Potential of roof screening
to reduce workers' compensation costs

by S.M. Moore, J. Pollard, S.K. Bhatt and C. Mark

Abstract Each year more than 400 coal miners are injured (fatally and nonfatally) by rock falling from between or around roof supports. Many of these injuries can be prevented by the installation of roof screen. However, many coal mines are reluctant to use roof screen because of the added cost. The goal of this study was to determine the potential savings in workers' compensation (WC) premiums that can be achieved due to a reduction in rock fall injuries after roof screening. The WC rate-setting methods utilized by Illinois and Kentucky were investigated in this study. Using data obtained from the Mine Safety and Health Administration, national and state WC bodies and individual insurance companies (e.g., average cost per injury, loss cost rate, number of injuries per year, number of injuries preventable each year with roof screening), baseline mines (representing two mine sizes: 67 and 150 employees) were constructed with realistic ranges for estimates of injuries and WC premium costs. Using each state's actual WC rate-setting formulas, a sensitivity analysis was conducted to determine the total savings in WC costs after a three-year period. Annual savings in WC premiums ranged from $41,000 to $326,000 for the 67-person mine, and $96,000 to $843,000 for the 150-person mine. An economic analysis of the cost of a roof screening program at a 67-person mine was also conducted. The annual cost of a roof screening program here was estimated at $240,000. At this mine, the reduction in WC premiums alone could pay for the entire screening program.

Introduction

More than 400 roof fall injuries are reported to the U.S. Mine Safety and Health Administration (MSHA) each year. Nearly all of these injuries are caused by rocks falling between and around roof supports. Such rock falls also caused six fatal injuries between 2006 and 2008. Technology is available to prevent the majority of these injuries and fatalities. Surface controls like straps, headers and large roof bolt plates can help, but the most effective prevention is roof screen (Fig. 1). Screen works best because it can cover up to 94% of the roof (Robertson et al., 2003). Screen also offers a first line of defense for roof bolter operators, by confining or deflecting small rocks that can come loose during drilling or bolt installation.

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Studies have shown that mines that use screen routinely have much lower rates of "struck by" rock fall injuries. Robertson et al. (2003) reported on two eastern longwall mines that reduced their rock fall injuries by more than 80% after screening was introduced. A room-and-pillar mine in Indiana implemented a screening program, in which screen was installed in about half of the total drivage, typically in the belt and track entries, and in the intake and return escapeways (Compton et al., 2007). The number of rock fall injuries that this mine reported to MSHA was reduced from an average of seven per year in the three years prior to screening to less than three per year in the five following years.

Despite the fact that roof screening has obvious benefits to the safety of mine workers, some mining companies have yet to implement this safety measure due to concerns about the cost. However, injuries are also very expensive. According to information provided to the National Institute for Occupational Safety and Health (NIOSH) by the National Council on Compensation Insurance (NCCI), in the years 2002–2004, the average lost time workers' compensation claim from a Kentucky underground coal mine cost $99,258. Medical inflation would have increased this loss to more than $130,000 in the years since (St. Louis Federal Reserve, 2010). While injury costs vary widely, the savings from preventing injuries may be so large that they can largely offset and, in some cases, even exceed, the direct costs of a

Figure 1

Roof screen provides superior protection from rock falls.

roof screening program.

In the U.S., the costs of injuries are covered by workers' compensation (WC) insurance. Some coal companies, generally the larger ones, are self-insured and essentially bear the costs of injuries themselves. The others buy coverage from WC insurance providers. The goal of this study was to quantify the potential reduction in WC premiums that mining operations might expect after reducing the number of rock fall injuries with roof screening. These savings are then compared to the costs associated with a roof screening program at a typical room-and-pillar mine.

Methods and results

This study focused on WC premiums in Illinois and Kentucky. These states were selected because mines in the Illinois Basin have higher rock fall injury rates than mines in other coalfields (Molinda et al., 2008). Mines in these states may be highly interested in reducing WC costs through various methodologies, such as the one proposed in this study.

WC rate-setting calculations for NCCI states. WC rate-setting functions may be performed by a state insurance fund or department of insurance. Some of these organizations designate these functions to rating bureaus or advisory organizations. The National Council on Compensation Insurance (NCCI) is the licensed rating organization in 36 states. Both Illinois and Kentucky are NCCI states.[1]

NCCI uses "experience rating" plans to modify premiums based on each individual employer's past loss experience. Experience-rating plans, therefore, provide economic incentives to employers to reduce the frequency and severity of work-related injuries. The experience period is usually three full policy years, ending one year prior to the effective date of the modification.

The NCCI formulas used to calculate the "experience rating modification" (MOD) are shown in Eqs. (1) and (2) (NCCI, 2003; printed with permission by NCCI). In Eq. (1), "Total A" reflects the individual employer's actual loss experience, while in Eq. (2), "Total B" reflects its expected loss experience, based on the entire group of similar employers.

Primary losses	Stabilizing values	Ratable excess	Total	
APL	$+ (1 - WV) \times EEL + BV$	$+ WV \times AEL$	= Total A	(1)
EPL	$+ (1 - WV) \times EEL + BV$	$+ WV \times EEL$	= Total B	(2)

Where:

APL	=	Actual primary losses
WV	=	Weighting value
EEL	=	Expected excess losses
BV	=	Ballast value
AEL	=	Actual excess losses
EPL	=	Expected primary losses

The total expected losses are determined by multiplying the expected loss rate (ELR – obtained using a table provided by NCCI; use Classification 1016 for underground bituminous coal) by the payroll for the three years used in the rating. This value is then multiplied by 0.01 to put the number in terms per $100 of payroll.

The primary losses are the ultimate losses with each injury at a mine up to the primary limiting factor ($5,000 per claim). The expected primary losses are then determined by multiplying the D-ratio (obtained using a table provided by NCCI; this ratio determines the portion of a mine's expected losses that are expected to be primary losses) by the total expected losses (EL) (Eq. 3). Expected excess losses (EEL) are determined by subtracting the total expected primary losses (EPL) from the total expected losses (Eq. 4).

$$EPL = (D \text{ ratio}) \times ELR \times (3\text{-year pay}) \times 0.01 \quad (3)$$

$$EEL = EL - EPL \quad (4)$$

[1]Prior to 2008, Illinois mines used a different equation to arrive at the WC premium to be paid by each mine than they do today. However, since Illinois now employs the same equation as Kentucky, the currently used equation was implemented in both states for the purpose of this study.

Table 1

Characteristics of WC claims, according to information provided to NIOSH by NCCI. Values are annual averages for the period 2002-2004.

State	Average annual payroll ($ million)	Estimated workers covered	Average annual WC claims	WC claims per worker per year	Average cost per WC claim
Illinois	$51.2	1,003	268	0.267	$29,577
Kentucky	$143.6	3,055	869	0.284	$40,829

The weighting value is obtained using a table from the *NCCI Experience Rating Plan Manual* and is based on the expected losses (note: different tables exist for different states). The weighting value determines how much of the actual losses and expected excess losses are used in the experience rating. The weighting value increases as expected losses increase. The ballast factor in the experience rating formula helps prevent the MOD from shifting too far above or below unity. It is added to both the actual primary losses and the expected primary losses. This value also increases as expected losses increase.

Finally, the MOD is calculated by dividing Total A by Total B:

$$MOD = \text{Total A} / \text{Total B} \quad (5)$$

An MOD that is less than unity implies that an employer has a better-than-average loss experience.[2]

Potential savings with roof screening. The rating period used for this study was 2001, 2002 and 2003, yielding WC costs for the year 2005. To demonstrate the expected amount of savings in WC premiums, baseline mines were created that are representative of mines that are experience-rated in Illinois and Kentucky. In each state, two baseline mines were used in the analysis, one with 67 employees and the other with 150 employees.

To conduct the analysis, data for the following parameters had to be obtained:

- payroll for 2001, 2002 and 2003;
- total number of injuries for each of the three years;
- number of injuries that would have been prevented by implementing roof screening for each of the three years;
- base loss cost rate in 2005;
- administrative fee multiplier applied by their insurance provider; and
- the ultimate losses associated with each injury.

In 2005, loss cost rate for Illinois was $33.13 (effective Jan. 1, 2005), which included $9.67 and $6.99 for the state and federal black lung coverage, respectively, leaving $16.47 subject to a MOD factor (NCCI, 2009). For Kentucky, the loss cost rate was $31.02 (effective 9/1/04), whereby $1.18 and $5.06 were for the state and federal black lung coverage, leaving $24.78 subject to a MOD factor (NCCI, 2009).

Communications with NCCI and a large insurance provider in Kentucky (NCCI, 2009; Kentucky Employers, Mutual Insurance, 2009) yielded information regarding typical administrative multipliers used by insurers in Illinois and Kentucky. The multipliers used for Illinois and Kentucky were 1.46 and 1.115, respectively. To estimate the remaining parameters, several assumptions were made:

- **Payroll** – The average mine worker salary in 2002 was determined to be $50,538 in Illinois and $47,473 in Kentucky (U.S. Bureau of the Census, 2002). These salaries were adjusted for inflation to estimate the salaries in 2001 and 2003. To determine the total payroll, the average salary was multiplied by the number of employees at the mine.
- **Total number of injuries** – Table 1 summarizes the data provided to NIOSH by NCCI for experience-rated coal mines for the claim years 2002 – 2004. (For Illinois, the actual period covered was April 2001 to March 2004. For Kentucky, the period was May 2001 to April 2004). The average number of workers covered by NCCI plans during those years was estimated to be 1,003 in Illinois and 3,055 in Kentucky.

Table 2

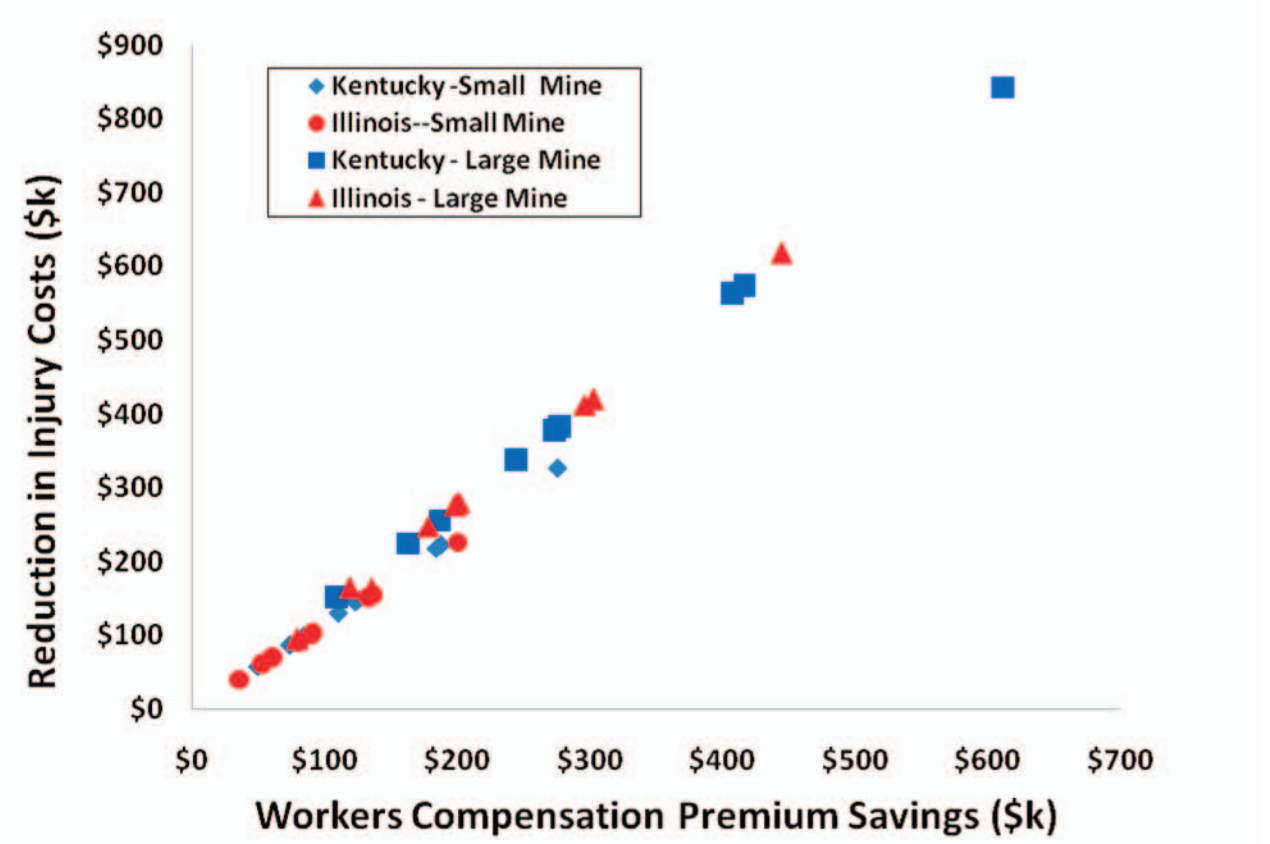
Characteristics of underground accidents from the MSHA database. Values are annual averages for 2002-2004.

State	Average annual workers	Average annual accidents	Accidents per worker	% Roof fall accidents	Avg. days lost per roof fall accident	Avg. days lost per nonroof fall accident
Illinois	2,555	335	0.131	20.0%	29.6	39.2
Kentucky	8,542	1,002	0.117	17.1%	48.2	46.0

[2] In many states, WC premiums may also be modified by a schedule rating factor. The schedule rating factor, which may be positive or negative, reflects additional characteristics of the employer such as its use of "safety devices." Details are reported in the NCCI Basic Manual, Appendix D, which can be obtained at www.ncci.com.

Figure 2

Potential cost savings from roof screening. The *x* axis is the potential reduction in WC insurance premiums and the *y* axis is the estimated total losses avoided, due to the screening program.



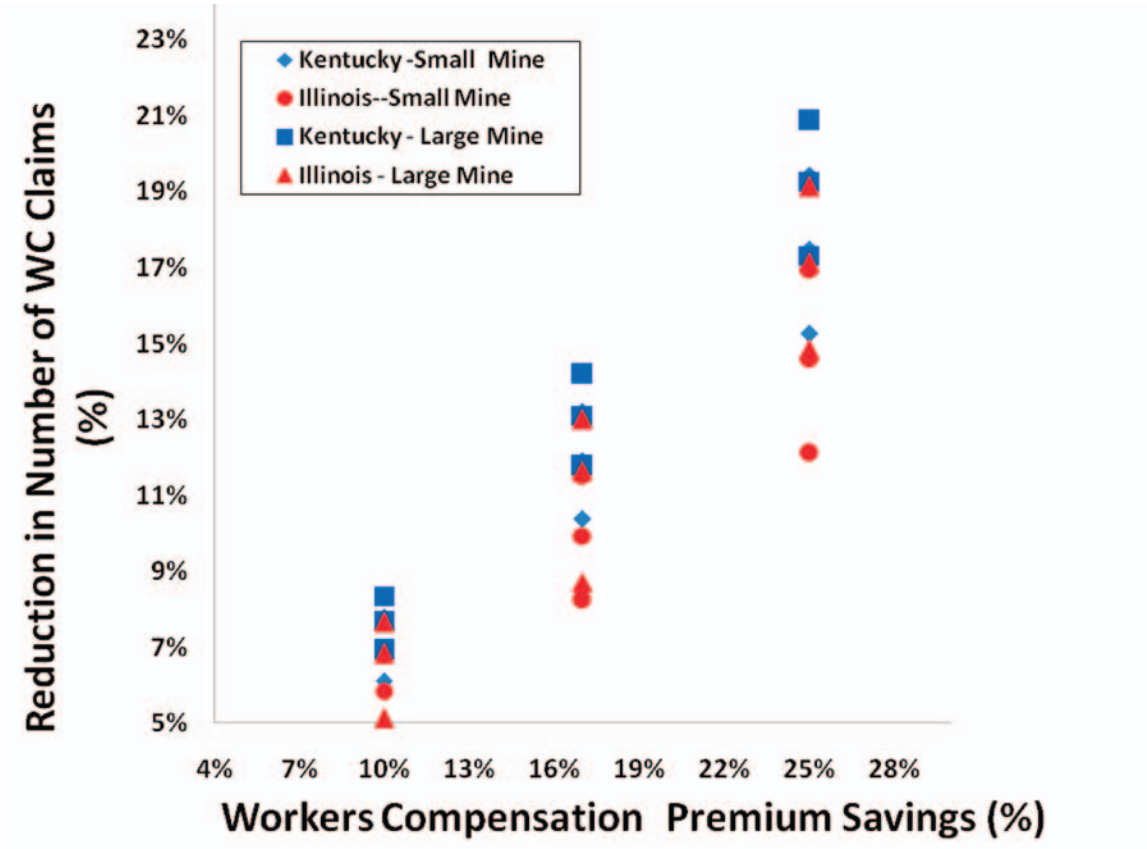
Dividing the reported number of claims by the estimated number of workers yields the average number of claims per worker. Using these data, the expected number of claims was then estimated to be 18 and 19 for the 67-person mines in Illinois and Kentucky, respectively, and 40 and 43 for the 150-person mines in the two states. To accommodate mines that would be slightly above or below this average number of claims, the ranges used in the sensitivity analyses were 12-27 claims per year for the 67-person mine, and 27-60 claims per year for the 150-person mine.

- **Number of preventable injuries** – NCCI does not report information on the causes of the injuries that result in WC claims. So the MSHA injury database was used to estimate the number of injuries that might have been prevented by roof screening. The MSHA data indicated that 17% of all Kentucky injuries, and 20% of all Illinois injuries, were the result of rock falls (Table 2). We assume these values to also be representative of the NCCI injury database. An analysis of the MSHA injury narratives determined that nearly all of these injuries could have been prevented by roof screen (Roberston et al., 2003). Table 2 also shows that the severity of the rock fall injuries, expressed in terms of the average days lost per injury, was similar to that of other injuries that occurred underground. To accommodate mines that would be slightly above or below these expected preventable injuries, the sensitivity analyses assumed that the screening program reduced the number of WC claims at the baseline mines by 10%, 17% and 25%.
- **Ultimate losses per injury** (actuarially determined amount; loss estimate at resolution of the claim based upon statistical trends for a specific state) – the incurred losses and claims data obtained from NCCI shown in Table 1 indicate that the average cost per claim (including both lost time and medical claims) was $29,577 in Illinois, while in Kentucky it was $40,829.
- **NCCI equation parameters:** The expected loss ratio used for Illinois was 10.21 and the discount ratio was 0.15. For Kentucky, these values were 12.9 and 0.17. The weighting value used for the 67-person mine was 0.40 in Illinois and 0.56 in Kentucky, and the ballast values were 133,125 and 133,900, respectively. For the 150-person mine, the weighting values were 0.55 in Illinois and 0.67 in Kentucky, and the ballast values were 260,925 and 285,693, respectively. Again, all of these values are determined using tables provided by NCCI for each state.

The findings from the analysis are summarized in Figs. 2 and 3. Depending on the total number of WC claims, the number of claims prevented by roof screening ranged between 1 and 7 for the 67-person mine, and between 3 and 15 for the 150-person mine. Figure 2 shows that the cost savings (total losses avoided) for these prevented injuries ranged from $35,000 to $612,000. The potential reduction in WC premiums actually exceeded the cost savings by 37% for the larger mines and 19% for the smaller ones. In Illinois, po-

Figure 3

Potential reduction in WC premiums (excluding Black Lung) due to roof screening.



tential annual savings in WC premiums ranged from $41,000 to $227,000 for the 67-person mine, and $96,000 to $612,000 for the 150-person mine. In Kentucky, potential savings were $58,000 to $326,000 for the smaller mine, and $151,000 to $843,000 for the larger one.

Figure 3 shows that, on average, a 10% reduction in the number of WC claims results in an average 6.2% reduction in the traumatic portion of the WC premium (the portion affected by the MOD, which does not include the state and federal Black Lung portions of the premium). The percent reduction in the premium varies substantially, however, with the highest value (of 7.7%) for the larger mines with the largest number of total WC claims.

Economics of screening. An economic analysis was conducted in order to estimate what fraction of the costs associated with the implementation of roof screening would be offset by the reduction in WC premiums. The analysis was performed for a typical Midwestern room-and-pillar mine employing 67 people and producing 726 kt (800,000 st) per year. The mine was assumed to operate two shifts per day, using a single super section employing two continuous miners and two roof bolters. A critical assumption was that adding roof screen did not decrease the footage of advance per shift. This assumption is reasonable if best practices for screen installation, such as those described by Compton et al. (2007), are used, and particularly if only about 50% of the drivage is screened. Other assumptions were:

- The section advances 122 m/shift (400 ft/shift) in a 1.5-m- (5-ft)- thick coal seam.
- Straps, costing $8 each, are currently installed in all headings and crosscuts.
- Screen installation requires an additional 10 minutes per 12 m (40 ft) of advance (Note: This additional time for screening affects the time to install roof support materials, but does not affect the time for cutting coal (production time), because that is done by the continuous mining machine in a different heading).
- Screen, costing $16 per piece, will replace the straps in 50% of the drivage.
- Labor cost (fully loaded) is $40/hour.
- Maintenance costs may be excluded, as they are not normally required for screening.
- No additional injuries due to material handling.

The incremental costs associated with the roof screening program can be calculated as follows:

- Cost of screen = $6.56/ m ($2/ft).
- Cost of labor to install screen = 0.82 min/m (0.25 min/ft) with two roof bolter operators = $1.08/m ($0.33/ft).
- Cost of supplying screen to the section is approximately $0.33/m ($0.10/ft).

The total cost for installing screen is, therefore, approximately $8/m ($2.43/ft) or $0.64/t ($0.58/st). If screen is installed in 50% of the drivage, the cost per ton for the mine

drops to $0.32/t ($0.29/st). If this one-section mine produces 726 kt (800,000 st) annually, the yearly cost for the screen installation in half of the drivage is approximately $240,000.

The analysis summarized in Figs. 2 and 3 showed that the potential WC premium savings after implementing a roof screening program could approach, or even exceed, these estimated costs for the screen installation. Moreover, it is important to consider that the WC expense is only a fraction of the total cost of "struck by" injuries. In addition, the mining operation will incur indirect administrative costs to replace injured workers, costs to train new replacement workers and production delays due to inexperienced workers on the continuous miner or roof bolter. A roof fall that causes an injury can also cause production delays, due to MSHA inspection of the fall area and plan/operational changes made to accommodate MSHA requirements to prevent further "struck by" accidents. "Struck by" injuries can have a negative effect on the morale of the entire underground work force and may make the miners question their own safety. There may also be legal costs linked to "struck by" injuries, such as fines or penalties related to reportable injuries, legal fees and possible "gross negligence" lawsuits. It should be noted that the costs discussed in this paper are from the employer's perspective and not from a societal perspective, which would also include the costs associated with pain and suffering of the mine worker and the consequences this would place on their families.

Roof screening also improves general ground control in the mine and can provide substantial economic benefits above and beyond those directly related to injury prevention by:

- Reducing the need for spot bolting due to deteriorating roof conditions.
- Minimizing production losses due to cleanup and resupport of important belt, travel and escape entries.
- Reducing major roof falls by providing confinement between bolts and preventing unraveling above bolt anchorage.

Conclusions

In this study, the methods utilized by Illinois and Kentucky to determine a mine's WC premiums were detailed. A sensitivity analysis was conducted, in which the number of total injuries and the number of injuries that could have been prevented with roof screening were varied. The potential savings were substantial. It was found that the reduction in premiums actually exceeded the reduction in actual losses by 19-37%, depending on the size of the mine evaluated. In many cases, the potential savings approached or even exceeded the estimated costs of a screening program. Roof screen can also bring additional benefits to a company's bottom line by improving ground control and reducing the sizable indirect costs of injuries.

There were several limitations to the current study. The mines utilized in the study were hypothetical, as opposed to using real mine demographic and injury data. The total number of injuries and the preventable injuries at each hypothetical mine were based upon injury data obtained from NCCI and the MSHA injury database in each state. For each state, an average injury cost was used for every claim, rather than using a realistic distribution of claim costs. Finally, it should be noted that large coal companies tend to purchase nonstandard WC policies. Specifically, they often purchase some type of risk-sharing policy, such as a large deductible, or they may be self-insured and purchase an excess WC policy. For the latter case, the cost associated with every claim eliminated through roof screening is directly saved by the company. Additional savings would then be observed by the reduction in the MOD associated with the excess WC policy.

Roof screen has the potential to prevent hundreds of injuries caused by the fall of small rocks between and around roof supports. Currently, these injuries occur while miners are located under "supported" roof. Many mines may be overestimating the costs of installing screen and underestimating the potential economic benefits from reducing the number of "struck by" injuries. It is hoped that this paper will help convince mining operations to give this valuable technology another look.

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Disclosure

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.

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