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Demonstrating the Financial Impact of Mining Injuries with the Updated Safety Pays in Mining V2.0 Web Application

J.R. Heberger
CDC NIOSH, Pittsburgh, PA USA

B.H. Ngo
University of Washington, Seattle, WA USA

ABSTRACT

The *Safety Pays in Mining v2.0* web application, developed by the National Institute for Occupational Safety and Health (NIOSH) Mining Program, helps mines determine the potential costs associated with mining injuries. This web app categorizes injury cost by part of body injured, by the cause of the injury, or by the nature of the injury. When the user selects one of over 150 common types of mining injuries, the app provides information on the distribution of costs of workers' compensation claims for that type of injury. Based on other user inputs, *Safety Pays in Mining v2.0* will estimate the total costs of the selected injuries and the estimated impact of total injury costs on mining company profits and will provide some examples of services and personal protective equipment on which companies could spend the savings that result from the prevention of injuries. This paper reviews the *Safety Pays in Mining* version 2.0 web application by discussing the development and updates to the app, how it is used to show the true costs of mining injuries, and how mines can benefit from using this app.

INTRODUCTION

Injuries on the job cause pain and suffering to the injured employee and profoundly affect company profits and daily operations (Cutler & James, 1996; Schulte, 2005). In addition to paying direct costs or increased premiums for workers' compensation insurance, a mine company might need to pay indirect costs from the injury, which can include paying overtime for other workers to fill an injured worker's job role, cover training costs for a replacement worker, or divert administrative resources after an injury (Leigh, McCurdy, & Schenker, 2001). *Safety Pays in Mining* is a web app developed by the NIOSH Mining Program that estimates the distribution of these injury costs and assesses the impact that occupational injuries have on a mining company's profits. This manuscript highlights the recent updates made to the *Safety Pays in Mining v2.0* app and builds off of the results published in the original 2018 publication (Heberger, 2018).

Before the original *Safety Pays in Mining* web app launched in 2017, the costs associated with specific types of mining injuries had limited availability as mining and insurance companies do not usually share this information. Therefore, companies are likely to only have cost information based on previous injury experience with their own employees. As a result, if a mine never experienced a concussion for one of its miners, it generally would not be aware of the possible costs associated with this type of injury. In addition, injury costs are unique in that the cost distribution is so wide and right skewed that just using the average mean cost of a specific injury type does not provide adequate information. Some injuries involve immensely high costs, and even though the risk of these high-cost injuries occurring is low, mines need to be aware of their potential impact on their company's financial health.

Safety Pays in Mining was designed to enable users to enter their own cost, sales, and profit margin values, or to use the default values based on the mining industry to show impact to profits. All injuries, costs, and values have been updated from the 2017 version of *Safety Pays in Mining* (Heberger, 2018). The app brings awareness of how much specific injuries, such as burns, fractures, dislocations, and sprains, might cost a mine—from $896 for a mean cost of

a medical-only finger laceration, $28,440 for a mean cost of a lost-time lower back sprain, to more than a $69,000 mean cost for a lost-time shoulder strain. The *Safety Pays in Mining* web application can be found on the NIOSH Mining Website at: www.cdc.gov/niosh/mining/content/economics/safetypays.html.

METHODS OF APP DEVELOPMENT

There are four sections in the *Safety Pays in Mining v2.0* application, including:

- Most Common Injuries and Work Activities for 2022
- What is the Cost of Occupational Injury?
- What is the Impact of the Cost of Occupational Injury on Your Company?
- How Could Your Company Spend the Savings from Preventing Injury?

The methods for developing each of these sections are described next.

Most Common Injuries and Work Activities for 2022

The Mine Safety and Health Administration's (MSHA) accident/injury/illness file for 2022 (National Institute for Occupational Safety and Health, 2023) was used to calculate the most common injury types and to identify the activities miners were performing when injured. This dataset includes all the injuries reported to MSHA in 2022. The injury data was sorted by commodity and then by: (1) the most frequent *Mine worker activities* during which a miner was injured and (2) common injuries, which is *Part of body* cross tabulated with *Nature of injury* to identify specific types of injuries.

What is the Cost of Occupational Injury?

Direct cost in *Safety Pays in Mining* is the cost of workers' compensation claims for a specific injury and includes medical expenses and indemnity for wage loss. The direct costs are presented by claim type (medical-only or lost-time injuries) and are represented as a mean cost and 25th, 50th (median), 75th, 90th, and 95th percentile costs. Costs can be selected by injury category which includes the part of body injured, the nature of injury, cause of injury, or selected combinations of part/nature/and cause. These selections are based off the Workers' Compensation Insurance Organizations (WCIO) injury description tables (www.wcio.org/injury-description-tables).

This data is based on the cost of mining-related workers' compensation insurance claims in the National Council on Compensation Insurance, Inc. (NCCI) system for policy years 2012 to 2015 (Heberger & Wurzelbacher, 2024). NCCI manages the nation's largest database of workers compensation insurance information. NCCI is a licensed rating and statistical organization providing to 35 states (and the District of Columbia) and collects a set of Workers' Compensation (WC) claims data from carrier-insured (private and state-funded) employers in these states. The NCCI data does not include claims from self-insured employers ((National Council on Compensation Insurance (NCCI), 2021)). The NCCI provides analysis of WC claim costs to guide the setting of rates/loss costs by insurance companies. NCCI analyzes industry trends, prepares workers compensation insurance rate recommendations, determines the cost of proposed legislation, and provides a variety of services and tools to maintain a healthy workers' compensation system (National Council on Compensation Insurance (NCCI), 2023). Certain types of information and data contained in this research article has been provided by NCCI to NIOSH in support of NIOSH research initiatives. The views and conclusions contained in this article are those of the authors and should not be interpreted as representing the opinions of NCCI, and NCCI makes no guarantees nor assumes responsibility for the accuracy of any results obtained through the use of the NCCI data.

NCCI agreed to share with NIOSH aggregated mining-related WC claims data from 2012–2015 for 35 states. The dataset grouped claims by type: Medical-Only and Lost-Time Non-Fatal injuries. The definition of Lost-Time varies by state from four or more to eight or more days away from work in U.S. states' WC systems (Utterback, Meyers, & Wurzelbacher, 2014). Medical-Only claims include only medical costs, while Lost-Time claims normally include both medical and indemnity costs. The NCCI dataset only includes claims that have been accepted for payment.

The cost data are incurred costs of medical treatments and indemnity for lost wages due to temporary and permanent disability. Incurred costs include both paid costs and reserves for anticipated future costs. Costs were valued as of the fifth report, which is provided approximately five and a half years after the policy year of injury. At the time of data receipt from NCCI, the 2012–2015 data had full fifth report development. All costs are nominal, as no inflation adjustments were applied.

Only non-zero cost injury types (diagnosis) with more than 50 cases were included. A total of 35,967 mining-related claims were included in the analysis with 21,223 medical only non-fatal injury claims and 14,744 lost-time non-fatal injury claims. The medical-only claims include injuries that only had medical-related payments with no time away from work. Lost-time claims include the medical

costs and indemnity for time away from work. Lost-time claims are generally more severe injuries than medical-only claims. Mining companies can enter their own injury cost data or can use one of the default values provided in the web application.

Looking at the differences between the 25th and 75th percentiles helps illustrate the wide distribution of the injury costs. Percentile is the percentage of injuries with equal or lower cost. After sorting the direct cost data in ascending order, the *n*-th percentile describes the value below which *n*% of the data falls. For a given injury, a direct cost in the 75th percentile would mean that the particular injury is likely to be at most this cost 75% of the time, and therefore only 25% of claims with that injury type's costs would be higher.

Indirect costs usually account for most of the true costs of an injury, and these costs may be uninsured and unrecoverable. The indirect costs used in *Safety Pays in Mining* are the costs to the employer beyond those covered by workers' compensation. Indirect cost estimates can include:

- Any benefits paid to injured workers for absences not covered by workers' compensation
- The wage costs related to time lost through work stoppage associated with the worker injury
- The overtime costs of other workers necessitated by the injury
- Administrative time spent by supervisors, safety personnel, and clerical workers after an injury
- Training costs for a replacement worker
- Lost productivity related to work rescheduling, new employee learning curves, and accommodation of injured employees
- Clean-up, repair, and replacement costs of damaged material, machinery, and property
- Increased workers' compensation insurance premiums (Jallon, Imbeau, & de Marcellis-Warin, 2011; Sun et al., 2006).

To estimate the indirect costs of injuries, *Safety Pays in Mining* uses an indirect cost multiplier of 2.12 (Huang et al., 2007). The indirect cost is calculated by multiplying the direct cost of an injury and the indirect cost multiplier as shown in Eq. (1).

$$\text{Indirect cost} = \text{Direct cost} \times 2.12 \quad (1)$$

Total cost of an injury is the sum of the direct and indirect costs.

What is the Impact of Occupational Injury?

The total injury cost, profit margin, and annual sales of a company are used to calculate the financial impact of occupational injuries. Profit margin measures how much of a company's sales it keeps as earnings, and in the web app this is calculated as after-tax profit divided by revenue. The profit margin used in *Safety Pays in Mining v2.0* can be either a company's actual profit margin (if the user chooses to enter it) or a pre-calculated default value. The default value of 11.7% represents the average of after-tax profits per dollar of sales for all mining commodities for the years 2018 through the first quarter of 2023, excluding 2020. Data from 2020 is excluded due to the COVID-19 pandemic's effect on the economy (Chen et al., 2021). The average was calculated using data from the U.S. Census Bureau's Quarterly Financial Reports for Manufacturing, Mining, Trade, and Selected Service Industries (2023). The default value gives the best estimate for corporations with North American Industry Classification System (NAICS) mining codes and assets of $50 million or more. Annual sales were averaged using U.S. Census Bureau Economic Census data for 2017 (2021) and are shown in Table 1. This is the average yearly sales estimate for the selected commodity based on NAICS codes. The total cost of the injury as a percentage of annual sales is calculated by dividing total cost by annual sales. To calculate the additional sales needed for a company to cover the total cost of the injury, total cost was divided by profit margin.

How Could a Company Spend the Savings from Preventing Injury?

Although a mining company might choose any number of ways to spend or reinvest savings from injury prevention, mines could decide to add to their workforce or better outfit their existing workers. *Safety Pays in Mining v2.0* calculates the number of employees a mine could hire for one year, the number of employees a mine could enroll in a hearing loss prevention program for one year, the number of pairs of MSHA-suitable safety boots, and the number of MSHA-suitable hard hats a company could purchase if an injury was prevented. The hardhats, boots, and hearing loss prevention program enrollment were incorporated because they are included in the MSHA rules in Title 30 of the Code of Federal Regulations, and therefore mines may be required to provide these (PPE/safety programs) for their employees (Hard hats, 1985; Occupational noise exposure, 1999; Protective clothing, 1974a; Protective clothing, 1974b; Protective footwear, 1985).

Table 1. Mining commodities and their associated default annual average 2017 sales values.

Commodity	Default Average Annual Sales
All Mines (except oil and gas)	$14,980,000
Coal	$42,610,000
Metal	$101,010,000
Nonmetal	$26,700,000
Stone	$6,150,000
Sand & Gravel	$4,770,000

To estimate the number of employees a mine could hire for one year if the injury was prevented, the total cost of the injury was divided by the product of total employee compensation and the average hours worked per year. Hourly wage data was retrieved from the Bureau of Labor Statistics (BLS) Occupational Employment Statistics, National Industry Specific Occupational Employment and Wage Estimates, which is calculated each May (BLS, 2023a). The default hourly wages were calculated from the five-year (2018 to 2022) average hourly wages for mining (based on NAICS coding) and are shown in Table 2.

Table 2. Average hourly wages from 2018 to 2022 for each mining commodity.

Commodity	Default Hourly Wage
All Mining (except oil and gas)	$27
Coal	$32
Metal	$33
Nonmetal	$25
Stone	$25
Sand & Gravel	$25

Employee compensation includes both the wage amount and any additional benefits a company provides to its workers. Employee benefits might include Social Security, insurance, retirement benefits, paid leave, and overtime pay. The average benefit amount for mining industries (calculated using 2018 to 2022 data) was one-third of the total compensation figure. Therefore, total compensation is equal to hourly wage plus another 50 percent of the wage value in employer-paid benefits. This data was retrieved from the BLS National Compensation Survey (BLS, 2023c). Data on the average weekly hours worked was retrieved from the BLS Current Employment Statistics program (BLS, 2023b). The average hours worked per week for the mining industry (for the years 2018 to 2022, excluding oil and gas) was 45.2 hours per week. Assuming 50 working weeks per year, the average employee worked 2,260 (45.2x50) hours per year.

To calculate how many employees a company could enter in a hearing loss prevention program for one-year, total injury cost is divided by the yearly cost of a hearing loss prevention program. The default $300-per-person annual estimate for a hearing loss prevention program is based on recent hearing conservation program publications (Rabinowitz et al., 2018; Sayler et al., 2018). To calculate how many employees could be provided with MSHA-suitable safety boots, the total cost of the injury is divided by the cost of a pair of MSHA-suitable safety boots. The default price of $175 for MSHA-suitable safety boots was averaged by NIOSH, using 2023 prices from numerous occupational safety and health equipment suppliers. To calculate how many employees could be provided with MSHA-suitable hard hats, the total cost of the injury is divided by the cost of an MSHA-suitable hard hat. The default price of $60 for MSHA-suitable hard hats was averaged by NIOSH, using 2023 prices from numerous occupational safety and health equipment suppliers.

RESULTS

The Results section focuses on the most common injuries for all mining commodities.

Common Injuries and Work Activities for 2022

Table 3 shows the most common mining activities performed when an injury occurred in 2022 for all mining commodities. In 2022, for all mining commodities, handling supplies or materials was the most common activity when an injury occurred, with 1,196 cases, making up 24% of mine worker activities performed when an injury occurred. Machine maintenance and repair was the second most common activity, occurring in 16% of all injury cases, followed by walking and running (11%), operating equipment (10%), and non-powered hand tools (10%).

Table 3. The most common mine worker activities performed when injuries occurred in 2022, for all mining commodities.

Mine Worker Activity	Percentage of All Injuries	Count
Handling material	24%	1,196
Machine maintenance/repair	16%	820
Walking/running	11%	558
Operating equipment	10%	521
Hand tools (not powered)	10%	507
Get on or off equipment, machines, etc.	7%	349
Roof bolting	5%	253
Inspecting	3%	130

These common mine worker activities had similar patterns in metal, nonmetal, and stone, sand & gravel commodities. Coal included the previous activities, but roof bolting was the second highest activity, which was the mine worker activity in 14% of all coal injuries (243 injuries); coal also included the activity of moving power cable, which occurred in 3% of all coal injuries (54 injuries) in 2023.

The common injuries also had similar patterns for each commodity and are shown in Table 4. For all mining, hand/finger cuts/lacerations/punctures were the most common injury, making up 13% of all injuries in 2023, followed by back sprains/strains (8%), hand/finger fractures (7%), leg sprains/strains (6%), and shoulder sprains/strains (6%).

What is the Cost of Occupational Injury?

The direct costs in *Safety Pays in Mining v2.0* are presented in percentiles. Table 5a shows the common injuries for all mining in 2022 and their medical-only claim direct cost percentiles. There are similar injuries in Table 5a since we included the injured body region, body region with nature of injury, and a combination of body part, nature of injury, and cause of injury. This gives a better picture of how costs can vary not only by body part and nature, but also how including cause can influence costs. Using lower back strain

Table 4. The most common injuries in 2022 for all mining commodities

Common Injuries	Percentage of All Injuries	Count
Hand/finger (cut, laceration, puncture)	13%	633
Back (sprains, strains)	8%	405
Hand/finger (fracture, chip)	7%	359
Leg (sprains, strains)	6%	308
Shoulder (sprains, strains)	6%	303
Ankle (sprains, strains)	4%	183
Face (dust in eyes/scratches)	3%	150
Face (cut, puncture, laceration)	3%	133

Table 5a. Percentiles of direct costs for the most common medical-only mining injuries in 2022.

Common Injuries	25th	50th Median	Mean	75th	90th	95th
Finger laceration by cut, puncture, or scrape	$362	$695	$1,210	$1,072	$2,261	$3,474
Finger laceration by hand tool (not powered)	$366	$758	$896	$1,063	$1,716	$2,402
Finger laceration by object being lifted or handled	$348	$605	$1,027	$1,061	$1,515	$2,874
Finger laceration when caught in, under, or between machinery	$638	$1,052	$1,446	$1,829	$2,727	$3,994
Finger laceration when caught in, under, or between object being handled	$442	$853	$1,216	$1,258	$1,859	$3,485
Finger laceration when caught in, under, or between other	$392	$900	$1,190	$1,602	$2,458	$2,943
Lower back strain	$304	$749	$1,221	$1,447	$2,606	$4,069
Lower back strain by fall, slip, or trip	$363	$763	$1,741	$1,542	$4,056	$7,845
Lower back strain by lifting	$310	$669	$1,680	$1,638	$3,539	$6,059
Lower back strain by pushing or pulling	$250	$549	$1,147	$1,302	$2,714	$4,029
Lower back strain by twisting	$314	$615	$1,331	$1,689	$3,410	$4,359
Lower back strain by using tool or machinery	$291	$650	$1,499	$1,448	$3,491	$6,325
Finger fracture when caught in, under, or between object being handled	$602	$1,129	$2,110	$1,822	$4,454	$9,398
Finger fracture when caught in, under, or between other	$564	$925	$1,827	$1,764	$4,469	$6,568
Lower Leg	$324	$722	$1,413	$1,464	$2,758	$4,311
Upper Leg	$301	$600	$1,367	$1,203	$2,254	$2,756
Shoulder strain	$393	$949	$1,791	$2,331	$3,678	$6,031
Shoulder strain by lifting	$350	$723	$2,279	$1,757	$4,480	$5,834
Shoulder strain by pushing or pulling	$358	$702	$1,363	$1,776	$3,610	$4,727
Ankle	$353	$599	$1,228	$1,206	$2,243	$3,500
Eyes	$183	$353	$665	$664	$1,208	$1,753
Facial Bones	$480	$1,220	$2,434	$3,281	$4,784	$6,683

as an example, the medical-only direct cost in the 75th percentile is $1,447. This means that for lower back strains with medical-only WC claims, the direct cost is likely to be at most $1,447 75% of the time, while direct cost is likely to be higher 25% of the time. For these medical-only claims shown in Table 5a, injuries to facial bones and finger fractures when caught in, under, or between an object being lifted had the highest median direct costs, and the same finger fractures category had the highest 95th percentile costs at $9,398.

Table 5b shows the common injuries for all mining in 2022 and the lost-time claim direct cost percentiles. Lost-time does include medical and indemnity, so these costs are much higher than the medical-only injuries shown in Table 5a and are usually considered more severe injuries. For lower back strains in Table 5b, the direct costs in the 75th percentile is $71,624. This means that for lower back strains with lost-time WC claims, the direct cost is likely to be at most $71,624 for 75% of the time, while direct costs are likely to be higher 25% of the time. For these lost-time mining injuries, shoulder strains from lifting had the highest median costs ($52,821) and lower back strains had the highest 95th percentile costs ($432,455).

When the indirect cost is considered, the total cost of injury can be quite surprising. Table 6 shows the common mining injuries with lost-time claims, their 75th percentile direct cost, the calculated indirect cost, and the total cost, which is the sum of direct and indirect costs. The total cost gives a good estimate of what the true cost of the specific injury can be to a company. A finger injury with a direct cost of $26,303 can end up costing a company about $82,000.

What is the Impact of Occupational Injury?

Using the total costs of the selected injuries from Table 6, the impact to a company's profits can be calculated. Table 7 displays the common mining injuries along with their total cost, total cost as a percentage of annual sales, and most importantly, the additional sales needed to pay for the total cost of that specific injury. The example in Table 7 is for a hypothetical mine with $14.98 million in annual sales and a 11.7% profit margin. To cover the cost of a shoulder

Table 5b. Percentiles of direct costs for the most common lost-time mining injuries in 2022

Common Injuries	25th	50th Median	Mean	75th	90th	95th
Hand (excluding fingers)	$6,238	$16,215	$46,975	$42,542	$83,037	$170,365
Finger(s) (excluding thumbs)	$6,079	$13,695	$25,301	$26,303	$51,331	$88,985
Cumulative lower back strain	$14,675	$26,172	$38,314	$44,156	$102,175	$120,780
Lower back strain	$9,004	$28,440	$80,311	$71,624	$268,485	$432,455
Lower leg	$8,105	$29,579	$105,095	$87,702	$228,618	$392,059
Upper leg	$4,371	$20,518	$66,148	$72,933	$156,160	$210,747
Shoulder strain	$19,596	$41,537	$62,006	$85,120	$110,210	$133,790
Shoulder strain by lifting	$14,935	$52,821	$69,426	$86,268	$161,223	$229,172
Shoulder strain by pushing or pulling	$24,257	$49,100	$56,743	$71,218	$112,974	$141,088
Ankle	$4,000	$13,396	$42,955	$38,050	$78,485	$141,597
Eyes	$2,673	$8,182	$55,452	$46,157	$117,875	$328,758

Table 6. Most common lost-time mining injuries and their associated 75th percentile direct costs, indirect costs, and total costs

Common Injuries	75th Percentile Direct Cost	Indirect Cost	Total Cost
Hand (excluding fingers)	$42,542	$90,189	$132,731
Finger(s) (excluding thumbs)	$26,303	$55,762	$82,065
Cumulative lower back strain	$44,156	$93,611	$137,767
Lower back strain	$71,624	$151,843	$223,467
Lower leg	$87,702	$185,928	$273,630
Upper leg	$72,933	$154,618	$227,551
Shoulder strain	$85,120	$180,454	$265,574
Shoulder strain by lifting	$86,268	$182,888	$269,156
Shoulder strain by pushing or pulling	$71,218	$150,982	$222,200
Ankle	$38,050	$80,666	$118,716
Eyes	$46,157	$97,853	$144,010

strain with a direct cost in the 75th percentile, a company would need to have additional sales of $2,269,867—which is calculated by dividing the total cost of the hand and finger fracture by the profit margin ($265,574 ÷ 0.117). Any one of these common injuries could cost a company at least over $82,000 and require over $700,000 in additional sales to recoup those injury costs.

How Can a Company Spend Savings from Preventing Injury?

To put these costs into perspective, or into different terms besides dollars, one could think of ways a company could spend money if an injury is prevented. Table 8 displays the common mining injuries and uses the total costs shown in Table 7 to give examples of what a company could spend money on if an injury was prevented. If an eye injury was prevented, instead of paying the costs associated with that injury, a company could pay one employee for a year, enroll 480 employees in a hearing loss prevention program for one year, purchase 822 pairs of safety boots, or purchase 2,400 hard hats.

DISCUSSION

Listing the most common injuries and the worker activities performed during injuries by commodity can help mines identify which possible hazardous activities and injuries are occurring in similar mining commodities. A stone mine might not have had a shoulder injury in the past, but it is helpful to be aware that shoulder injuries are the fifth most common injury in that industry. If they are occurring at other stone mines, it is likely they could also occur at any stone mine. Compared to the injuries reported in the

Table 7. Most common lost-time mining injuries from 2022, their estimated total costs, the total cost as a percentage of $14.98 million in annual sales, and the additional sales needed to pay for the injury cost with a 11.7% profit margin

Common Injuries	Total Cost	Total Cost as Percentage of Annual Sales	Additional Sales Needed to Pay for Injury Cost
Hand (excluding fingers)	$132,731	0.89%	$1,134,453
Finger(s) (excluding thumbs)	$82,065	0.55%	$701,413
Cumulative lower back strain	$137,767	0.92%	$1,144,493
Lower back strain	$223,467	1.49%	$1,909,973
Lower leg	$273,630	1.83%	$2,338,720
Upper leg	$227,551	1.52%	$1,944,880
Shoulder strain	$265,574	1.77%	$2,269,867
Shoulder strain by lifting	$269,156	1.80%	$2,300,480
Shoulder strain by pushing or pulling	$222,200	1.48%	$1,899,147
Ankle	$118,716	0.79%	$1,014,667
Eyes	$144,010	0.96%	$1,230,853

Table 8. Most common lost-time mining injuries and examples of how savings from preventing these lost-time injuries could be spent by a company

Common Injuries	Additional Employees Company Could Employ for One Year	Employees that Could Enroll in Hearing Loss Prevention Program	Pairs of MSHA-Suitable Safety Boots	Number of MSHA-Suitable Hard Hats
Hand (excluding fingers)	1	442	758	2,212
Finger(s) (excluding thumbs)	0	273	468	1,367
Cumulative lower back strain	1	459	787	2,296
Lower back strain	2	744	1,276	3,724
Lower leg	3	912	1,563	4,560
Upper leg	2	758	1,300	3,792
Shoulder strain	2	885	1,517	4,426
Shoulder strain by lifting	2	897	1,538	4,485
Shoulder strain by pushing or pulling	2	740	1,269	3,703
Ankle	1	395	678	1,978
Eyes	1	480	822	2,400

original 2017 version of *Safety Pays in Mining*, the 2022 data includes fewer injury counts, but the pattern and percent of injury associated with mine worker activity and common injuries are similar.

Within this NCCI mining-related injury cost dataset, the mean was always higher than the 50th percentile, and for about half of the injuries, the mean was higher than the 75th percentile. The mean would generally overestimate injury costs, as the mean alone does not fully represent a distribution of costs. Variability and skewness must also be taken into account. Showing percentiles of the direct costs helps show the distribution of this injury cost data. Additionally, percentiles require no distributional assumptions. The cost data is less skewed than the data used in the 2017 version of Safety Pays in Mining. In that cost data, the mean was always higher than the 75th percentile, and for about half of the injuries, the mean was higher than the 90th percentile (Heberger, 2018). This is likely because the NCCI data used for Safety Pays in Mining v2.0 has nearly nine times the claims used from the original web app and includes data from 35 states while the original web app only used data from Ohio. The original version also adjusted costs from a ten-year period (2001–2011) into 2015 dollars (Heberger, 2018).

There are two main reasons why a mine might want to use different percentiles rather than the 50th percentile, or median, which is usually the most familiar. The median provides a good estimate for a single "typical" claim because half of the claims have higher costs and half of them have lower costs. One reason to select a cost higher than the median is related to the total number of claims that are expected. If a mine is expecting more than one claim, the chances of having a very expensive claim increase. As a result, if expecting two to ten claims, using the 75th percentile for each claim will lead to a better estimate for total costs. When the number of claims exceeds fifteen, the 90th percentile for each claim provides a better estimate (Heberger, 2018).

Another reason to select a cost higher than the median is concern about the risk of having a high-cost claim that costs much more than the typical claim. There is substantial risk that claims will cost much more than the "typical" claim, as illustrated by the cost of claims at the 90th percentile and above. Even if a mine has a single claim, there is a 10% chance that the claim will exceed the 90th percentile cost. Tables 5a and 5b show why different percentiles are used. For a lower leg injury, the median (50th percentile) cost is $29,579 but the mean is $105,095, which is much too high an estimate for a typical injury. The skewness in the cost data indicates that every injury has a few cases of extremely high costs. Generally, costs will be between the first and third quartiles, but it is important to be aware that there are also those high-cost cases (95th percentile). Allowing the web app user to choose direct cost percentile based on number of injuries or their own risk profile allows users to explore the various costs per injury and how these costs can impact the financial success of a company.

The costs are difficult to compare between the original 2017 version of *Safety Pays in Mining* and the updated *Safety Pays in Mining v2.0.* The main reason is because the original version used all claim types and did not differentiate between medical-only and lost-time claims. The lost-time claim costs are much higher than medical-only claims for the same types of injuries. Finger lacerations in v2.0 are all from medical-only claims and the direct cost percentile values are similar to the original. When looking at back strains in v2.0, the claim types include medical-only and lost-time claims. The medical-only claim cost percentiles are much lower than the 2017 Safety Pays in Mining costs for back strain/sprain, but the lost-time claims are much higher. The two versions also have slightly different categorizations of injury, especially for the part of body, nature of injury, and injury cause combinations. This is partly due to the different WC datasets, but also the v2.0 data had many more claims allowing costs to be generated for very specific injuries.

Safety Pays in Mining v2.0 is intended for mine managers, safety managers, consultants, researchers, government agencies, and students—or anyone who is interested in the costs of specific injuries in the mining industry. Mines can benefit the most from *Safety Pays in Mining v2.0*, as it can help them prioritize safety and health interventions and focus on areas for improvement. Mines may want to focus on eliminating the higher-cost injuries first. By showing the additional sales needed to cover the injury cost and providing examples of how money could be spent instead of paying for an injury, the web app presents the same information in different terms, which can be useful for safety managers who do not have experience analyzing financial aspects of the industry. They can also use the web application to assist with cost-benefit analysis for safety budget allocations to help justify purchasing personal protective equipment (PPE), enrolling in safety programs, or obtaining engineering controls to reduce exposure to injury (Heberger, 2018).

LIMITATIONS

A primary limitation of the total cost calculation comes from the estimate of indirect costs by using the indirect cost ratio. There is not a universally accepted method for estimating indirect cost ratios (Manuele, 2011). The survey

study by Huang et al., (2007) focused on large manufacturing, healthcare, and finance/insurance industries, which are markedly different than mining; the mining industry tends to have fewer available skilled workers and employ fewer workers per location, with many mines employing five or fewer miners. Therefore, the indirect cost ratio of 2.12 may underestimate indirect costs in the mining industry.

Additionally, direct costs are not paid by all mine companies experiencing an injury. Direct costs are paid by those companies who self-insure (i.e. do not purchase WC insurance) which are usually very large companies. Companies who purchase WC insurance would have these direct costs paid by the insurance company. However, the cost impact for mines with WC insurance would largely be through increased premiums and even eligibility to participate in group policies (Ruser, 1985).

Finally, it should not be assumed that all injuries result in WC claims. Many injuries are unreported. These injuries can result in costs for employers as well, although there is some evidence that the unreported injuries tend to be less severe. Unreported injuries can still result in reduced productivity, absenteeism, sick days, and group medical costs (Almberg et al., 2018; Boden & Ozonoff, 2008; Leigh, Marcin, & Miller, 2004; Ruser, 2008).

CONCLUSION

The *Safety Pays in Mining v2.0* web application can be used by mine companies to estimate the costs associated with common mining injuries. This web app can raise awareness of the distribution and wide range of occupational injury costs for various types of medical-only and nonfatal-days-lost injuries. For specific injuries, mine management will find it useful to see the distribution of medical-only and days-lost injury costs as well as the associated indirect costs, which are often overlooked. The web app demonstrates that even a common injury has the potential to be extremely expensive. *Safety Pays in Mining v2.0* can be used to help mines prioritize health and safety interventions.

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DISCLAIMER

The findings and conclusions in this paper are those of the author and do not necessarily represent the official position of the National Council on Compensation Insurance, Inc. or the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

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