Fall 2020

Safety Climate in MT Mining: A Case Study

Ty Murphy

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Received: date; Published:

Abstract: A safety climate case study was carried out at a surface metal mine where investigators administered the Liberty Mutual Short Scale Safety Climate Survey to 365-368 miners to measure safety climate in consecutive years. Following the baseline safety climate survey in 2019, Foundations for Safety Leadership (FSL) training was conducted with 81 middle to upper management employees at the mine site. Investigators found statistically significant differences in the pre vs. post-training FSL assessment scores of the middle to upper management employees who attended the training. The follow-up safety climate evaluation was compared to baseline scores and revealed no significant improvement. The overall baseline company safety climate score of 76.38 increased minimally to 76.50 (p-value=0.616). Investigators also evaluated differences in safety climate between the company's three major divisions (operations, maintenance, and administration). Both years administration had the highest mean score and operations had the lowest mean score. The authors attributed the statistically significant differences found among the three major divisions to various dissimilarities in their work environments.

Keywords: Safety Climate, Safety Culture, Mining.

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1. Introduction

Mining is an industry that presents an abundance of risk to its workers including physical, chemical, biological, and psychosocial hazards (Donoghue, 2004). The mining industry has a long history of safety failures and resulting tragedies that have taken the lives of many miners. At the beginning of the twentieth century the average death toll per year reached greater than 1,500 in the mining industry (Kowalski-Trakofler & Barrett, 2003). In 2019, 15 miners died and 567 recordable injuries were reported in the United States metal/ nonmetal mining industry. (Metal/Nonmetal Fatalities, n.d.) (NIOSH Mining, n.d.). Improvements in safety leadership, working conditions, and work practices have been identified as key factors in reducing injury, illness, and fatality rates in mining (Saleh & Cummings, 2011; Hine, 1999).

Despite advancements, metal mining still presents substantial occupational safety and health hazards. Bonsu, van Dyk, Franzidis, Petersen, & Isafiade (2017) analyzed 91 mining accidents and found the majority of the accidents were caused by inadequate leadership. It has often been found that inadequate and/ or deficient training by mine operators was responsible for the injury, fatality, or hazardous exposures (Filigenzi, Orr, & Ruff 2010; Saleh & Cummings, 2011; van Wyk & Villiers, 2009). Injuries have much greater economic impacts than just the direct costs. the direct to indirect cost ratio for an injury is between 1:3 to 1:5 (Camm & Girard-Dwyer n.d.). Indirect costs include training costs for replacement workers, lost productivity, and increase error due to new employee learning curves, whereas direct costs include workers' compensation and medical expenses (Heberger, 2018). Waehrer & Miller (2009) found that safety training both decreases days-away-from-work injuries and reduces overall injury rates.

1.1 Safety Climate

A crucial factor in reducing lost workdays and injury rates is positive safety climate (Zohar, 2010). Safety climate was originally described in literature by Zohar (1980) as a summary of perceptions and assumptions that employees share about their work environment. Gilkey et al., (2012) described safety climate as something that, "results from the enacted policies and procedures related to safety and the employee's perceptions and assumptions about the real priorities and consistency of management policies and procedures and their application for day-to-day business and decision making, particularly by frontline supervisors when company goals are conflicting".

Zohar (1980) found safety climate level could be measured and it is correlated with safety program effectiveness. This correlation has led to an abundance of research aimed at finding tools to measure safety climate, identifying other factors

correlated with high safety climate, and finding methods that are effective at improving safety climate. Huang, Chen, DeArmond, Cigularov, & Chen (2017) collected surveys from 29,179 frontline workers from various industries including manufacturing, construction, and transportation to validate the Liberty Mutual Short-Scale Safety Climate Survey. Ismail (2015) found a positive relationship between miners' perceptions of safety climate, and their safety performance at a gold mining company in Ghana. Pandit, Albert, Patil, & Al-Bayati (2019) found high levels of hazard recognition were correlated with high levels of safety climate in a study involving over 280 construction workers. Sparer, Catalano, Herrick, & Dennerlein (2016) utilized a safety communication and recognition program that led to improvements in safety climate, awareness, teambuilding, and communication.

Safety climate has also been linked to other factors such as job satisfaction and turnover rate. Balogun, Andel, & Smith (2020) conducted research in stone, sand, and gravel research and found that increasing safety climate perceptions leads to increased job satisfaction and a reduction in turnover intention. Shaw (2010) found turnover rates have negative implications in a variety of areas including safety and profits. It has also been found in research that employees who are satisfied with their job are more likely to be safety compliant (Masia & Pienarr, 2011) All of this research is consistent with Zohar (2010) who reported over 200 research articles had been published on safety climate and the overwhelming conclusion among them was that high levels of safety climate were associated with lower injury, illness, and fatality rates.

Safety training has been shown to make an immediate and lasting improvement on safety climate. Firoozi, Beheshti, & Poursadeghiyan (2015) found that when they provided health and safety training courses to miners working at an Iranian mine, it made a significant change in their safety climate scores. Safety climate surveys can be used to identify weaknesses in safety, which reveal opportunities for improvement (Firoozi et al., 2015; Stemn, Bofinger, Cliff & Hassall, 2019). Ma & Yuan (2009) found the largest difference among all factors influencing safety climate was the employee's perception of safety training. Their research suggests that company owners/ operators should use training programs that have been designed and validated to increase safety climate. In Ghana, Stemn et al.(2019) looked at the correlation between safety climate elements and incident rates in 4 gold mines. They found the mines with lower incident rates consistently had higher safety climate scores than mines with higher incident rates (Stemn et al., 2019). Despite the broad dissemination of research on safety climate and improvement methods, there remains a paucity of published work on the safety climate in US mining operations, with none from Montana.

1.2 Foundations for Safety Leadership (FSL) Training

The Foundations for Safety Leadership (FSL) was designed specifically for employees with supervisory responsibilities, with a goal of improving their safety leadership skills (Goldenhar, Schwatka, & Johnson 2019). Management has been consistently shown in literature to have a direct impact on company safety climate (Flin, 2007; Kozlowski & Doherty, 1989). The FSL training program teaches five safety leadership skills they can use to improve their safety leadership practices, strengthen jobsite safety climate, and ultimately reduce the incidence of adverse safety and health outcomes (Schwatka et al., 2019). Improving safety leadership skills in those with management responsibilities has been shown to improve jobsite safety climate and therefore lead to fewer injuries, illnesses, and lost time incidents (Williams, 2002). A positive safety leadership has also been shown to have a statistically significant negative correlation with turnover intention in the mining industry (Amponsah-Tawiah, Ntow, & Mensah, 2016). Goldenhar et al., (2019) found that many frontline leaders do not receive leadership training and therefore the FSL training program was designed to help provide a solution to this insufficiency.

1.3 The Purpose of this study

Researchers partnered with a surface metal mining operation in Montana. The purpose of this study was to investigate and evaluate the company's safety climate by establishing a baseline measurement, followed by Foundations for Safety Leadership Training, and then a post-intervention safety climate measurement to determine if the intervention was effective at improving the company's safety climate. Researchers also investigated whether or not differences in safety climate existed between the company's major divisions (operations, maintenance, and administration). The intervention used in this study was the FSL training program, a three-hour workshop, conducted by investigators with middle to upper management personnel at the mine. A FSL training program assessment was given immediately before and after training to determine if participants' knowledge of safety leadership skills improved and if they planned on utilizing the skills on their jobsite. The intervention was implemented after the baseline safety climate measurement in an effort to improve the company's safety climate as a whole. The null hypotheses used for the study were:

1. No statistically significant differences existed between the three major divisions of the companyin either year surveyed HØ: All company division's median safety climate scores are equal
2. No statistically significant improvements in the training assessment would occur in middle-upper management personnel's pre and post-training FSL assessment scores. HØ: $\text{Median}_{\text{Pre-Training}} \geq \text{Median}_{\text{Post-Training}}$
3. No statistically significant improvements would occur in the company's pre and post-training safety climate measurements. HØ: $\text{Median}_{\text{Pre-Intervention}} \geq \text{Median}_{\text{Post-Intervention}}$

Specific Aims were as follows:

1. Measure and evaluate potential differences in safety climate scores between the major divisions of the company

2. Measure and evaluate middle & upper management workers' knowledge of FSL skills pre to post-training
3. Measure and evaluate overall companywide safety climate scores comparing pre to post intervention

2. Methods

This investigation was carried out in three phases: Phase 1) baseline safety climate survey in 2019; Phase 2) intervention using FSL training with pre and post-training FSL assessment survey; and, Phase 3) follow-up safety climate survey one year later in 2020. Researchers secured authorization to use the Liberty Mutual, Safety Climate Short-Scale Survey from Liberty Mutual (Liberty Mutual Insurance, 2019). The same survey instrument was used for both pre and post-intervention measurements. Company executives agreed to allow 365 full-time employees at the mine to be surveyed both years. The 19-item survey instrument was designed to evaluate perceptions held by company personnel about management's commitment to safety and communication pertaining to safety (Huang et al., 2017). All statistics in this paper were analyzed using Minitab® Statistical Software version 18, which included basic descriptive and frequencies to describe the population and mean scores.

Survey items were presented in the form of statements in two major categories, with statements 1-8 pertaining to top management at the mine and statements 9-19 pertaining to the respondent's direct supervisor (Huang et al., 2017). For example, in relation to top management the following statements included, "tries to continually improve safety levels in each department" or "quickly corrects any safety hazard (even if it's costly)" (Huang et al., 2017). Statements related to supervisors included the following examples: "frequently checks to see if we are all obeying the safety rules" and "discusses how to improve safety with us" (Huang et al., 2017). Respondents were asked for their level of agreement with each statement using a 1 – 5 scale where, 1 = highly disagree to 5 = highly agree (Huang et al., 2017). The instrument is based off of a 32-item safety climate survey that was validated by safety climate expert Dov Zohar (Zohar & Luria, 2005). The survey was then shortened to 19 items in an attempt increase the utility of the survey in both research and practice (Huang et al., 2017). The short-scale survey has also been used in prior research and validated in various industries including manufacturing, construction, and transportation (Huang et al., 2017). Additional questions were added to the safety climate survey to identify various demographics including the division the respondent worked in (operations, maintenance, or administration), gender, race, age, and time worked with the company. Mean scores within each division were generated. Differences and similarities between divisions' mean safety climate scores were analyzed using the Kruskal- wallis test statistic with a 95% confidence interval. Comparing the individual safety climate statements and overall mean scores using two of the three divisions at a time was analyzed using the Mann- Whitney test statistic with a 95% confidence interval.

All surveys in this study were administered and collected onsite during annual Mine Safety and Health Administration (MSHA) refresher training in 2019 and 2020. Surveys were then collected by researchers for coding, data entry, and analysis. Differences and similarities between the pre and post-intervention safety climate survey scores were analyzed using the Mann-Whitney test statistic with a 95% confidence interval. The investigation protocol was approved by the university's Institutional Review Board.

2.1 FSL Training

Two months after the baseline safety climate surveys were administered, the FSL training sessions were conducted with 81 employees who had middle to upper management responsibilities at the mine This was accomplished using a three-hour workshop designed to teach the FSL's five critical leadership skills: 1) Leads by Example; 2) Engages and Empowers Team Members; 3) Actively Listens and Practices 3-Way Communication; 4) Develops Team Members through Teaching, Coaching, and Feedback; and, 5) Recognizes Team Members for a Job Well Done (Golenhar, 2019).

Mining supervisors and company leaders who completed the three-hour FSL training workshop were given the FSL assessment survey pre and post-training. This assessment was used to evaluate if the training was effective in improving safety leadership skills, and jobsite safety climate (Schwatka et al., 2019). The pre- and post-training assessments consists of 23 statements associated with positive safety leadership skills. Respondents were asked to rate their level of agreement with each statement on a scale ranging from 1 – 5 where, 1=strongly disagree to 5=strongly agree. Pre and post-training assessments as a whole, and all 23 question individual questions on the pre and post-training assessments were analyzed for potential differences using the Wilcoxon Signed-rank test with a 95% confidence interval.

3. Results

The study population demographics can be seen in Table 1. The majority of respondents in combined surveys were male (96%), Caucasian (96%), and worked in operations (63%). A total of 23 respondents (3.2%) reported they had been employed with the company for over 30 years and 414 respondents (59%) reported they had been working for the company less than 11 years. The age of participants ranged from less than 25 to over 65 years, with 49% of them younger than 45 years.

Table 1. Study Population Demographics and Work Characteristics

Variable	Characteristics	Frequency (*n*) (2019)	Percent (2019)	Frequency (*n*) (2020)	Percent (2020)
Division	Operation	178	61.2%	156	67.2%
	Maintenance	93	32.0%	61	26.3%
	Administration	20	6.9%	15	6.5%
Gender	Male	263	96.0%	292	96.0%
	Female	11	4.0%	12	3.9%
Race	Asian	0	0.0%	0	0.0%
	Black	0	0.0%	1	0.0%
	Caucasian	308	92.8%	335	94.9%
	Latino	3	0.9%	3	0.9%
	Pacific Islander	1	0.3%	1	0.3%
	Native American	5	1.5%	3	0.9%
	Mixed Race	14	4.2%	9	2.6%
	Other	1	0.3%	1	0.3%
Age (y)	18 – 25	14	4.1%	11	3.1%
	26- 35	90	26.4%	93	26.1%
	36 - 45	66	19.4%	76	21.3%
	46 – 55	107	31.4%	106	29.7%
	56 – 65	59	17.3%	62	17.4%
	More than 65	5	1.5%	8	2.2%
Time worked (y)	Less than 5	102	29.8%	114	32.0%
	5 – 10	99	28.9%	99	27.8%
	11 – 15	55	16.1%	37	10.4%
	16 – 20	54	15.8%	72	20.2%
	21 – 25	7	2.0%	10	2.8%
	26 – 30	17	5.0%	9	2.5%
	31 – 35	8	2.3%	11	3.1%
	36 – 40	0	0.0%	4	1.1%
	41 – 45	0	0.0%	0	0.0%
	More than 45	0	0.0%	0	0.0%

3.1 2019 and 2020 Safety Climate

The total company safety climate score in 2019 was 76.38 out of a possible 95. Researchers defined a positive response as either "agreeing" or "highly agreeing" with the statement. Slightly less than three-quarters (74.8%) of total responses were positive for an overall mean score of 4.02/5.0. Three statements had less than 70% positive responses. Two of the three statements that had less than 70% positive responses were regard to top management. Three other statements saw greater than 80% positive responses. All three of the statements that had greater than 80% positive responses were with regard to top management. Less than two-thirds (64%) of responses were positive with regard to the statement "Top management of this company considers safety when setting production speed and schedules" with an overall mean score of 3.77. More than four-fifths (83%) of responses were positive with regard to the statement "Top management of this company gives safety personnel the power they need to do their job" with an overall mean score of 4.26.

The total company safety climate score for 2020 was 76.50 out of a possible 95 points. Over three-quarters (76.5%) of all responses were positive for an overall mean score of 4.03/5.0. Two statements had less than 70% positive responses. One of the two statements that had less than 70% positive responses were with regard to top management. Four additional statements had a greater than 80% positive response rate. Three of the four statements that had greater than 80% positive response rate were with regard to top management. A little more than two-thirds (68%) of all responses were positive with regard to the statement "top management listens carefully to workers' ideas about improving safety" for an overall mean score of 3.77. Eighty-five percent of responses were positive with the regard to the statement "top management gives safety personnel the power they need to do their job" for an overall mean score of 4.21.

3.2 FSL Training

The FSL training sessions were conducted one to two months after the 2019 safety climate survey. A total of eight training sessions were completed with 81 employees who had middle to upper management responsibilities over an eight week period. Table 3 presents the pre and post-training results of those employees who completed the FSL Training. The post-training median score saw a statistically significant improvement compared to the pre-training median score. All 23 questions had statistically significant median score improvements when comparing pre and post-training results. The pre-training assessment found nearly ninety percent (88.9%) of employee responses were positive. In the post-training assessment this number increased to just over ninety-eight percent (98.1%) of employee responses being positive.

Table 3. Pre vs. Post Training Assessment Scores

	Pre			**Post**			
Question/Variable	Mean	SD	Median	Mean	SD	Median	*P*-Value[a]
1. Lead by example	4.63	0.85	5	4.90	0.30	5	0.006
2. Engage my team members in safety	4.46	0.97	5	4.87	0.37	5	0.001
3. Actively listen when team members speak to me	4.46	0.87	5	4.86	0.35	5	<0.001
4. Practice 3-way communication	3.78	1.07	4	4.67	0.67	5	<0.001
5. Develop my team members through teaching, coaching, and providing feedback	4.33	0.88	5	4.80	0.51	5	<0.001
6. Recognize team members for a job well done	4.43	0.98	5	4.94	0.24	5	<0.001
7. Establish safety as a core value of my team	4.52	0.77	5	4.96	0.24	5	<0.001
8. Maintain a positive attitude about safety	4.65	0.65	5	4.90	0.30	5	0.003
9. Set high safety expectations for team members	4.54	0.69	5	4.89	0.35	5	<0.001
10. Follow safe work procedures and practices	4.69	0.62	5	4.95	0.27	5	0.001
11. Communicate with my team that everyone owns safety	4.52	0.79	5	4.87	0.38	5	<0.001
12. Engage team members in daily safety meetings	4.00	1.02	4	4.65	0.63	5	<0.001
13. Request input from team members about safety	4.30	0.82	4	4.84	0.40	5	<0.001
14. Encourage team members to report safety issues such as hazards, safety concerns, near misses	4.64	0.69	5	4.93	0.30	5	0.001
15. Treat team members with respect when communicating with them	4.70	0.64	5	4.89	0.38	5	0.019
16. Actively listen to team members when they speak to me	4.55	0.72	5	4.86	0.39	5	0.003
17. Practice 3-way communication with team members to ensure my directions are understood	3.90	0.93	4	4.76	0.60	5	<0.001
18. Teach and coach team members in a respectful manner	4.57	0.65	5	4.90	0.37	5	<0.001
19. Focus on the problem rather than judging the person when I give feedback	4.31	0.73	4	4.76	0.58	5	<0.001
20. Make sure team members know how to do a task before they actually do it	4.40	0.81	5	4.89	0.42	5	<0.001
21. Say "good job" or "thank you" to team members who go above and beyond to create a safe jobsite	4.57	0.78	5	4.93	0.303	5	<0.001
22. Use positive recognition of team members to encourage jobsite safety	4.54	0.72	5	4.88	0.362	5	0.001
23. Encourage safe work practices by praising team members who do more than the minimum for safety	4.50	0.72	5	4.90	0.413	5	<0.001

3.3.1. Comparing Safety Climate Between Divisions 2019

Figure 1 shows an interval plot comparing all three divisions' mean scores in 2019 with a 95% confidence interval. Administration had the highest score mean score (4.39), followed by maintenance (4.09), and then operations (3.96). These mean scores showed statistically significant differences (p-value=0.007). Comparing administration to operations found statistically significant differences on 10 of the 19 statements. Comparing maintenance to operations found statistically significant differences on 5 of the 19 statements. Administration had a higher mean score than maintenance and operations on 18 of the 19 statements in the 2019 survey.

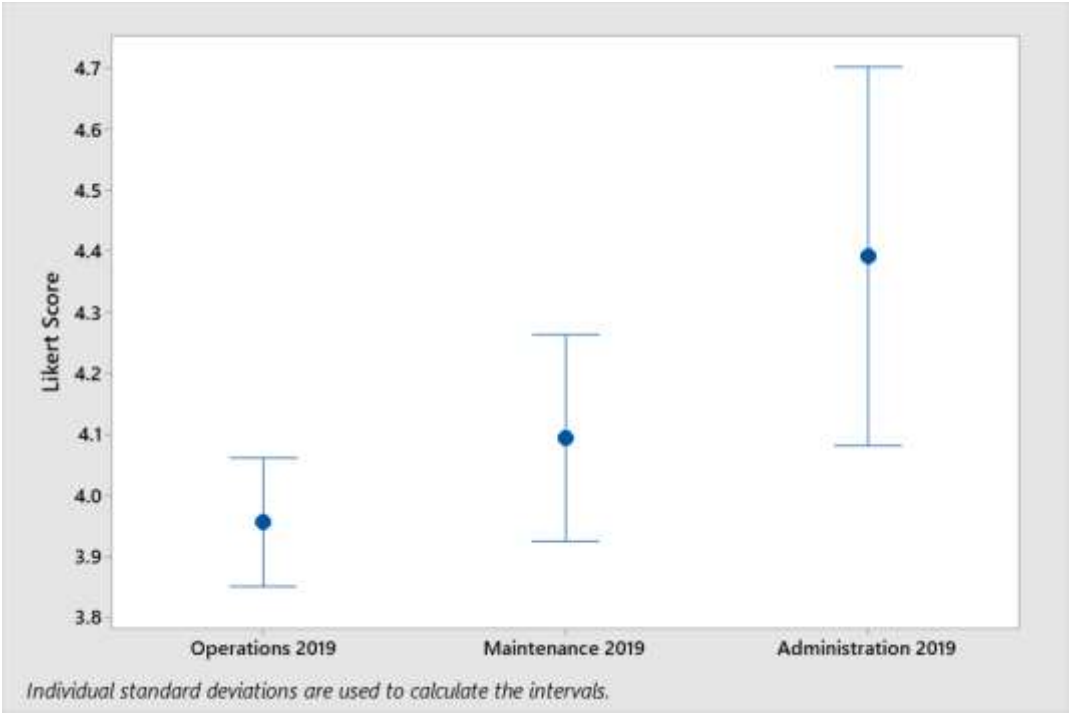

Figure 1. Interval plot showing the mean safety climate scores in 2019 of the three major divisions with a 95% confidence interval

3.3.2 Comparing Safety Climate Between Divisions 2020

Figure 2 shows an interval plot comparing all three divisions' mean scores in 2020 with a 95% confidence interval. Administration had the highest score mean score (4.40), followed by maintenance (4.08), and then operations (3.98). These scores showed statistically significant differences when comparing each division (p-value= 0.041). When comparing administration to operations we found statistically significant differences on 8 of the 19 statements. When comparing maintenance to operations we did not find statistically significant differences on any of the 19 statements. Administration had a higher mean score than maintenance and operations on all 19 statements in the 2020 survey.

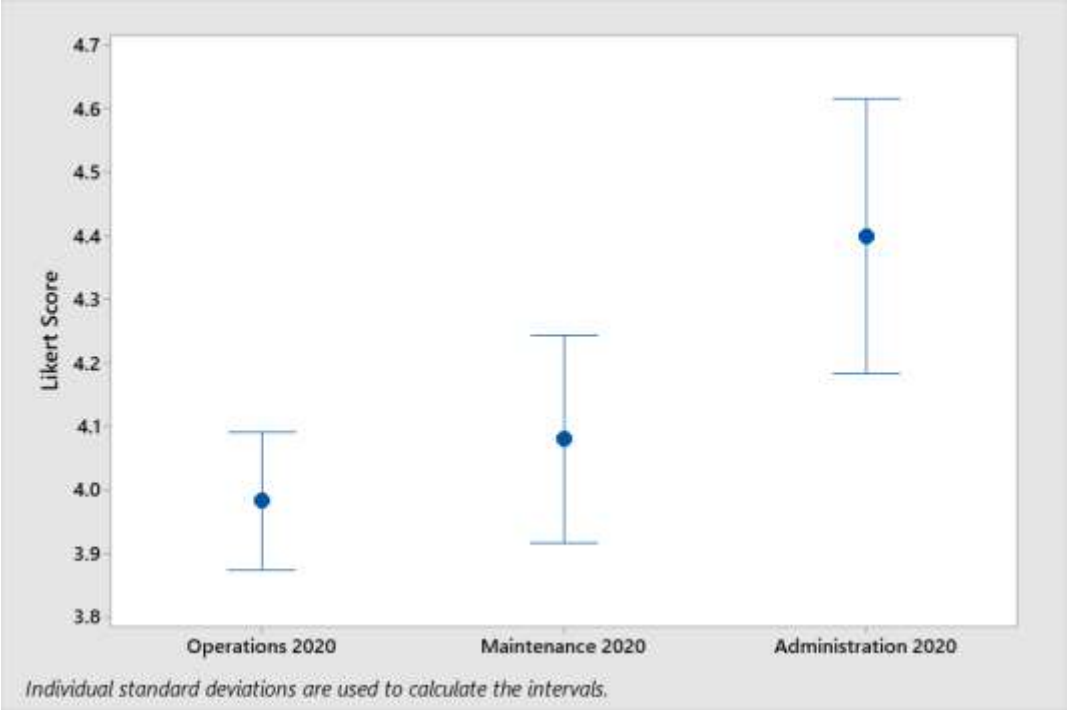

Figure 2. Interval plot showing the mean safety climate scores in 2020 of the three major divisions with a 95% confidence interval

3.4 Comparing 2019 vs. 2020 Safety Climate

Figure 3 shows an interval plot comparing the company's 2019 and 2020 safety climate means with a 95% confidence interval. The mean score increased from 4.02 in 2019 to 4.03 in 2020. The company's mean score increased on 10 out of the 19 statements in the survey. The Mann-Whitney statistical test found no statistically significant changes (p-value=0.616) from 2019 to 2020 in the company's overall mean score. 9 of 19 statements from the 2019 survey had a mean score greater than 4, while 11 of 19 statements on the 2020 survey registered a mean score greater than 4.

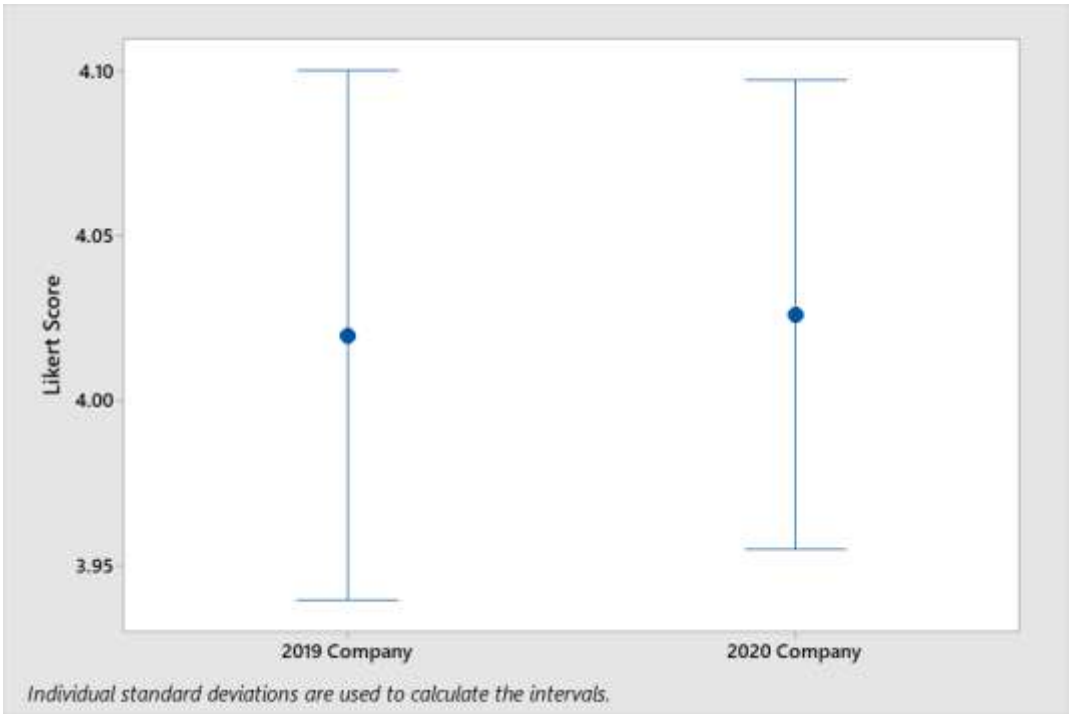

Figure 3. Interval plot showing the mean safety climate scores of the company mean in 2019 and 2020 with a 95% confidence interval Company Safety Climate

4. Discussion

The purpose of this study was to investigate and evaluate safety climate at a Montana metal mining company. The population characteristics of those surveyed were similar to national data reported by the U.S. Bureau of Labor Statistics (BLS) in 2018. The BLS (2018) reported nearly 90% of US miners identified as white males. The demographics section of the survey found 96% of the population at this mine identified as being male and 92.8% identified as white. The race demographic found in the mine were very comparable with the 2019 census data from the local community, which was 94.2% white (Butte-Silver Bow Census). The BLS reported the combined industry sectors (mining, quarrying, and oil and gas extraction) had a population distribution of 87.3% white and 86.2% male. Researchers were very successful in data collection; both 2019 and 2020 safety climate surveys achieved a response rate greater than 95% of people employed at the mine. This investigation was able to achieve the three study aims: 1) Measure and evaluate potential differences in safety climate scores between the major divisions of the company; 2) Measure and evaluate middle and upper-management worker's understanding of FSL skills pre and post-training; and, 3) Measure and evaluate safety climate scores comparing pre to post-intervention.

4.1 Differences Between Company Divisions

Investigators rejected null hypothesis 1) and determined that statistically significant differences in median safety climate scores existed between the three major divisions. Statistically significant differences were found when comparing the overall mean scores of all three divisions in both 2019 (p-value= 0.041) and 2020 (p-value= 0.041). Statistically significant differences in specific safety climate scores between operations maintenance, and administration were found in many areas. These results were consistent with (Zohar & Luria, 2005) who found who found group-level variation in safety climate within a single organization. On most items, operations had the lowest mean score and administration had the highest mean score. Administration had higher mean scores than operations and maintenance on 18 of 19 statements in 2019 and 19 of 19 statements in 2020. These differences might be partially explained by the fact that operations and maintenance workers face significantly more hazardous working conditions than administrative personnel.

Some of the most common hazards in mining include rock fall, mobile equipment accidents, explosions, falls from height, and crystalline silica exposure (Donoghue, 2004). Company administrative personnel routinely work at a desk or meeting room for the majority of their shift. They generally face fewer hazards and risks compared to maintenance and operations workers. Jiskani et al., (2020) concluded that higher levels of hazards in mining are a predictor for poor levels of safety and low safety climate. We believe that this may partly explain the differences in scores seen our study between administration compared to the other two divisions that face more daily hazards in the course of their usual work.

Findley, Smith, Gorski, & O'neil (2006) investigated a nuclear facility where they found administrative personnel's mean safety climate score was 10% higher than workforce/ craft workers. Results found in this study were similar, with administration having a mean score 10.2% higher than operations and 7.1% higher than maintenance in 2020. When a worker from either group is asked to increase speed of work, it will likely lead to quicker fatigue and therefore increase the risk of making a mistake (MacDonald, 2003). These factors elevate the likelihood the employee could suffer an injury or damage equipment (Putz-Anderson et al., 1997). Administration personnel do not face the same level of risk as operations and maintenance personnel when they are asked to increase work speed.

Operations and maintenance workers face similar hazards on a consistent basis while working at the mine site. This could explain why operations and maintenance scores for both 2019 and 2020 were more similar than administrations' scores. Though these divisions were more comparable than administration, maintenance had a significantly higher median score than operations in 2019 (p-value= 0.07). Maintenance also scored higher on 16 of 19 items in 2019 and 2020. A possible explanation for the differences found between operations and maintenance is the amount of interaction between employees and their supervisors/foremen within each group. Maintenance workers tend to have more face to face interaction with direct supervisors/foreman than operations workers due to simple geographical work area differences. The work area for maintenance workers is more of a team environment with each crew being limited to three or fewer buildings. Operations personnel on the other hand are located throughout the entire mine site, for example a worker may be isolated to a haul truck for their entire shift moving ore from excavation locations to dump locations. These types of jobs limit communication between workers and supervisor/foremen to primarily radio usage. Looking at some of the safety climate items with larger differences in mean scores between operations and maintenance, it is noted that most are linked to communication with supervisors/foreman. Communication is key to an effective safety climate (Gilkey and Lopez del Puerto, 2018). Being limited to radio communication as the primary source of interaction between foremen/supervisors and workers could limit relationship potential. Ean (2010) found that face-to-face communication most effective in building interpersonal relationships between employees and managers when comparing it to computer-mediated communication.

Variability exists in the work schedules of the company's three major divisions. Operations workers work 12-hour shifts, with one of four crews working onsite at all times, and all crews rotating between day and night shift. Maintenance workers are scheduled from 7 A.M. to 3:30 P.M. Monday through Friday, and they are on-call at all times in the event a pivotal piece of equipment breaks down. Administration workers generally work 7 A.M. to 3:30 P.M. Huang et al., (2007) found that night shift workers perceived a higher level of injury risk compared to day shift workers. Half of operations worker's shifts are night shifts, which may have negatively affected their safety climate scores.

4.2 FSL Pre vs. Post-Training Scores

Investigators rejected the null hypothesis 2) and found statistically significant differences when comparing pre vs. post-training Foundations for Safety Leadership assessment scores. All 23 variables on the survey saw statistically significant improvements. The authors believe that that the positive increase in scores represents a level of effectiveness of the training. Schwatka et al., (2019) found similar evidence that the FSL training can, at least in the short-term, improve FSL assessment scores in construction frontline leaders. These results were similar to the ones found in this study, but Schwatka et al., (2019) also acknowledged that further research is necessary to determine if these results lead to long-term improvements. The company plans on continuing to focus on training in the future to improve their safety climate.

Haas, Hoebbel, Patrick (2020) found that improving training, communication, and follow-up after training should be considered highest priority rather than the volume of training. Haas et al., (2020) also found, in general that the mining industry often lacks "soft skills" training such as sustaining communication and leadership. The FSL training is based around these "soft skills" and researchers in this study found a high level of engagement in the miners who took the class. This high level of engagement was reflected by the pre vs. post training assessment scores. Robson et al., (2010) performed a comprehensive literature review on training effectiveness and concluded that further research on high quality training effectiveness was needed. This study demonstrates that FSL training has the potential to increase miners with management responsibilities' knowledge of safety leadership skills.

Post-training scores show that these managers developed skills they could use to improve communication with the employees they oversee. Wu , Feng, Zou, & Fang (2016) found frontline leaders who display a "caring" dimension are particularly effective in safety leadership. FSL training stresses the importance of actively listening, engaging, empowering, and communicating with all members of their workforce. When these skills are put to use it shows workers they are valued members of a team. The authors believe that if managers utilized the skills learned from FSL training they could become better safety leaders and therefore improve the company's safety climate. Given that the company had a high level of safety climate prior to the onset of the study, it will be a challenge to move the climate scores to significantly higher levels.

4.3 Overall Company Pre vs. Post-Safety Climate Scores

Investigators failed to reject the null hypothesis 3) that no statistically significant changes would occur between the pre and post-training safety climate measurements. Investigators did see an increase from 76.35 pre-training to 76.49 post-training out of a possible 95. The mean scores were 4.02 for 2019 and 4.03 for 2020. This increase was not found to be statistically significant (p-value= 0.616). Investigators also observed an increase in positive responses with 74.8% of total responses being positive in 2019 compared to 75.8% in 2020, a negligible increase of 1%.

Researchers in Ghana used surveys to assess the maturity of safety climate in a large gold mine operation with 9,767 employees located at four sites. Investigators administered 1,040 surveys across the four sites and received 828 back for an 80% response rate. Researchers found an overall climate score of 3.42 from a possible 5.0 with a 68% positive response. Significant differences were found between various mine locations (Stemn et al., 2019). They found a higher safety climate maturity was correlated with lower incidence rate among the four mines (Stemn et al., 2019). The authors believe the high baseline measurement (4.02) correlates well with the fact the mine surveyed in this study had gone over 11 years without a recordable injury as of October, 2020. This extraordinary achievement speaks to the high level of safety management in place at the mine. Mine operators in this study stated that they go above and beyond annual refresher training required by the MSHA. This includes mandatory daily toolbox talks and various annual trainings depending on the employee's job and responsibilities, such as first aid, trench safety, fall protection, lockout tagout, etc. Research supports the assertion that all mine operators should implement safety training beyond what is required by law (Haas et al., 2020). The high initial state of the company's safety climate makes it more difficult to increase the company's safety climate.

Though the FSL training assessment demonstrated significant improvements on all 23 items when comparing the pre vs. post-training results, this improvement did not translate to the post-training safety climate scores. Murre & Dros (2015)

replicated and validated the Ebbinghaus forgetting curve research that claimed people often forget 90% of what they learned within 3-6 days unless learning is reinforced with multiple repetitions. This research aligns with claims made by (Haas et al., 2020) who found that reminding employees of training concepts and post-training communication may be the key to improving employees' safety knowledge. A follow-up plan was not used in conjunction with the training intervention to consistently remind supervisors/ managers of FSL training concepts and practices after training concluded. By consistently reminding employees of the skills they learned in the FSL training, they may be more likely to utilize the skills on their jobsites. The authors believe this could lead to a greater increase in safety climate scores in future investigations.

Another possible factor that may have negatively affected post-training safety climate scores was the occurrence of COVID-19 pandemic during this study. Three-months before the post-training safety climate assessment the World Health Organization declared COVID-19 a pandemic (WHO Timeline - COVID-19, 2020). The Center for Disease Control and Prevention stated that COVID-19 pandemic can cause stress, fear, and anxiety for people (Coping with Stress, 2020). They also reported that social distancing protocols utilized by the mine operators to reduce the spread of COVID-19 can make people feel isolated and further increase stress and anxiety (CDC Coping with Stress, 2020). Therefore, COVID-19 is a variable that could have biased scores towards the null. In light of the COVID-19 pandemic occurring prior to and throughout the post intervention assessment, the small but insignificant increase in safety climate scores is remarkable.

5. Limitations

This study has a number of limitations. The safety climate surveys were completed by individuals and may be subject to response bias. Self-report surveys are also subject to recall bias. Individuals may not have accurately recalled the circumstances for which they formed their opinions. The company experienced changes in middle to upper management positions between 2019 and 2020 during the study period. This could also have led to bias in the results of 2020 either toward or away from the null depending on how employees perceived the new managers views on safety. The newly appointed management personnel also did not receive Foundations for Safety Leadership training and therefore were not taught the skills to make potential improvements in the company's safety climate. The high level of safety climate and safe work practices in place at the mine bias the results toward the null. The company may not represent the average metal mine in Montana or elsewhere.

6. Conclusions

In this study we found statistically significant differences in safety climate between the company's three major divisions in both 2019 and 2020. We also found statistically significant differences in the FSL pre vs. post-training assessment scores indicating the training was effective. Despite the positive evaluation findings we did not see a statistically significant increase in the overall company mean safety climate scores when comparing 2019 to 2020. The next phase of this study includes identification, development, and implementation of additional strategies to further improve safety climate followed by future re-evaluations to assess changes in safety climate scores for the company as a whole and by division. Future strategies to improve the company's safety climate will include follow-up and communication with employees to remind them of key concepts after training concludes.

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