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Research Article

Natural Resource Extraction: Montana Workers' Compensation Claims Analysis 2011-2020

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Abstract

An analysis of Montana mining, quarrying and oil and gas extraction workers' compensation claims was carried out to identify injury characteristics and patterns. Investigators evaluated 4,782 injury claims from 2011 to 2020 identified to be part of North American Industry Classification System (NAICS) 21: Mining, Quarrying and Oil and Gas extraction as they appeared in the Workers Compensation Insurance Organizations' (WCIO) database. The claims were provided by the Montana Department of Labor and Industry and Occupational Health Surveillance Division using the Workers' Compensation Administrative Network database of all workers' compensation claims in the state. Similar patterns were identified in Montana claims as observed nationally. Claims totaled $48,640,228 and declined significantly in frequency by 49%, p-value < 0.01 for the period studied. Mining not otherwise classified (NOC), underground and above ground coal operations and drivers comprised 58% of all claims. Strains and sprains totaled 42% of all claims costing $25,079813. Employees in this sector between 25 and 34 years of age filed 1,285 claims consisting of 26% of all claims. The analysis of mining, quarrying and oil and gas extraction-related workers' compensation claims is an important step toward conducting effective (evidence-based) safety research that can lead to relevant intervention programs and educational activities to reduce injuries and death to workers within the industry.

Keywords: Mining; Quarrying; Oil and Gas Extraction; Injuries; Montana

Introduction

Mining, quarrying and oil and gas extraction industries are characterized by rapidly changing workplace environments, variability of work tasks, parallel activities, ubiquitous hazards, and overall complexity of the work environment. The mining, quarrying, and oil and gas extraction sector is part of the natural resources and mining supersector. Organizations that extract naturally occurring mineral solids, liquid minerals, and gases comprise the mining, quarrying, and oil and gas extraction sector [1]. From 1911 through 1997, approximately 103,000 miners died in the United States [2]. The fatal injury rate among the US mining, quarrying and oil and gas extraction sector was 12.9 per 100,000 workers in 2017 [3]. The mining, quarrying and oil and gas extraction sector in Montana ranked 8th in GDP in 2022 accounting for $2,827,344,970 in revenue [4] while the sector employed nearly 600,000 workers in the United States [5]. Montana's tradition of mining has led to 194,081 registered mining claims in the state, with less than 20,000 remaining active [6]. Research related to injury, illness, and fatalities found in the published literature was carried out looking at national injury data such as Survey of Occupational Injuries and Illnesses (SOII) and Census of Fatal Occupational Injury (CFOI) cases [7]. Articles often identified characteristics and patterns of reported events with limited information and detail. Consequently, state workers' compensation claims that provide additional details about cases including nature, cause, body part, and costs associated with each injury are rarely analyzed and reported. There exists a priority to evaluate available loss data from the mineral and gas extraction industry to understand hazards, risks, and their causal pathway to injury, illness, or fatality for the purpose of developing interventions that might lessen the burden of human suffering and associated losses.

The nature of injuries that take place in the mining sector vary depending on the type of work being performed. The associated costs of the injury, and the resulting financial impact may have an extensive adverse effect on any given company. The extent of the injury and/or fatality may have a significant effect on the injured individual and their family, as well as the morale among workers in the work environment and operations. Impacts include days away from work, legal fees, incurred medical expenses, resulting in temporary total and/or permanent disability, and even rehabilitation costs that collectively place a significant burden on stakeholders. Frequency and/or severity of claims while at work increase workers' compensation insurance premiums for employers. Tools are available that estimate the financial impact of mining injuries such as the "Safety Pays in Mining" web application [8]. The Safety Pays in Mining etool was developed by the U.S National Institute for Occupational Safety and Health (NIOSH) and has the ability to estimate the costs of mining injuries when virtually any kind of injury is selected either by cause or nature of the injury.

Sprains, strains, and soft tissue tears were the leading nature of injury in 2020 accounting for 1,050 nonfatal injuries requiring days away from work in the US mining, quarrying and oil and gas extraction sector [9]. Injuries classified as sprains, strains, and soft tissue tears can often be attributed to ergonomic health hazards. Sprains are an injury to the ligaments connecting bone to bone and a strain is an injury to a muscle and/or tendon. These injuries often occur when the ligament, muscle or tendons are over-worked, stretched excessively, suddenly loaded, or torn by forceful contraction or sudden movement. The mining industry requires a substantial amount of manual materials handling although more processes have become automated in recent years [10]. Manual materials handling, if not conducted properly, can cause ergonomic stress on the body that may result in mild to severe outcomes. Multiple tasks require abducting the arms away from the body repeatedly, holding postures for extended periods of time, pushing, pulling, and lifting materials as well as bending and squatting. Frequency, force, awkward postures, and short duration cycle times are all potential risk factors that may have an adverse effect on the body and must be considered when evaluating work demands and working environments.

Mining, quarrying and oil and gas extraction related injuries are frequently associated with heavy machinery encounters used in operations. There were 1,750 contact with object/equipment nonfatal occupational injuries reported that included struck-by, struck-against, and caught-in injuries in the US mining, quarrying and oil and gas extraction sector requiring days away from work [11]. Struck-by or caught-in accidents represent workers becoming trapped or entangled in moving or rotating machinery, run over, or struck by moving equipment [12]. These types of injuries are often attributed to improper lockout/tag-out procedures and forgetting to render machinery de-energized for the completion of maintenance tasks. Roof bolting machines and continuous miners are high-risk pieces of machinery that have frequently been associated with injuries in coal miners [13]. Dozers, excavators, jackleg drills, and haul trucks are additional pieces of heavy machinery that show correlation with high-risk injuries. In some cases, incidents of this nature involving heavy machinery can be attributed to ineffective or inappropriate training methods [14].

Maintenance and repair related tasks in mining are associated with a substantial number of injuries that requires time away from work and can be very costly [15]. These injuries ranged from amputated fingers, fractured hands and/or fingers, and hand and finger lacerations. The maintenance and repair related injuries are often caused by hands being caught in or struck by the equipment being serviced. A lack of proper precautions such as machine guarding, lockout/tagout procedures, or proper personal protective equipment (PPE) when servicing equipment may result in such injuries. The use of the proper tools for service tasks is necessary to lessen risks of injuries and/or equipment breakage. Training and tool selection are important factors to consider when conducting service work on equipment and workers are wisest to practice safe work procedures and use the proper tools.

Length of employment has shown to be another predictor in determining the likelihood of sustaining an occupational injury. Workplace injury trends across the United States indicate that, regardless of age and industry, more than one-third of injuries occur in the first year of employment [16]. A study conducted by Traveler's Insurance analyzed 1.5 million workers' compensation claims from 2015-2019 and pinpointed new employees as the group with the highest risk of being injured while at work. This demographic may be at the highest risk due to unfamiliarity with new work processes, tools, equipment, demands, and environments increasing the probability of sustaining a workplace injury. In addition, risk perception involving certain tasks may be underestimated due to lack of adequate training, knowledge, and experience on the job. Solutions to curbing the number of injuries among new employees include competent person supervision and guidance, enforcing repeated awareness training, and adequate new hire orientation to prepare and protect employees for scenarios they may encounter at work [17].

Methods

De-identified data were received from the Montana Department of Labor and Industry including 4,782 injury claims in the Mining, Quarrying and Oil and Gas Extraction industry group. The data were collected from the Workers' Compensation Administrative Network database as of December 2021.

Data included information from the first report of injury (FROIs) for the calendar years 2011-2020. The FROIs are required to be submitted within twelve months of the injury. The FROIs compiled in this dataset were submitted by injured workers, employers, or insurers. The dataset included information pertaining to total wage-losses paid and total medical paid for the claims that occurred within the date range studied. Total wage-loss paid included payments paid for temporary total disability (TTD), temporary partial disability (TPD), permanent partial disability (PPD), and permanent total disability (PTD). Total medical paid information includes payments for hospitals, physicians, pharmaceuticals, physical therapy, and other medical-related payments. Lump sum payments were included for both wage-loss and medical benefits. Wage-loss designations indicated if the claim has paid wage-loss benefits or no paid wage-loss benefits. In the state of Montana, insurers are not required to submit information on claims with no paid wage-loss to the BLS. If wage-loss claims have no associated paid wage-loss, no further information was collected beyond the submission of the FROI. The supplied data set excluded payments related to vocational rehab, legal expenses, or fatality-related expenses, including dependent payments and funeral payments. Select workers' compensation claims had the potential to exist without both total medical benefits and total wage loss benefits. Eligibility for wage-loss benefits was established after the first 32 hours or four days of loss of wages (whichever is less) [18].

Cause of injury, part of body, and nature of injury codes/descriptions included in the data set followed the WCIO and are identified by a workers' compensation analysis to select the category of best fit. Over 80 unique WCIO cause of injury codes and 42 nature of injury codes were used to identify the claims in the supplied data set. North American Industry Classification System (NAICS) 6-digit codes were assigned to the claim data. Supplied claims were identified to be a part of the mining, quarrying, and oil and gas extraction sector, NAICS 21. The supersector consists of three subsectors NAICS 211: Oil and Gas Extraction, NAICS 212: Mining (Except Oil and Gas), NAICS 213: Support Activities for Mining. Codes further classified claims including industry group, NAICS industry, and national industry.

Data were provided in Microsoft® Excel® workbooks and organized based on continuous or categorical information and then moved to MiniTab™ version 21 for variable manipulation and analysis. Descriptive statistics such as means, medians and frequencies were generated. Annual employment was supplied for the mining, quarrying, and oil and gas extraction sector in Montana for the ten-year period. The chi-squared goodness of fit test was used to test for statistical significance in the number of observed claims per year compared to the expected number of claims with 95% significance. Claim rates per 1,000 employees were calculated utilizing the annual employment data by dividing the count of claims in a year by the annual employment and multiplying the proportion by 1,000. A one-way ANOVA (analysis of variance) at 95% significance was conducted to evaluate differences in means between total cost of benefits and age of injured employee.

Results

The Montana Department of Labor and Industry identified 4,782 workers' compensation claims from 2011 to 2020 as being related to the mining industry in Montana. The sum of workers' compensation claims had a total cost of $48,640,228. Total costs associated with the injury are a sum of total medical benefits paid and total wage-loss paid benefits. Of the claims analyzed, 3,498 of them had a total cost of $0 associated with the injury. In total, 3,622 claims existed without wage-loss benefits and 3,510 required no medical benefits.

Workers' compensation claim information related to the mining, quarrying and oil and gas extraction sector in Montana from the 10-year period is contained in Table 1 below. After the removal of claims resulting in $0 monetary benefits and outliers present in both total medical paid ($671,396) and total wage loss paid ($664,166) information, benefits for both total medical paid and total wage - losses paid are reported in monetary amounts. Removed outlier costs were associated with a singular claim totaling $1,335,562 in combined paid benefits.

Data from the Montana Department of Labor and Industry in-

Type of Benefit	*N*	Mean	Median	Min	Q1	Q3	Max	Total
Medical Paid	1271	$ 20,741	$ 8,027	$20	$ 2,451	$ 22,468	$ 369,109	$ 26,362,094
Wage-Loss Paid	1159	$18,070	$ 6,057	$18	$ 1,704	$ 19,008	$ 269,495	$ 20,942,572

Table 1: Montana workers' compensation benefits in the Mining, Quarrying and Oil Extraction Sector 2011- 2020, excluding $0 benefits and outliers.

cluded the National Council on Compensation Insurance (NCCI) codes categorizing the claims by profession. The leading 10 NCCI codes that reported injury claims (including claims which did not result in monetary benefits) from the period evaluated are displayed in Table 2, below. The leading NCCI codes were identified as *Mining NOC- Not Coal- Underground and Drivers* comprising 1,387 of the total claims, followed by *Coal Mining- Surface and Drivers* with 756 claims, and *Oil and Gas - Lease Work NOC - By Specialist Contractor and Driver* with 331 claims. The three NCCI codes as mentioned accounted for 67% of the total claims by NCCI code.

Claim data included age ranges to further classify the information. Claims were categorized into one of six age ranges: 15-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, or 65-74 years. The age range with the largest percentage of injury claims is 25- 34 years of age with 1,285 claims consisting of 26% of the total claims for the period. Length of employment at time of injury could be calculated by utilizing the supplied hire year and injury year values. First year employees were the most represented group accounting for 1,512 claims, constituting approximately 32% of the total claims for the 10-year period. Gender was identified in 4,705 claims; males filed 4,489 (95%) claims while women filed 216 (4%) claims. Refer to Figure 1 for the distribution of claims by age.

Industry Group - Top 10	Number of Claims	Percent of Claims in Top 10
Mining NOC-not coal- underground- and drivers	1387	38%
Coal mining - surface and drivers	756	20%
Oil or gas - lease work NOC - by specialist contractor and drivers	331	9%
Oil or gas lease operator-all operations and drivers	305	8%
Quarry NOC and drivers	278	8%
Oil or gas - well - drilling or redrilling and drivers	159	4%
Oil or gas - well - cleaning or swabbing of wells - by specialist contractor - no drilling and drivers	153	4%
Coal mining-NOC	128	3%
Stone cutting or polishing NOC and drivers	98	3%
Sand or gravel digging and drivers	94	3%
Total	3689	100%

Table 2: Top 10 claims by NCCI industry code in the Mining, Quarrying and Oil and Gas extraction sector 2011-2020.

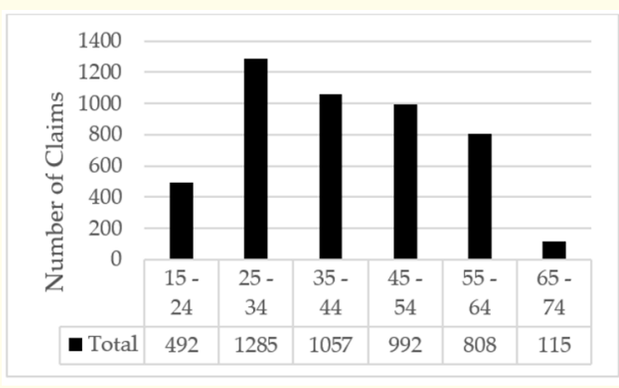

Figure 1: Montana workers' compensation claims by age at injury in the Mining, Quarrying and Oil and Gas Extraction sector 2011-2020.

Claims with associated monetary benefits were compared to the age of the injured employees to evaluate significant mean differences existing between the variables. The average of total costs was the highest among employees within the 65-74 age range at $17,402 regardless of having the fewest number of claims (115). A one-way ANOVA identified statistically significant differences of means when comparing total costs of benefits and age at injury, p = 0.014. The analysis indicates that average total costs vary between the six age groups included in the data set. An interval plot of total costs as they compare to age at injury is displayed below in figure 2.

The distribution of claims made per year compared to the expected number of claims is shown below in Figure 3. The Chi-square goodness of fit test revealed the annual employment experience varied significantly from actual claims filed per year:

X^2 (9, N = 4782) = 218.35, p = < 0.01

Claim rates per 1,000 workers for the individual years analyzed

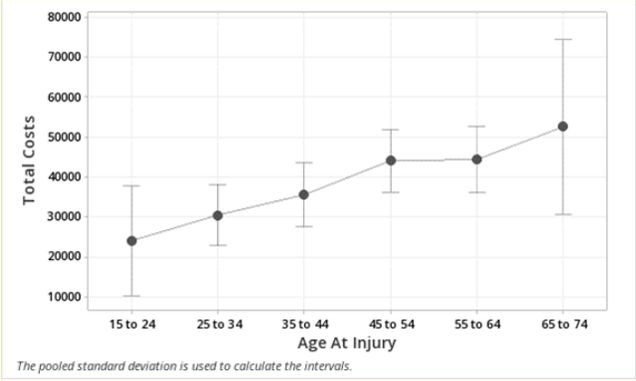

Figure 2: Interval Plot of Total Cost and Age in the Montana Mining, Quarrying and Oil and Gas Extraction sector 2011-2020.

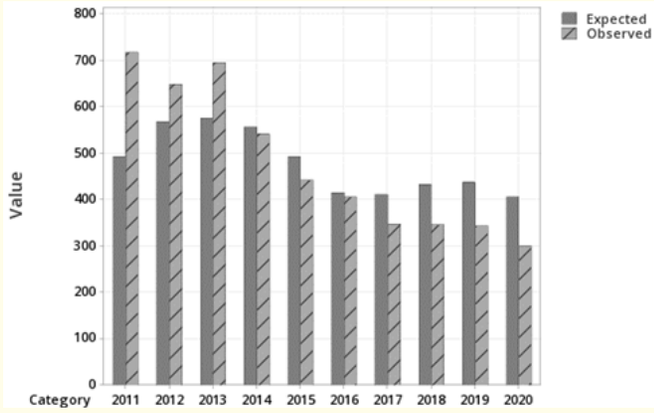

Figure 3: Numbers of claims by year of injury compared to the expected number of claims in the Montana Mining, Quarrying and Oil and Gas Extraction sector 2011-2020.

were calculated using annual employment data. Rates are displayed in figure 4. Claim rates were highest in 2011 at 94.3 claims per 1,000 workers and plummeted by 49% to 48.1 claims per 1,000 workers by 2020.

Descriptive statistics are provided in table 3 for the top ten types of injury, cause of injury and body part with the total costs and number of claims (including claims totaling $0). Sprains or soft tissue tear injuries accounted for nearly a third of the total costs in the top ten analysis at 29% with 1,082 associated claims and comprising 27% of the total for all claims from the ten-year period, responsible for $13,331,181 in total costs. Strains or tear injuries were the second leading nature of injury with 906 claims totaling $11,748,632 in total costs.

The cause of injury was most attributed to twisting, lifting, or

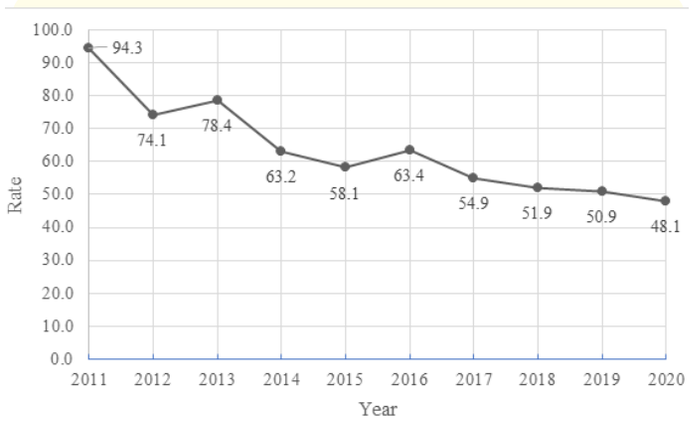

Figure 4: Rate of claims per 1,000 workers in the Montana Mining, Quarrying, and Oil and Gas Extraction sector 2011-2020.

falling/flying object encounters. Injuries classified with these causes surpassed $16.9 million in total costs. Back, including spine claims were identified as the leading part of body group injured by both count of claim (843) and total cost of claims ($14,806,150). The second most reported part of body injured were hands or fingers with 805 claims totaling $3,008,648.

Average cost of total benefits among the top ten leading injuries by count is displayed in Figure 5 below. Of the natures of injury, multiple physical injuries had the highest average total cost of benefits at $45,337. Multiple physical injuries indicate the presence of trauma in more than one body area or system. Amputations averaged $34,450 in average total costs and are defined as a limb or appendage that has been severed, cut off, either partially or completely amputated and fingertip amputations with or without bone loss.

Discussion

Nature of Injury	Multiple Physical Injuries	Amputation	Fracture	Burn	Strain or Tear	All Other Specific Injuries, NOC	Sprain or Tear	Inflammation	Contusion	Laceration
Average of Total Costs	$45,337	$34,450	$22,872	$16,750	$12,968	$12,478	$12,321	$8,940	$5,787	$1,966

Figure 5: Average Cost of Injury in the Montana Mining, Quarrying and Oil and Gas Extraction sector 2011-2020.

	Description	Sum of Total Costs	Number of Claims
Nature of Injury	Sprain or tear	$ 13,331,181	1082
	Strain or tear	$ 11,748,632	906
	Fracture	$ 7,021,598	307
	Contusion	$ 4,507,809	779
	Burn	$ 1,909,533	114
	All other specific injuries, NOC	$ 1,584,667	127
	Inflammation	$ 1,376,683	154
	Laceration	$ 1,224,718	623
	Multiple physical injuries only	$ 1,224,111	27
	Amputation	$ 757,909	22
Cause of Injury	Twisting	$ 8,464,166.00	585
	Lifting	$ 5,205,685.00	364
	Falling or flying object	$ 3,241,108.00	438
	Fall on same level	$ 2,610,194.00	275
	From different level (elevation)	$ 2,536,027.00	138
	Pushing or pulling	$ 2,515,359.00	214
	Machine or machinery	$ 1,978,022.00	156
	Strain or injury by, noc	$ 1,872,257.00	152
	Hot objects or substances	$ 1,664,610.00	31
	Using tool or machinery	$ 1,438,120.00	129
Part of Body Group	Back Including Spine	$ 14,806,150	843
	Shoulder	$ 4,039,926	229
	Knee	$ 3,979,892	386
	Hand or Finger(s)	$ 3,008,648	805
	Multiple Upper Extremities	$ 2,977,906	85
	Arm	$ 2,121,587	259
	Multiple Parts or Body Systems	$ 2,064,457	116
	Head	$ 1,915,034	235
	Ankle	$ 1,649,536	185
	Neck	$ 1,470,731	143

Table 3: Description of injury by cost of nature of injury, cause of injury, and part of body group in the Mining, Quarrying and Oil and Gas Extraction sector 2011-2020.

This evaluation provides the first analysis of Montana workers' compensation claims in the mining, quarrying and oil and gas extraction sector as they relate to cost of claims [19]. Analysis of this detail is significant in the assessment of identifying leading causes of injury within these industries. Knowledge of injury-risk scenarios is vital for the development of controls including the creation of training programs and enhanced awareness of hazards within the mining, quarrying, and oil and gas extraction industry.

The results of our claim analysis for the Montana mining, quarrying and oil and gas extraction sector was relatively consistent with national averages in several categories such as length of employment at injury, leading natures of injury, and primary employment age. Averages for length of employment at injury in the state of Montana were consistent with national findings and more likely to occur in the first year of employment, regardless of age or industry. It was reported that nearly one-third of nonfatal injuries and illnesses requiring time away from work in 2013 in the U.S. involved workers in their first year of service [17]. Sprains, strains, and fractures have been shown to be a leading nature of injury in the mining sector. Sprains and strains accounted for 37% of all nonfatal occupational injuries and illnesses involving days away from work in 2010 in the U.S. mining, quarrying, and oil and gas extraction sector. In the same year and sector, fracture injuries made

up 17% of nonfatal injuries [20]. The mining, quarrying and oil and gas extraction sector was primarily compromised of individuals with a median age of 42.5 years according to the U.S Bureau of Labor and Statistics [7]. The highest percentage of those employed fell within the 35-44 age range accounting for 29% of the employed population in the sector for 2021, followed by those in the 25- 34 age range comprising of 24% of the industry [5].

The cost of injury among Montana employees in the mining quarrying and oil and gas extraction sector increased in relation to age at injury. In 2012, the U.S. BLS reported that workers age 65 and older had the lowest incidence rate as compared to younger employees, but required the most time away from work [21] and were often associated with higher costs. Comorbidities such as hypertension and diabetes impacted the ability to return quickly to work, consequently extending the duration of absence.

Sprains, strains, soft tissue tears, or fractures were identified as injuries with the highest prevalence in the nature of injury analysis. On average, total costs including total medical paid and total wage loss paid benefits associated with fractures were $22,871. Strains and tears averaged $12,967 in total costs while sprains and tears had a slightly lower average total cost of $12,320. These averages are consistent with the average cost of a sprain/strain injury which was reported to be $12,800 in the US [22]. Measures to reduce the prevalence of sprain and strain injuries can include the implementation of primary controls such as engineering interventions that remove the worker exposure to offending forces.

Significant attention has been paid to the need for innovations that increase productivity and reduce hazards, risk and exposures to workers [23,24]. The Rio Tinto Innovation Center was established in 2007 to embrace, support, and develop industrial automation and control, design, software, and general engineering services to serve metal mining operations [25]. The center has an explicit goal of developing and delivering new technologies to metal mining. Engineering examples include Rio Tinto's AutoHaul™ truck [25,26]. The AutoHaul™ is the world's first automated long-distance heavy-haul rail network in Western Australia [25]. The center worked with Komatsu to develop a fleet of 190 autonomous trucks that have moved more than 130 million tons of materials in Australian mining operations [25]. Rio Tinto also developed autonomous blast-hole drills that have drilled more than one million meters of blast holes [25].

Codelco's driverless trucks are another example of using engineering technology controls [27] Despite the hesitation of industry to use autonomous vehicles a small number of mines adopted driverless haul trucks and now data exists that supports their positive safety record and benefit the bottom line profits [28]. Working with Komatsu, Codelco led the way, initially with a trial at its Radimiro Tomic copper mine in northern Chile. Driver related fatalities occur annually due to human error, autonomous trucks have prevented such loss of life [28]. Hitachi, began work in April of 2014 at the Meandu coal mine in Queensland. The use of autonomous vehicles in mining is expanding.

Information technology offers the promise of more efficient systems that can both increase productivity and safety and health. An example includes Strabag's matDOC Software system. Better software resulted in lower operating costs, improved resource use, and reduced number of employees needed for operations [23]. Increases in efficiency and innovative engineering facilitate the opening of new mines that otherwise would not be economically feasible [23]. Areas of innovation also include the adaption of VR for worker training [29]. Interactive computer-based VR of mine environments have been used to improve safety. VR delivers an improved understanding of mine operations, environmental conditions, safety hazards, as well as presenting and visualizing safe work procedures, and processes. This improved training has been successful because of the unique ability of VR to immerse and engage industry personnel with real life simulations [29].

Ergonomic design strategies to improve productivity and safety have included adjustability of equipment and workstations to accommodate anthropometric characteristics of different sized workers [30]. Additional applications of ergonomic principles have been used for workspace setup and layout to increase efficiency, productivity and safety and health as well as in seat design for comfort and improved visibility for safety [30]. Administrative controls have included power line awareness training, safer electrical maintenance procedures to ensure worker awareness of electrical hazards as well as pre-shift stretching and frequent stretch breaks to enhance worker flexibility and physical readiness for the demands of their work [30]. It is clear that additional ergonomic interventions are needed to reduce workers' strain and sprain associated with materials handling and equipment maintenance. Increased frequency of safety training with assistive technology such as VR might also be effective tools to increase awareness of ergonomic risks and proper safe work practices to reduce the number of common injuries.

There are limitations associated with a study of this nature. Workers' compensation data is summary data that has limited descriptions and detail. There is potential for information bias due to the misrepresentation of claim information due to using categorical methods to classify the claim. The selection of a singular code to represent a situation that may have multiple categories of best

fit increases the possibility of misclassifying the event. Another limitation associated with the data is that it had been manipulated by the DLI and investigators assumed that all information is correct upon receiving it. Utilizing WCIO categorical strategies to categorize claims has inherent limitations since only one code can be selected for the category being evaluated. In addition to this weakness, as more information is gathered on a claim the initial WCIO code may no longer be the best fit for the scenario and the initial selection may fail to be updated.

An essential aspect of workers' compensation evaluation in industry is understanding that workers' injuries are often underreported thus underestimating the actual impact to workers, the company, and industry. Underreporting occupational injuries can be a result of several situational factors, limiting the true representation of injuries taking place at work. Leading reasons for forgoing reporting occupational injuries have been associated with an array of outlooks, ranging from poor perception of safety climate within the organization to simply being unfamiliar with injury reporting requirements. Employees may choose to not report injuries in order to avoid retaliation by damaging the "accident-free" company experience, or fear of losing company incentives for no injuries, or decide to handle the injury/problem on their own and not seek a medical intervention [31].

Conclusions

The mining, quarrying and oil and gas extraction industry is composed of high-hazard, high-risk work environments and the associated work-related accidents and injuries may be catastrophic and costly. However, this study found a precipitous drop in claims from 2011 through 2020 suggesting that improvements in safe work practices are ubiquitous throughout the MT. There are many hazardous situations that if not handled correctly, can result in bodily harm or even death. Strains, sprains, soft tissue tears, lacerations, fractures, contusions, and bruises are common mining and natural resource extraction work related injuries that occur resulting from manual materials handling, encounters with heavy machinery, and machine maintenance. With such scenarios it is crucial to ensure adequate safety precautions are in place such as machine guarding, warnings, lockout/tagout procedures, and appropriate personal protective equipment. Engineering interventions are common and have saved lives. Ergonomic interventions must include training on the use of the correct tools, equipment, postures and forces necessary to complete higher-risk tasks. Job hazard evaluation should be a routine for the entire work process to achieve optimal compatibility with worker abilities and risk reduction. The industry continues to look for ways to improve not only productivity but also safe work practices to ensure the safety and well-being of its workers. Appropriate safety training in the context of a positive safety climate are critical factors for educating workers, supporting best practices, and worker safety on the job that effectively reduces workplace injury, illness, and fatality. Resulting injuries are often costly for both the affected party and the associated business, causing an excessive burden in incurred medical costs and lost wages, in addition to the traumatic event sustained. The current trend seen in this research suggests that the MT mining, quarrying and oil and gas extraction industries are committed to creating safer workplaces.

Declarations

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results. Author Contributions: Ms. Lindsey Madison lead author was a graduate student earning her MS degree and participated in all phases of the research process, data collection, coding, data entry, analysis, and manuscript preparation. Dr. Gilkey was Chair of the graduate committee and oversaw the study from conception to completion. Dr. Autenrieth provided statistical support and manuscript preparation and review. Professors Rosenthal and Tregidga were graduate committee members and contributed to all phases of the study and manuscript preparation and review.

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