AN ANALYSIS OF THE POTENTIAL OF ROOF SCREENING TO REDUCE WORKERS' COMPENSATION COSTS

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ABSTRACT

Each year more than 400 coal miners are injured (fatal and non-fatal) by rock falling from between or around roof supports. Many of these injuries could be prevented by the installation of roof screen (wire mesh). However, many coal mines may be reluctant to use roof screen because of the added cost. The goal of this study was to determine the potential saving in workers' compensation (WC) premiums that could be achieved due to a reduction in rock fall injuries after roof screening. The WC rate-setting methods utilized by IL and KY were investigated in this study. Using actual data obtained from MSHA, 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), hypothetical 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, total savings in WC costs after a three-year period were determined. Across both states, savings in WC premiums ranged from 1.8% to 14.6% when injuries were reduced by 10% to 20%. Additionally, an economic analysis was performed for an existing mine consisting of 67 employees. For this mine, the annual cost of a roof screening program was estimated at $240,000. If the screening prevented 13 "struck by" WC claims over a 3-year period 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 MSHA each year. Nearly all of these injuries, which included six fatal injuries between 2006 and 2008, are caused by rocks falling between and around roof supports. Technology is available to prevent the vast majority of these injuries and fatalities. Surface controls like straps, headers, and large roof bolt plates can help, but by far the most effective prevention technique is roof screen. 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. Numerous studies have now shown that mines that use screen routinely have much lower rates of "struck by" rock fall injuries. At a Maryland mine that the National Institute for Occupational Safety and Health (NIOSH) studied, there was an average of 14 roof fall injuries per year prior to their implementation of roof screening. The number of injuries was then tracked for 5 years following the implementation of roof screening and averaged 2.2 per year. NIOSH also studied an Illinois mine where there was an average of 8 injuries per year prior to roof screening. After implementing roof screening, the number of roof fall injuries was tracked for an additional 8 years. Over this 8 year period, the average number of injuries per year was only 0.25. Despite the fact that roof screening has obvious benefits to the health and safety of mine workers, some mining companies have yet to implement this safety measure due to concerns for the cost. However, by preventing injuries to the mine workers, roof screening has a direct impact on a mine's workers' compensation (WC) premiums. In fact, benefits in WC premiums may be so large that they can largely offset, or even exceed, the direct costs of a roof screening program. The goal of this study was to quantify the financial savings related to lower WC premiums that mining operations might expect after implementing roof screening as a method to reduce rock fall injuries. Estimates for WC premiums were determined before and after the simulated implementation of roof screening for hypothetical mines (representing two mine sizes: 67 and 150 employees) in Illinois and Kentucky.

METHODS AND RESULTS

The WC rate-setting methods utilized by Illinois and Kentucky for experience rating plans were investigated. These states were selected because mines in the Illinois basin have higher rock fall injury rates than mines in other coal fields (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 largest rating organization in the United States and provides services to some 40 states. Both Illinois and Kentucky are NCCI states. Several types of rating plans exist whereby the general principles are similar (e.g. experience rating, manual rating). However, experience rating plans are the most common and are, therefore, the focus of this study. Experience rating plans encourage employers to reduce the frequency and severity of work-related injuries through economic incentives. According to NCCI, typically a company that has been paying $5,000 average annual premium for the past few years or has paid $10,000 or more in a single recent year, qualifies to be experience rated. The experience period is usually three full policy years, ending one year prior to the effective date of the modification. 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. The NCCI formula used for the rating [NCCI 2003] are shown in Eqns 1 and 2.

Primary Losses		Stabilizing Values		Ratable Excess	Total	
APL	+	(1 - WV) x EEL + BV	+	WV x AEL	Total A	(1)
EPL	+	(1 - WV) x EEL + BV	+	WV x 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 actual primary losses are the ultimate losses with each injury at a mine up to the primary limiting factor ($5,000). The expected primary losses are then determined by multiplying the D-ratio (obtained

using a table provided by NCCI (2003); this ratio determines the portion of a mine's expected losses that are expected to be primary losses) by the expected losses, Eqn 3. The 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. Expected excess losses are determined by subtracting the total expected primary losses from the total expected losses, Eqn 4.

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

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

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 value is a stabilized element designed to limit the effect of any single loss on the experience rating modification (MOD). It is added to both the actual primary losses and the expected primary losses. This value also increases as expected losses increase.

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

Expected Savings with Roof Screening

The rating period utilized for this study was 2001, 2002, and 2003 yielding WC costs for the year 2005 (recall, the equation used from 2008 onward for the state of Illinois will be implemented in this study since the former equation is no longer utilized). To demonstrate the expected amount of savings in WC premiums, hypothetical mines were created that are representative of mines that are experience rated in the United States. Two sizes of mines were used in the analysis, one with 67 employees and the other with 150 employees. Sixty-seven employees was chosen for the first mine since that was the number of employees at a mine NIOSH studied that performed a cost analysis for implementing roof screen (presented later; see *Economics of Roof Screening*). The second mine size was 150 since this would depict the cost savings that may be expected for some of the larger mines in these states. In order to estimate the savings in WC premiums that mines of this size would experience if they implemented roof screening, the following parameters were necessary: payroll for 2001, 2002, and 2003; total number of injuries each of the three years; number of injuries that would have been prevented by implementing roof screening 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 rates for IL was $33.13 (effective 1/1/05) whereby $9.67 and $6.99 were for the state and federal black lung coverage, respectively leaving $16.47 subject to a MOD factor. (NCCI, 2009) For KY 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 the state of KY (NCCI, 2009; Kentucky Employers Mutual Insurance, 2009) yielded information regarding typical administrative multipliers used by insurers in Illinois and Kentucky. The multipliers used for IL and KY were 1.46 and 1.115, respectively. To obtain the remaining parameters, several assumptions were made:

- Payroll – The average mine worker salary in 2002 was determined to be $50,538 and $47,473 for IL and KY, respectively (U.S. Census Bureau, 2002). This salary was used to estimate the salaries in 2001 and 2003 by adjusting for 4.6% inflation between 2001-2002 and 2002-2003. An average salary of $51,000 and $47,000 was used for IL and KY, respectively. To determine the payroll this average salary was multiplied by the number of employees at the mine and then multiplied by three to account for the three calendar years of 2001, 2002, and 2003.
- Total number of injuries – A sensitivity analysis was carried out where the total number of injuries over the three year period at both mines was defined as being 30%, 50%, and 70% of the number of employees. These percentages were based upon actual injury data reported to MSHA for experience rated mines in IL and KY which demonstrated that the total number of injuries at these mines ranged from 30%-70% of the total number of employees. Based on data obtained from NCCI, it was determined that more WC claims are submitted due to differences in what is considered a reportable injury. It was found that 1.4 and 1.8 times as many claims were submitted to NCCI as were reported to MSHA for IL and KY, respectively. Therefore, the total number of injuries were then multiplied by these factors to get the total number of injuries used in this study.
- Number of preventable injuries – The sensitivity analysis was extended to cases where 10%, 15%, and 20% of the estimated total number of injuries reported to NCCI were hypothetically prevented by roof screening. These percentages were based upon actual injury data reported to MSHA for experience rated mines in IL and KY. From these data, it was determined that the number of injuries deemed preventable by roof screening ranged from approximately 10%-20% of the total number of injuries reported to MSHA. (Injury narratives were read and the number of injuries that were considered preventable by roof screens was determined based upon the size of the rock(s) involved in the roof fall).
- Ultimate losses per injury (actuarially determined amount; loss estimate at resolution of the claim based upon statistical trends for a specific state) – For both states, incurred losses and claims data were obtained from NCCI for underground coal mines and represented all experience rated coal mines. Using claim data from IL between 4/01 – 3/04, the average cost per claim was determined to be $28,449. For KY, claim data between 5/02 – 4/04 yielded an average claim cost of $35,582.

The demographics associated with each mine are shown in Table 1 (see Appendix A)for IL and KY. The calculated parameters to obtain the WC cost with and without screening are shown in Table 2 (see Appendix A). The overall WC costs and savings when screen is implemented are shown in Table 3 (see Appendix A). The expected loss ratio used for IL was 10.21 and the discount ratio was 0.15 while these values were 12.9 and 0.17 for KY. The weighting value used for mines 1 to 9 was 0.40 and 0.56 for IL and KY, respectively, and 0.55 and 0.67 for mines 10 to 18, respectively. Finally, the ballast value used for mines 1 to 9 was 133,125 and 133,900 for IL and KY, respectively, and 260,925 and 285,693 for mines 10 to 18, respectively. Again, all of these values are determined using tables provided by NCCI for each state. Figure 1 (see Appendix B) depicts the estimated percent savings in WC premiums.

Economics of Screening

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 seen from reduced injuries, an economic analysis was performed. This analysis was performed for a room and pillar mine employing 67 people and producing 800,000 tons per year (Compton et al 2007). The mine operates two shifts per day with a single super-section employing two continuous miners and two roof bolters. It was assumed that adding roof screen did not decrease the footage of advance per shift as long as two roof bolters were being utilized. Other assumptions were:

- The section advances 400 feet/shift in a 5-foot thick coal seam
- Straps, costing $8 per piece, are currently installed in all headings and crosscuts
- Screen installation requires an additional ten minutes per 40 feet 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

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

- Cost of screen = $2/ft.
- Cost of labor to install screen = 0.25 minutes/ft with two roof bolter operators = $0.33/ft.
- Cost of supplying screen to the section is approximately $0.10/ft.

The total cost for installing screen is therefore approximately $2.43/ft or $0.58/ton. If screen is installed in 50% of the drivage, the cost per ton for the mine drops to $0.29/ton. If this one-section mine produces 800,000 tons annually, the yearly cost for the screen installation is $240,000.

Mines 1 to 9 of KY have demographics that are a reasonable approximation to the mine that the economic analysis was performed from. For these mines, the annual savings in WC premiums ranged from $51,000 to $241,000. Therefore, it is possible that savings in WC premiums may entirely offset the cost of roof screening.

However, it is important to consider the additional savings beyond those of WC premiums. "Struck By" injuries incur many other costs to a mining operation. There will be direct administrative costs to replace these injured workers, costs to train a new replacement worker, and production delays due to inexperienced workers on the continuous miner or roof bolter. A roof fall that causes an injury will 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 will 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, possible "gross negligence" law suits, and an increase in overall insurance costs due to the negative impact on mine property injury statistics. It should also 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.

The total economic benefits to a mine that installs roof screen as part of their regular mining cycle can therefore be substantial. A mine that installs roof screen during the mining cycle will see cost savings by:

- Reducing cost of replacing injured workers,
- Improving workforce morale and reducing turnover of face workers,
- Reducing immediate requirements for spot bolting to support bolts that become loose due to deteriorating roof conditions,
- Minimizing production losses due to clean-up and re-support of important belt, travel, and escape entries,
- Reducing major roof falls by providing confinement between bolts and preventing unraveling up above bolt anchorage.

DISCUSSION

In this study, the methods utilized by IL, and KY to determine a mine's WC premiums were detailed. Additionally, the WC savings incurred when roof screening is implemented were calculated for 18 hypothetical mines in both IL and KY. The 18 mines represented a sensitivity analysis where the number of total injuries and the number of injuries that could have been prevented with roof screening were varied. This was done for a medium sized mine (67 employees) and for a larger mine (150 employees). It was demonstrated that reducing actual losses by a set dollar amount does not reduce WC premiums by that same dollar amount. However, across both states, savings in WC premiums ranged from 1.8% to 14.6% when injuries were reduced by 10% to 20%. For mines with a larger number of employees, and thus a larger payroll, the percent savings in WC premiums was greater than that of a smaller mine with similar percentage improvement. Finally, a general cost estimate was generated for incorporating roof screening into a mines process for a real mine with 67 employees ($240,000). Thus, since this was for specific mine demographics, the cost may be more or less for other operations.

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 the MSHA injury database in each state. Another limitation to the study was that, for each state, an average injury cost was used instead of determining the true injury costs associated with known injuries at a specific mine. The economic analysis of roof screening presented was only for one mine of 67 employees; however, these numbers were based on an actual mine giving them more validity than a completely hypothetical estimation of costs. Finally, it should be noted that large coal companies tend to purchase non-standard WC policies. Specifically, there would be 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.

The data presented in this study demonstrate that a savings in WC costs may be expected after roof screening for a three-year period. While the savings in WC is less than the value saved in direct injury costs, these savings are still substantial. Future studies, such as those conducted by Compton et al. (2007), should evaluate the methodology used for roof screening to assess the physical demands on the worker and suggest work station design to minimize these demands. In the future more detailed information on the application of WC rate-setting methods for IL, KY, and PA will be published in an Information Circular by NIOSH.

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APPENDIX A

Table 1. Demographics of each Illinois and Kentucky hypothetical mine.

	# Empl	Total Inj (over 3 yrs)	Prev Inj (over 3 yrs)	Avg Loss Payout/ Injury	Yearly Payout	Loss Cost Rate (excluding black lung)	Admin Fee	Avg Yearly Salary	1 Year Payroll
Illinois Hypothetical Mines									
Mine 1	67	28	3	$28,449	$799,417	$16.47	1.46	$51,000	$3,417,000
Mine 2	67	28	4	$28,449	$799,417	$16.47	1.46	$51,000	$3,417,000
Mine 3	67	28	6	$28,449	$799,417	$16.47	1.46	$51,000	$3,417,000
Mine 4	67	47	5	$28,449	$1,334,258	$16.47	1.46	$51,000	$3,417,000
Mine 5	67	47	7	$28,449	$1,334,258	$16.47	1.46	$51,000	$3,417,000
Mine 6	67	47	9	$28,449	$1,334,258	$16.47	1.46	$51,000	$3,417,000
Mine 7	67	66	7	$28,449	$1,869,099	$16.47	1.46	$51,000	$3,417,000
Mine 8	67	66	10	$28,449	$1,869,099	$16.47	1.46	$51,000	$3,417,000
Mine 9	67	66	13	$28,449	$1,869,099	$16.47	1.46	$51,000	$3,417,000
Mine 10	150	63	6	$28,449	$1,792,287	$16.47	1.46	$51,000	$7,650,000
Mine 11	150	63	10	$28,449	$1,792,287	$16.47	1.46	$51,000	$7,650,000
Mine 12	150	63	13	$28,449	$1,792,287	$16.47	1.46	$51,000	$7,650,000
Mine 13	150	105	11	$28,449	$2,987,145	$16.47	1.46	$51,000	$7,650,000
Mine 14	150	105	16	$28,449	$2,987,145	$16.47	1.46	$51,000	$7,650,000
Mine 15	150	105	21	$28,449	$2,987,145	$16.47	1.46	$51,000	$7,650,000
Mine 16	150	147	15	$28,449	$4,182,003	$16.47	1.46	$51,000	$7,650,000
Mine 17	150	147	22	$28,449	$4,182,003	$16.47	1.46	$51,000	$7,650,000
Mine 18	150	147	29	$28,449	$4,182,003	$16.47	1.46	$51,000	$7,650,000
Kentucky Hypothetical Mines									
Mine 1	67	36	4	$35,582	$1,288,068	$24.78	1.115	$47,000	$3,149,000
Mine 2	67	36	5	$35,582	$1,288,068	$24.78	1.115	$47,000	$3,149,000
Mine 3	67	36	7	$35,582	$1,288,068	$24.78	1.115	$47,000	$3,149,000
Mine 4	67	60	6	$35,582	$2,145,595	$24.78	1.115	$47,000	$3,149,000
Mine 5	67	60	9	$35,582	$2,145,595	$24.78	1.115	$47,000	$3,149,000
Mine 6	67	60	12	$35,582	$2,145,595	$24.78	1.115	$47,000	$3,149,000
Mine 7	67	84	8	$35,582	$3,003,121	$24.78	1.115	$47,000	$3,149,000
Mine 8	67	84	13	$35,582	$3,003,121	$24.78	1.115	$47,000	$3,149,000
Mine 9	67	84	17	$35,582	$3,003,121	$24.78	1.115	$47,000	$3,149,000
Mine 10	150	81	8	$35,582	$2,882,142	$24.78	1.115	$47,000	$7,050,000
Mine 11	150	81	12	$35,582	$2,882,142	$24.78	1.115	$47,000	$7,050,000
Mine 12	150	81	16	$35,582	$2,882,142	$24.78	1.115	$47,000	$7,050,000
Mine 13	150	135	14	$35,582	$4,803,570	$24.78	1.115	$47,000	$7,050,000
Mine 14	150	135	20	$35,582	$4,803,570	$24.78	1.115	$47,000	$7,050,000
Mine 15	150	135	27	$35,582	$4,803,570	$24.78	1.115	$47,000	$7,050,000
Mine 16	150	189	19	$35,582	$6,724,998	$24.78	1.115	$47,000	$7,050,000
Mine 17	150	189	28	$35,582	$6,724,998	$24.78	1.115	$47,000	$7,050,000
Mine 18	150	189	38	$35,582	$6,724,998	$24.78	1.115	$47,000	$7,050,000

APPENDIX A (cont'd)

Table 2. Factors to calculate the MOD for Illinois and Kentucky (NS = no screen, S = screen).

	Exp Losses, $k	Exp Prim Losses, $k	Exp Ex Losses, $k	Actual Prim Losses, $k		Actual Ex Losses, $k		Total A, $k		Total B, $k		MOD	
							Illinois						
				NS	S	NS	S	NS	S	NS	S	NS	S
Mine 1	$1,047	$157	$890	$141	$127	$659	$593	$1,071	$1,031	$1,180	$1,180	0.908	0.874
Mine 2	$1,047	$157	$890	$141	$120	$659	$560	$1,071	$1,011	$1,180	$1,180	0.908	0.857
Mine 3	$1,047	$157	$890	$141	$113	$659	$528	$1,071	$990	$1,180	$1,180	0.908	0.840
Mine 4	$1,047	$157	$890	$235	$211	$1,100	$990	$1,341	$1,274	$1,180	$1,180	1.137	1.080
Mine 5	$1,047	$157	$890	$235	$200	$1,100	$936	$1,341	$1,241	$1,180	$1,180	1.137	1.052
Mine 6	$1,047	$157	$890	$235	$188	$1,100	$879	$1,341	$1,206	$1,180	$1,180	1.137	1.022
Mine 7	$1,047	$157	$890	$329	$296	$1,541	$1,386	$1,612	$1,517	$1,180	$1,180	1.366	1.286
Mine 8	$1,047	$157	$890	$329	$280	$1,541	$1,311	$1,612	$1,471	$1,180	$1,180	1.366	1.247
Mine 9	$1,047	$157	$890	$329	$263	$1,541	$1,233	$1,612	$1,423	$1,180	$1,180	1.366	1.206
Mine 10	$2,343	$351	$1,992	$315	$284	$1,477	$1,330	$2,285	$2,172	$2,604	$2,604	0.877	0.834
Mine 11	$2,343	$351	$1,992	$315	$268	$1,477	$1,255	$2,295	$2,125	$2,615	$2,615	0.878	0.813
Mine 12	$2,343	$351	$1,992	$315	$252	$1,477	$1,182	$2,295	$2,070	$2,615	$2,615	0.878	0.792
Mine 13	$2,343	$351	$1,992	$525	$473	$2,462	$2,216	$3,047	$2,859	$2,615	$2,615	1.165	1.093
Mine 14	$2,343	$351	$1,992	$525	$446	$2,462	$2,092	$3,047	$2,764	$2,615	$2,615	1.165	1.057
Mine 15	$2,343	$351	$1,992	$525	$420	$2,462	$1,970	$3,047	$2,671	$2,615	$2,615	1.165	1.022
Mine 16	$2,343	$351	$1,992	$735	$662	$3,447	$3,102	$3,799	$3,536	$2,615	$2,615	1.453	1.352
Mine 17	$2,343	$351	$1,992	$735	$625	$3,447	$2,929	$3,799	$3,403	$2,615	$2,615	1.453	1.302
Mine 18	$2,343	$351	$1,992	$735	$588	$3,447	$2,758	$3,799	$3,273	$2,615	$2,615	1.453	1.252
							Kentucky						
Mine 1	$1,219	$207	$1,011	$181	$163	$1,107	$997	$1,380	$1,300	$1,353	$1,353	1.020	0.961
Mine 2	$1,219	$207	$1,011	$181	$154	$1,107	$942	$1,380	$1,260	$1,353	$1,353	1.020	0.932
Mine 3	$1,219	$207	$1,011	$181	$145	$1,107	$887	$1,380	$1,221	$1,353	$1,353	1.020	0.902
Mine 4	$1,219	$207	$1,011	$302	$272	$1,844	$1,661	$1,913	$1,780	$1,353	$1,353	1.414	1.316
Mine 5	$1,219	$207	$1,011	$302	$257	$1,844	$1,569	$1,913	$1,714	$1,353	$1,353	1.414	1.267
Mine 6	$1,219	$207	$1,011	$302	$241	$1,844	$1,474	$1,913	$1,645	$1,353	$1,353	1.414	1.217
Mine 7	$1,219	$207	$1,011	$422	$380	$2,581	$2,324	$2,446	$2,261	$1,353	$1,353	1.809	1.671
Mine 8	$1,219	$207	$1,011	$422	$359	$2,581	$2,193	$2,446	$2,165	$1,353	$1,353	1.809	1.601
Mine 9	$1,219	$207	$1,011	$422	$338	$2,581	$2,064	$2,446	$2,072	$1,353	$1,353	1.809	1.532
Mine 10	$2,728	$464	$2,265	$405	$365	$2,477	$2,229	$3,098	$2,891	$3,014	$3,014	1.028	0.959
Mine 11	$2,728	$464	$2,265	$405	$344	$2,477	$2,104	$3,098	$2,787	$3,014	$3,014	1.028	0.925
Mine 12	$2,728	$464	$2,265	$405	$324	$2,477	$1,982	$3,098	$2,685	$3,014	$3,014	1.028	0.891
Mine 13	$2,728	$464	$2,265	$675	$608	$4,129	$3,716	$4,474	$4,130	$3,014	$3,014	1.484	1.370
Mine 14	$2,728	$464	$2,265	$675	$574	$4,129	$3,508	$4,474	$3,957	$3,014	$3,014	1.484	1.313
Mine 15	$2,728	$464	$2,265	$675	$540	$4,129	$3,303	$4,474	$3,786	$3,014	$3,014	1.484	1.256
Mine 16	$2,728	$464	$2,265	$945	$851	$5,780	$5,202	$5,851	$5,369	$3,014	$3,014	1.941	1.781
Mine 17	$2,728	$464	$2,265	$945	$803	$5,780	$4,911	$5,851	$5,127	$3,014	$3,014	1.941	1.701
Mine 18	$2,728	$464	$2,265	$945	$756	$5,780	$4,624	$5,851	$4,887	$3,014	$3,014	1.941	1.621

Table 3. Workers' compensation costs and savings for Illinois and Kentucky (NS = no screen, S = screen).

	Illinois							Kentucky						
	WC Per $100 Payroll		WC Per $100 Payroll with Admin Fee		WC Premium, $k		WC Savings, $k	WC Per $100 Payroll		WC Per $100 Payroll with Admin Fee		WC Premium, $k		WC Savings, $k
	NS	S	NS	S	NS	S		NS	S	NS	S	NS	S	
Mine 1	$31.61	$31.05	$46.15	$45.33	$1,577	$1,549	$28	$31.52	$30.06	$35.15	$33.52	$1,107	$1,056	$51
Mine 2	$31.61	$30.77	$46.15	$44.92	$1,577	$1,535	$42	$31.52	$29.33	$35.15	$32.71	$1,107	$1,030	$77
Mine 3	$31.61	$30.49	$46.15	$44.51	$1,577	$1,521	$56	$31.52	$28.60	$35.15	$31.89	$1,107	$1,004	$102
Mine 4	$35.39	$34.44	$51.66	$50.29	$1,765	$1,718	$47	$41.29	$38.86	$46.04	$43.33	$1,450	$1,364	$85
Mine 5	$35.39	$33.98	$51.66	$49.61	$1,765	$1,695	$70	$41.29	$37.64	$46.04	$41.97	$1,450	$1,322	$128
Mine 6	$35.39	$33.50	$51.66	$48.91	$1,765	$1,671	$94	$41.29	$36.39	$46.04	$40.57	$1,450	$1,278	$172
Mine 7	$39.16	$37.83	$57.17	$55.24	$1,954	$1,887	$66	$51.06	$47.65	$56.93	$53.13	$1,793	$1,673	$120
Mine 8	$39.16	$37.19	$57.17	$54.30	$1,954	$1,855	$98	$51.06	$45.91	$56.93	$51.19	$1,793	$1,612	$181
Mine 9	$39.16	$36.53	$57.17	$53.33	$1,954	$1,822	$131	$51.06	$44.21	$56.93	$49.29	$1,793	$1,552	$241
Mine 10	$31.11	$30.40	$45.42	$44.38	$3,475	$3,395	$80	$31.71	$30.01	$35.35	$33.46	$2,492	$2,359	$133
Mine 11	$31.12	$30.05	$45.43	$43.87	$3,476	$3,356	$120	$31.71	$29.15	$35.35	$32.50	$2,492	$2,291	$201
Mine 12	$31.12	$29.70	$45.43	$43.36	$3,476	$3,317	$159	$31.71	$28.31	$35.35	$31.57	$2,492	$2,226	$267
Mine 13	$35.85	$34.67	$52.34	$50.62	$4,004	$3,872	$132	$43.02	$40.19	$47.97	$44.82	$3,382	$3,160	$222
Mine 14	$35.85	$34.07	$52.34	$49.74	$4,004	$3,805	$199	$43.02	$38.77	$47.97	$43.23	$3,382	$3,048	$334
Mine 15	$35.85	$33.49	$52.34	$48.89	$4,004	$3,740	$264	$43.02	$37.37	$47.97	$41.66	$3,382	$2,937	$445
Mine 16	$40.59	$38.93	$59.26	$56.84	$4,533	$4,348	$185	$54.34	$50.38	$60.59	$56.17	$4,272	$3,960	$311
Mine 17	$40.59	$38.10	$59.26	$55.62	$4,533	$4,255	$278	$54.34	$48.39	$60.59	$53.95	$4,272	$3,804	$468
Mine 18	$40.59	$37.27	$59.26	$54.42	$4,533	$4,163	$370	$54.34	$46.42	$60.59	$51.76	$4,272	$3,649	$623

APPENDIX B

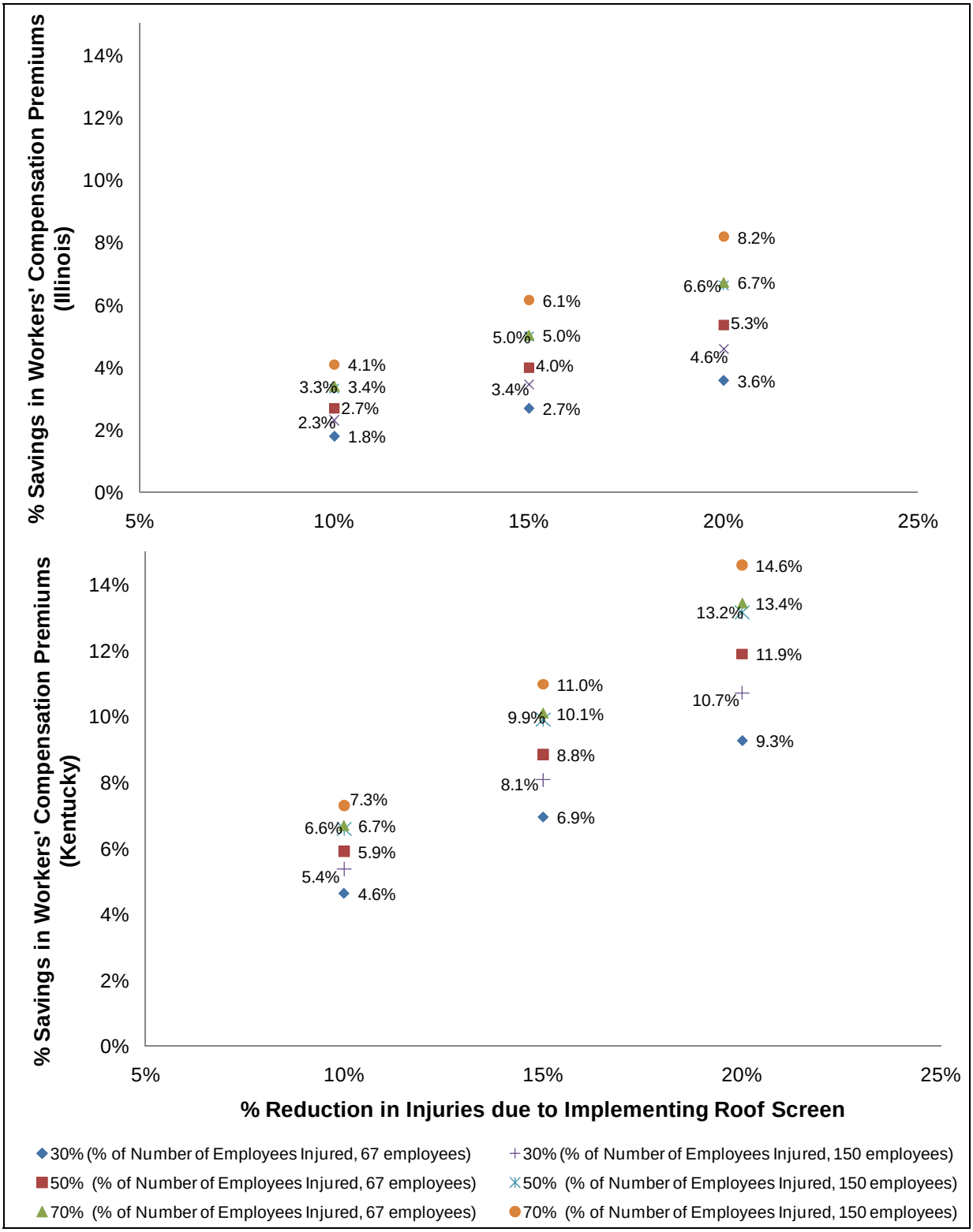

Figure 1. Percent reduction in workers' compensation costs for Illinois and Kentucky if injuries were reduced by 10%, 15%, or 20% due to implementing roof screening. Figure also shows expected savings when the number of MSHA reportable injuries is 30%, 50%, and 70% of the total number of employees. (Note: Number of injuries reported to NCCI during this time period were greater than the number of MSHA reportables by a factor of 1.4 and 1.8 for IL and KY, respectively.)