantitative and qualitative data show that a prominent focus on the social factors within an STS framework could help reduce organizational unpredictability and may improve communication within the system to help reduce technology adoption time.

Introduction

Arguments placing communication as critical during any technology integration have put a focus on the social factors within meta-design STSs [1]. One assumption of meta-design is that future problems cannot always be predicted, and that if users become “co-designers” during development and implementation, then the system’s boundaries can be extended to support the needs of workers, workgroups and the organization [2]. Therefore, the principles of meta-design facilitate action-research that can help improve worker and organizational performance [3, 4].

Methods

The roles of dust exposure regulation in mining (environment), dust assessment technologies (technical), and worker awareness and performance along with management implementation and support (social) are not completely clear, nor can a standardized approach exist to ensure that the organizational system remains intact during technology implementation. Specific to respirable dust control in the mining industry, several engineering controls have been identified, developed and implemented [5,6], but many engineering solutions can be better integrated with the organization and workers [7].

This paper sought to extend STS in mining through applying principles of meta-design to analyze the results of two case study interventions. We examined the impact of an unregulated dust control technology (the Helmet-CAM) and a regulated dust control technology (the continuous personal dust monitor (CPDM)) on employees’ knowledge of, communication about, and maintenance of dust-reducing work practices within their mine organization. The first case study with the Helmet-CAM involved 48 miners and 17 managers from five industrial mineral mines. The second case study with the CPDM involved 35 miners and 15 managers from three underground coal mines. For both case studies, a convenient, purposive sampling strategy was used to recruit each mine and the participating workers. The two technologies and the interventions developed for both the Helmet-CAM and CPDM studies are reviewed in the paper.

Results

Specific results related to engineering controls and other fixes identified through the two technologies to reduce workers' exposure to respirable dust are covered in the references cited in the paper. Because this paper focuses on the "socio" factors of STS with an emphasis on collaborative participation, the current results examined how regulated and nonregulated technology implementation may have impacted social aspects within the meta-design process. Broadly, the meta-design principles are centered around participation, adaptability and flexibility, and communication. Quantitative and qualitative data were used to contribute to these overarching areas.

Participation in identifying sources of respirable dust. Engaging individual workers and managers fostered greater participation and contributions to technology implementation by the end of the intervention. For example, the pre- and post-surveys with workers from both case studies indicated that, regardless of whether a technology is regulated or not, engaging users in what the technology is communicating about their personal health can be used to motivate workers' performance. In the Helmet-CAM pre- and post-survey results, workers reported higher levels of personal proactivity, compliance, engagement, and coworker communication about health and safety. There was also a significant increase in proactive behaviors from time 1 ($M = 4.84$) to time 2 ($M = 5.10$), $t(33) = -2.545$, $p < 0.016$ (two-tailed). The mean increase in proactivity scores was 0.268 and the η^2 statistic (0.16) indicates a large effect size. The same proactivity questions were asked of coal miners who participated in the CPDM interventions. Statistical significance, using the same paired t-test option, was not obtained within this sample, but the averages improved in all but one item.

Adaptability and flexibility. Reliable technology development can take a long time, and if a regulation comes before the technology is available, maintaining an adaptable system is not always possible. However, results from both case studies lend themselves to the positive outcomes of increased participation from workers during technology design and even pre-implementation. For example, workers were able to give feedback on the Helmet-CAM and CPDM during the initial design phases and during the development of their respective updated versions. In addition, for the CPDM, the MSHA regulation allotted a grace period of 18 months for the industry to integrate this technology. Even this grace period written into regulations provides some initial flexibility for organizations to identify and mitigate potential problems. Regulatory agencies and mine companies can work together on this practice to ensure organizations and workers have time to learn how to use and respond to information from the technology. Other research in mining has discussed this approach while examining unintended consequences of new technologies [8].

Improving management interactions. There was a clear, identified missing link of managers' roles within the entire STS and, specifically, within social processes. Results showed the importance of clear communication paths among social factors, including among coworkers and between workers and managers. Providing a structured mechanism for workers to interact with and learn from the technologies was critical, as was managers supporting these efforts among their employees. Results showed that active participation on behalf of workers and managers is imperative whenever any new process is implemented on site. Specifically, when managers took a more active role in the implementation of the technology at the ground level, particularly following up with workers about dust exposure and asking for their expert feedback in mitigating exposure sources in the future, workers' perceptions changed, as evident in both the quantitative and qualitative case study feedback.

Conclusions

When any new technology is introduced on site, the choice that organizations and workers make is not a choice between adopting and not adopting; rather, the choice is between adopting now or deferring until later [9]. The results show that the technologies were adopted by workers at different rates due to issues such as regulatory measures, design of the technology, and organizational support. Ultimately, these results argue for the necessary attention to the social and organizational factors within the STS through the inclusion of meta-design principles. Regardless of whether a technological innovation is regulated or not, factors of the STS eventually co-evolve until they fit into the mine environment. To that end, a meta-design framework is an important consideration to improve the identified inter-organizational communication gaps. The longitudinal results also demonstrate that it is possible for mine organizations to foster a more adaptive culture and be better prepared for not just new assessment technologies, but other integral innovations to come. ■

Disclaimer

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