Validating the Safety Measurement Culture Survey: Assessing Employee Safety Reporting

by

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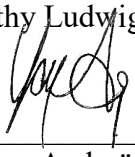

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Abstract

Organizations are increasingly using data and the outcome of data analysis to make decisions. However, certain organizational practices may reduce the value of the data, thereby hindering the decisions made based on analytics. The safety measurement culture of an organization, which we define as the culture of an organization around collecting, recording, and using data, arguably plays a large role in determining the quality of data. Accordingly, if organizations can improve their safety measurement culture, their data may more accurately represent behaviors occurring in their facilities and decisions based on data analytics will become more valuable. To assess employee perceptions that impact data quality, a Safety Measurement Culture Survey was developed to assess factors impacting employee participation and management action in promoting safety measurement. This study examines the tool's criterion-related validity by assessing the relationship between the results of the survey and actual employee reporting, such as near misses and minor injuries, in an organization. The results of this study indicate that questions 6 (*My supervisor encourages employees to participate in decisions that affect safety*), 11 (*I help investigate safety incidents and near misses*) and 15 (*When we report safety issues it helps prevent potentially serious injuries*), on the survey are significantly correlated with the aforementioned outcomes of the companies in our study. This study also measures the content validity of the safety measurement culture survey by assessing the relationships between average survey response and number of incidents. The results from this analysis indicate a positive relationship with the average survey response and number of incidents of the companies in our study.

Validating the Safety Measurement Culture Survey: Assessing Employee Safety Reporting

In addition to the emotional and psychological toll an injury in the workplace can cause an employee and organization, there are the associated medical bills, lost productivity, potential lawsuits, property damage, and a myriad of financial consequences. According to the National Safety Council, in the year 2017, there were approximately 4,572 preventable workplace deaths and workplace injuries cost $171 billion in 2019 (National Safety Council, 2020).

The three leading causes of major injuries (i.e., overexertion, slips/trips/falls, and contact with objects and equipment) account for 84% of all injuries (National Safety Council, 2020) yet are among the most preventable. Injuries such as these can be mitigated by interventions in the workplace informed when employees voluntarily report near miss incidents and minor injuries. However, 8.8% of minor injuries and 90.9% of near misses are not reported (Marsden, 2020).

Measures of Safety

The planning for safety interventions (e.g., better tools and equipment, rules and procedures, staffing, and training) can be helped by analyzing past injuries which suggest root causes of injury trends. Injuries are "lagging indicators" of safety performance that occur after an intervention could have prevented the incident (Sheehan, C., Donohue, R., Shea, T., Cooper, B., & Cieri, H. D., 2016). As a result, analyzing data on lagging indicators may not provide the right information to act as predictors for future accidents (Hinze, Thurman, & Wehle, 2013). Unfortunately, lagging indicators are the only data collected and analyzed to introduce interventions in most organizations. Approaching safety through lagging indicators is a reactive, "failure-focused" response as the consideration of safety interventions occurs after an event or failure has occurred (Sheehan, Donohue, Shea, Cooper, & Cieri, 2016).

In contrast, “leading indicators” of safety performance can provide early warning signs of future accidents (Sinelnikov, Inouye, & Kerper, 2015). Collecting data on leading indicators is the result of an approach called active monitoring (Shiskin & Moore, 1968). Active monitoring “evaluates the present state of a facility” allowing failures to be found before they result in accidents (Hopkins, 2009, p. 7). The use of leading indicators allows management to actively enable workers to get involved and demonstrate commitment by acting on employee reports (Toellner, 2001).

Heinrich, in the second edition of his book, Industrial Accident Prevention: A Scientific Approach, proposed a ratio suggesting that for every fatal accident approximately 30 injuries occur, and for every injury approximately 300 minor incidents such as near misses and minor injuries take place (Heinrich, H.W. 1941). According to this ratio, near misses and minor injuries occur much more frequently than major injuries (Heinrich, H. W., 1969). In other words, attempting to identify near misses and minor injuries should help direct interventions reduce the overall number of injuries, both minor and major. Because they happen more frequently, near misses and minor injuries result in more chances to identify safety issues and fix them. However, timely data must be collected through employee reporting. In most cases, the collection of data for safety and health interventions requires workers to commit time and effort in observing and recording leading indicators.

Near Misses and Minor Injuries

According to OSHA, minor injuries are those incidents that do not involve death, loss of consciousness, days away from work, restriction of work or motion, transfer to another job, medical treatment other than first aid, or diagnosis of a significant injury or illness by a physician or other licensed health care professional (OSHA, 2001). A near miss is “any situation in which an ongoing sequence of events was prevented from developing further… preventing the

occurrence of potentially serious (safety related) consequences" (van der Schaaf, 2013, p. 5). Minor injuries and near misses happen frequently without producing many negative effects, making them a good leading indicator to find trends in the data. Therefore, employee reporting of minor injuries and near misses offers management a low risk method to reduce accidents (McKinnon, 2012).

The occurrence of minor safety incidents can be recorded in two main ways: by the person who experienced the incident or by observations performed by equipment or human observers (van der Schaaf, 2013). Both methods of recording near misses require the participation of employees working on the frontlines.

Employee Participation and Management Action

Employee participation in safety interventions has been found to improve the outcomes of those interventions (Hagge, McGee, Matthews, & Alberle, 2017). Many safety interventions rely on the collection of data, such as minor injuries and near misses, by frontline workers. Because minor injuries and near misses often occur in private moments, management often do not know they have occurred unless an employee voluntarily reports the incident. A company may have the best possible safety system, but the system will be ineffective if employees are not willing to participate in reporting data (Compagnone, M. (2020).

Often there are barriers to reporting incidents such as minor injuries and near misses. Employees may be hesitant to report a minor injury because they want to avoid a) potential punishment for safety violations, b) the time and effort it takes to complete reporting forms, c) the embarrassment from the attention raised by reporting and d) lack of management action responding to reporting (Ludwig & Laske, in press; Prang & Jelsness-Jørgensen, 2014).

To overcome these barriers, it is necessary to create a non-blaming culture at employee and management levels (Vrbnjak, Denieffe, O'Gorman, & Pajnkihar, 2016). One way to achieve this is to analyze factors leading up to near misses and minor injuries rather than seeking out a culprit for punishment. A lack of feedback may also be a deterrent to employee reporting because the effort it takes to submit a report is not met with any activity. When employees are kept out of the loop as to how reports are being used and actions taken for improvement, reporting is not reinforced and will eventually extinguish (Ludwig & Laske, in press; Vrbnjak, Denieffe, O'Gorman, Pajnkihar, 2016). Therefore, publicized management action following up on reporting through mitigation of hazards, changing work processes, and providing better tools encourages employees to participate in reporting. When employees are actively engaged in reporting leading indicators such as near misses and minor injuries and managers are taking action on the information provided, this is indicative of a safety culture conducive to active monitoring and mitigation of safety issues (Compagnone & Young, 2020).

Safety Culture

Safety Culture is the set of shared beliefs, norms, attitudes, roles, and social and technical practices concerned with minimizing harm to people in the workplace (Mearns & Flin, 1999). Organizations with a strong safety culture have higher engagement in safe behaviors and tend to have fewer injuries (Hahn & Murphy, 2008). Persistent motivation to be aware of dangers in the workplace is important to the safety culture (Schaaf, 2013).When a visible effort is made by managers to improve the safety environment, employees have higher levels of motivation and commitment, leading to higher safety performance (European Agency for Safety and Health at Work, 2007).

According to OSHA, worker participation in creating safety and health programs results in better design, higher reporting, and more successful implementation (Occupational Safety and Health Administration, 2016). Involving all levels of employees gives the entire community a feeling of ownership over the safety program. Sharing results will drive further improvement in the resulting safety culture (OSHA, 2016). Discussing safety in all these forms has been shown to build shared norms necessary for strong safety culture (Ludwig, 2018).

Safety Measurement Culture

Safety measurement culture is "the extent to which employees and management are willing to provide valid accounts of what is happening in the workplace by completing inspection forms, conducting observations, or reporting close-call incidents." (Compagnone, 2020, p. 20). Measurement culture is an important subfactor of safety culture because the rate of incident reporting, the core of measurement culture, assesses "the frequency of reporting incidents and near misses" (Frazier, Ludwig, Whitaker, Roberts, 2013, p. 25). The cultivation of a good measurement culture plays a vital role in the overall efficacy of the safety culture of an organization (Compagnone, Young, Laske, Foreman, & Ludwig, 2020). Having an effective safety measurement culture is beneficial to any organization as it increases the efficacy of evidence-based decision making. In order to receive accurate analytical outcomes necessary for measurement culture, the data collection process must be of high quality. Organizations would benefit from being able to measure their safety measurement culture, however, the existing measure needs evidence to demonstrate criterion-related validity.

We propose that organizations can improve data quality and analytical outcomes by improving safety measurement culture through reinforcing participation, removing barriers that may punish participation, engage in discussions about how reporting data is being used and what

it shows, and follow up improvements directed by reporting (Compagnone et al., 2020; Foreman et al., 2020). An organization with a strong measurement culture will have more collaboration, increased data collection and better analytical output which direct safety interventions to better reduce injuries (Foreman et al., 2020). For that reason, a survey that assesses the safety measurement culture through perceptions and behaviors among employees is proposed.

Dysfunctional safety measurement culture practices such as those mentioned above are thought to be the product of personal and organizational barriers. Personal barriers include a) fear of vilification and conflicts, b) lack of technological confidence and knowledge, c) time and d) a perceived low degree of severity of the incident (Prang & Jelsness-Jørgensen, 2014). Organizational barriers may include a) lack of support, b) unclear outcomes and c) unclear routines (Prang & Jelsness-Jørgensen, 2014). Organizational barriers draw attention to management involvement in the active maintenance of a safety culture. As we seek to develop an assessment of safety measurement culture, perceptions of these personal and organizational barriers offer insights into how a culture may influence employee reporting.

Engaging in discussions about reporting and why employees may not be reporting can be a critical component to improving safety measurement culture. Reasons an employee may not report data include a lack of a no-blame safety culture, fear of reprisal, and excusing the near miss/incident (Rutledge DN, Retrosi, T, Ostrowski, G. 2018). One cultural practice that results in inaccurate data is pencil whipping when a worker completes a report or checklists without performing the necessary observations, inspections or other safety tasks (Ludwig, 2014). Unfortunately, pencil whipping and other cultural practices that result in non-reporting can leave the perception that there is not a safety problem, so interventions are directed elsewhere. Many possible reasons a safety culture may promote pencil whipping or record inaccurate data

practices exist. For example, employees may report 100% safe wanting to make themselves and their coworkers look good (Ludwig, 2014).

Safety Measurement Culture Survey

The goal of this study is to support the construct validation of a Safety Measurement Culture Survey through an analysis of voluntary reporting in two organizations. The survey was developed from a content analysis within a systematic literature review focusing on measurement-related questions from established safety culture surveys. The survey was formatted as a behaviorally anchored rating scale (BARS). BARS surveys offer a unique procedure to capture performance by requiring the respondent to choose from a range of specific observable behavior-specific anchors that respond to a specific question (Schwab, Heneman, & DeCotiis, 1975). This format was chosen over a Likert-type scale, which relies on a numeric scale, because of the susceptibility of a Likert-type scales to rater error and pencil whipping (Compagnone, Young, Laske, Foreman, & Ludwig, 2020). Because BARS surveys are based off of observable behavior, they have high inter-rater reliability; meaning that even when different people rate the performance of an individual their ratings match. BARS also has more objective choices than a Likert-type survey as there is less left to interpretation and personal bias because each choice includes a behavioral anchor (Martin-Raugh, Reese, Tocci, & Tannenbaum, 2016).

The resulting safety measurement culture survey consisted of 15 questions and was found to have two distinct factors in an exploratory factor analysis which Compagnone, et al. (2020) labeled *Employee Participation* and *Management Action*. Those factors showed a reliability coefficient of $\alpha = .69$ for management action and $\alpha = .83$ for employee participation during initial administrations of the survey. See Table 5 for definitions, examples, and psychometric information for these two factors.

Intent of this study

Based on the suggestions of Frazier et al. (2012), this study will examine the criterion-related validity of the Safety Measurement Culture Survey. In order to accomplish this, we will use archives of recent near misses and minor injuries to concurrently assess the criterion validity of our survey (Laerd, 2012). Specifically, we will seek to determine whether our assessment of safety measurement culture can make accurate predictions about actual safety outcomes such as near misses and injuries in an organization. A high average score on the questions in the Safety Measurement Culture Survey should be related to higher frequency of near misses and minor injuries reported because a better measurement culture would lead to more reporting. Therefore, I hypothesize a significant positive correlation between the mean safety measurement culture survey response and an aggregate of near miss, first aid injuries, and hazards divided by number of employees. I also hypothesize that average Safety Measurement Culture Survey response will be negatively correlated with number of incidents because if there are more near-miss, first aids, and hazards being reported there are more chances for supervisor to fix safety issues before they become injuries resulting in fewer injuries.

Methods

Participants

Participants of this study included employees from two companies. Company A is a global specialty chemical company employing approximately 15,000 people worldwide. At Company A surveys were completed by frontline workers across two divisions and eight departments. From company A, surveys were completed by 660 frontline workers across eight departments. These departments were selected because they represent the departments that completed more than fifteen surveys or had more than 50% participation from their department. Company B is a parent

company of five distinct textile companies with 37 facilities employing over 15,000 people (Compagnone, 2020). From Company B, surveys were completed by 436 frontline workers across eleven plants. These plants were chosen as they were the continental US plants from this company. Departments were chosen based on whether they completed more than ten surveys or had more than 50% participation from their department. Appalachian State University's Institutional Review Board approved this research (IRB # 19-0072).

Safety Measurement Culture Survey

The Safety Measurement Culture Survey (Compagnone, et al., 2020) was administered within departments at Company A & Company B assessing two distinct factors related to measurement culture. Questions assessing the factor of Employee Participation included (a) employee openness to reporting and (b) quality of minor injuries and near miss reports. Questions relating to this factor measure voluntary involvement and commitment to accuracy of reporting among employees. These questions also measure how often employees engage in "pencil whipping" (Ludwig, 2014). Items on the culture survey used to assess employee participation include:

My supervisor responds quickly to solve problems when safety issues are reported

Supervisors have us report safety-related issues to keep people safe, instead of using them solely as a performance measure

I report all minor injuries

I report all near misses

I find the forms used to report safety information easy to use

Questions assessing the factor management action on our survey focus on (a) managements encouragement in participation of safety reporting, (b) their ability to resolve

barriers to reporting, and (c) involving workers in all aspects of safety programs (Compagnone, et al., 2020). Items used to assess management action include:

> *My supervisor encourages employees to participate in decisions which affect safety (operating procedures, PPE…)*
>
> *I am involved in safety audits, inspections, and behavior observations on a regular basis.*
>
> *My supervisor regularly asks employees about safety concerns and listens to our ideas*
>
> *My supervisor talks about lessons from incidents and other things we've reported (minor injuries, near misses).*
>
> *Improvements made because of our safety reporting.*
>
> *I help investigate safety incidents and near misses.*
>
> *All incidents that have the potential for serious injury (P-SIFs) are thoroughly investigated with accurate information.*
>
> *There is so much "pencil whipping" (completing the form without doing inspection or observation) that data quality cannot be trusted.*
>
> *Safety audits, inspections, and observations are routinely performed in my work area.*

Administration of Survey

The survey was slightly altered to accommodate the differences of each company including specific plant names, department names, and number of shifts. At Company A, the survey was distributed in an online format. The surveys were kept anonymous by using Qualtrics, survey software provided by Appalachian State University to their staff and students. The survey link was distributed by email and the results submitted to Qualtrics where the research team had access to the data in an anonymous fashion. Company B elected to take the survey in an anonymous paper format. Surveys were distributed to frontline employees and then collected by HR personnel. Once all the surveys were collected, they were sent through the mail to the Psychology Department at Appalachian State University.

Archival Near Miss and Minor Injury

In order to validate the Safety Measurement Culture Survey, the results of the survey were compared to Near Miss and Minor Injury reports archived from Company A and Company B. At Company A near miss and minor injuries are reported electronically and stored in a master database. Company A gave Appalachian State University log in information to their master database which allowed access to their Near Miss and Minor Injury data, all personal identifiers were removed. At Company B near misses and minor injuries are reported to supervisors by frontline workers in a paper format. These reports then travel up the chain of command reaching the safety coordinators who record the data electronically. Near Miss and Minor Injury Data was shared on a mutual Dropbox where all personal identifiers were removed.

Results

Description of the sample

Data collected from company A included 660 survey responses across two divisions which consisted of nine departments. Data collected from company B included 436 survey responses across eleven plants which consisted of 39 departments. A department was included in the final dataset if more than 15 surveys were completed or there was more than 50% participation from the department. Data from companies A and B also included the number of employees per department, number of near misses, first aids, and hazards recorded in the 2020 calendar year (see Table 1).

In the final dataset, there were a total of 627 survey responses subject to analysis. These surveys came from 2 companies consisting of 12 plants and 27 departments. The survey did not collect employee characteristics or demographics. Table 1 contains the mean survey response and standard deviation by department.

Descriptive statistics

A final dataset sample size consisted of 27 departments. Survey response mean and standard deviation for each department can be found in Table 1. In order to account for the small sample size, it was determined that a correlation of 0.30 would be large enough to be deemed as a relationship and that an alpha of 0.10 was large enough to rule out a type one error. After running descriptive statistics, we found Company A contained two departments with outliers in their hazard identifications. These departments recorded more than 300 hazard identifications each. This is more than 9 times the number of hazard identifications recorded by the next highest reported number of hazard identifications and skewed our data.

When these outliers were removed, we discovered there was a positive correlation between the average response on the Safety Measurement Culture Survey and the number of incidents (see Graph 1). This means that as the average survey response increased, the number of incidents also increased, and the survey does not have good criterion-related validity. The correlation was 0.426, with a p-value of 0.027 (see Figure 1 and Table 3).

Hypothesis Testing

In order to create our criterion variable, we aggregated near misses, first aids, and hazards. To have a normalized value, this variable was divided by the number of employees in each department. Because of the small sample size, the data was skewed.

After running a Spearman's Rho correlation, we saw Questions 6, 11, and 15 had correlations over .30 and p-value less than 0.10 when correlated with an aggregate of recorded near misses, first aids, and hazards (see Table 2, Figures 2-4). This means that questions 6 (*My supervisor encourages employees to participate in decisions that affect safety*), 11 (*I help investigate safety incidents and near misses*) and 15 (*When we report safety issues it helps*

prevent potentially serious injuries), may represent the most valid questions within the Safety Measurement Culture of an organization due to their relationship with actual counts of reporting across our participating departments. It does suggest that removing the twelve questions on the survey that did not have a strong correlation should be considered as they are not predictive of safety measurement culture.

Discussion

The aim of this study was to determine whether or not the Safety Measurement Culture Survey has construct validity in that it shows a relationship with the variables it attempts to predict (i.e., safety reporting). Our findings marginally support our first hypothesis that there would be a significant positive correlation between the mean measurement culture survey response and an aggregate of near-miss, first aid injuries, and hazards divided by employees as three of the fifteen questions have a strong correlation and twelve of the questions did not have a strong correlation.

The particular questions that had a statistically significant correlation seem to involve critical path that produce safety reporting. These involved the prompting of safety reporting by supervisors (question 6), employee participation in following up on near misses and incidents (question 11), and the perception that reporting reduces injuries as an outcome (question 15). These questions also show a working relationship between management and employees in using reporting to improve safety.

Question six asks whether supervisors are encouraging employees to participate in safety decisions. When employees are encouraged to participate in safety decisions it increases their ownership of safety interventions (Occupational Safety and Health Administration, 2020). Question eleven asked if employees help investigate incidents and near misses. In order to help

investigate an employee must have an understanding of factors that lead to an incident or near miss. When combined with question six employee's unique perspective of the causes of incidents and near misses more appropriate action can result from the collaboration between supervisors and employees. Finally, question fifteen suggests a perceived link between reporting safety issues and the prevention of serious injuries. If employees believe reporting helps prevent injury, they are more likely to participate in safety reporting. It also indicates that employees trust management to take their reports seriously and values their input.

Our second hypothesis, testing the content validity of the survey, was that higher average survey response would be negatively correlated with the number of incidents. However, this hypothesis was not supported (See Figure 1). This hypothesis was based on the idea that a higher average response on the Safety Measurement Culture Survey would indicate a strong safety measurement culture, thus a decreased number of incidents. However, a strong safety measurement culture could lead to increased reporting of incidents even when they are minor. This would result in a positive correlation between average Safety Measurement Culture Survey response and number of incidents as we saw in our study.

Limitations

This study did encounter some potential limitations, most notably the low sample size (n = 27) of our participating departments. This can lead to range restriction and skewed data, which required increasing our p-value to 0.10. Further, the base rates of injuries, thankfully, are quite low and represent further range restriction in our injury analysis. This study enlisted participation from departments across two companies which different work processes and safety reporting practices. This resulted in a somewhat bi-modal distribution across companies and led to the outliers we had to discard. In the future, obtaining a larger sample size would lead to more

reliable results. These samples may be gathered from one, very large organization. However, this may not be feasible as even large organizations have variation in work processes and safety reporting practices. Therefore, future studies should engage more companies in hopes of attaining a full range of variables.

Another potential limitation is the self-selection bias. Each employee was given the opportunity to fill out the Safety Measurement Culture Survey at both company A and company B. However, they were not required. The employees who filled out the survey may be more likely to report safety observations and not represent the true population, skewing the data.

Future Research

Decreasing incidents in the workplace can be difficult, the use of observations and data collection as a part of big data analytics can be useful in the creation of safety decisions and interventions. However, in order for the data collected (such as near misses, first aids, and hazard identifications) to be used to create interventions in a manner that will authentically reduce incident rates, the data must be true to life. Analytics and graphics generated from inaccurate data will be flawed. As a result, decisions based on flawed analytics will be unreliable. Effectively creating a strong safety culture, especially when battling against a poor safety measurement culture, can feel like an uphill battle. However, if done properly, the results can decrease the number of incidents, improve productivity, decrease time and money lost due to injury, and much more. Questions 6, 11, and 15 from the Safety Measurement Culture Survey can help companies determine the status of their Safety Measurement Culture and lead to discussion and decisions that will lead to decreased increased safety.

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Table 1:
Descriptives

Plant	Number of Survey Responses	Number of Employees	Near Miss	First Aid	Incidents	Hazards	Mean Response	Response Standard Deviation
B1	24	44	0	10	2	0	3.15	1.00
B2	29	40	4	9	0	0	3.90	0.98
B3	27	72	6	4	3	0	2.82	1.02
B3	26	75	2	4	0	0	3.54	1.18
B3	3	7	0	1	0	0	4.07	0.67
B4	14	62	0	0	0	0	3.15	1.47
B5	9	17	0	0	0	0	3.06	1.22
B6	5	8	0	1	0	0	3.75	1.11
B7	23	29	1	1	0	0	3.45	1.12
B7	13	40	0	3	1	0	3.57	1.07
B7	23	54	1	3	1	0	3.44	1.09
B8	5	12	0	3	0	0	3.31	1.10
B8	10	12	0	3	0	0	2.93	1.20
B8	16	50	2	2	1	0	3.31	1.09
B8	18	55	0	17	0	0	3.61	1.09
B9	21	63	0	1	2	0	3.02	1.23
B9	19	34	2	1	1	0	3.85	1.03
B9	21	133	0	0	0	0	3.70	0.97
B10	37	70	5	0	0	0	3.71	1.17
A1	13	177	0	0	6	28	3.80	1.04
A1	22	38	0	0	0	0	4.18	0.89
A1	26	154	0	0	8	29	4.29	0.88
A1	74	395	0	0	31	41	4.10	0.98
A1	44	187	0	0	5	44	3.98	0.96
A2	18	95	0	0	1	3	4.28	0.86
A2	31	135	3	0	3	425	4.24	0.86
A2	56	337	10	0	8	383	4.13	0.97

Table 2

Correlation matrix between employee reporting (i.e., near miss, first aid, and hazard reporting divided by number of employees) and the average survey response for each questions.

Correlation Matrix

		Aggregate_ees	Avg_Q1	Avg_Q2	Avg_Q3	Avg_Q4	Avg_Q5	Avg_Q6	Avg_Q7	Avg_Q8	Avg_Q9	Avg_Q10	Avg_Q11	Avg_Q12	Avg_Q13	Avg_Q14	Avg_Q15
Aggregate_ees	Spearman's rho	—															
	p-value	—															
Avg_Q1	Spearman's rho	0.159	—														
	p-value	0.429	—														
Avg_Q2	Spearman's rho	0.042	0.550	—													
	p-value	0.834	0.003	—													
Avg_Q3	Spearman's rho	0.092	0.515	0.760	—												
	p-value	0.649	0.006	<.001	—												
Avg_Q4	Spearman's rho	0.119	0.510	0.809	0.811	—											
	p-value	0.554	0.007	<.001	<.001	—											
Avg_Q5	Spearman's rho	0.218	0.305	0.513	0.519	0.688	—										
	p-value	0.274	0.122	0.006	0.006	<.001	—										
Avg_Q6	Spearman's rho	0.397	0.407	0.682	0.565	0.675	0.679	—									
	p-value	0.041	0.035	<.001	0.002	<.001	<.001	—									
Avg_Q7	Spearman's rho	0.217	0.430	0.558	0.601	0.665	0.811	0.710	—								
	p-value	0.278	0.025	0.003	<.001	<.001	<.001	<.001	—								
Avg_Q8	Spearman's rho	0.048	0.324	0.727	0.487	0.693	0.561	0.722	0.679	—							
	p-value	0.813	0.099	<.001	0.010	<.001	0.002	<.001	<.001	—							
Avg_Q9	Spearman's rho	0.318	0.281	0.568	0.368	0.559	0.416	0.771	0.514	0.769	—						
	p-value	0.106	0.155	0.002	0.059	0.002	0.031	<.001	0.006	<.001	—						
Avg_Q10	Spearman's rho	0.286	0.562	0.529	0.509	0.597	0.723	0.744	0.783	0.676	0.628	—					
	p-value	0.149	0.002	0.005	0.007	0.001	<.001	<.001	<.001	<.001	<.001	—					
Avg_Q11	Spearman's rho	0.326	0.417	0.660	0.625	0.779	0.793	0.762	0.846	0.771	0.642	0.846	—				
	p-value	0.097	0.031	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—				
Avg_Q12	Spearman's rho	0.052	0.358	0.544	0.599	0.674	0.778	0.619	0.816	0.711	0.481	0.822	0.845	—			
	p-value	0.798	0.067	0.003	<.001	<.001	<.001	<.001	<.001	<.001	0.011	<.001	<.001	—			
Avg_Q13	Spearman's rho	0.135	0.524	0.630	0.566	0.705	0.685	0.684	0.721	0.558	0.389	0.694	0.822	0.731	—		
	p-value	0.501	0.005	<.001	0.002	<.001	<.001	<.001	<.001	0.003	0.045	<.001	<.001	<.001	—		
Avg_Q14	Spearman's rho	0.232	0.500	0.592	0.567	0.628	0.749	0.755	0.859	0.717	0.604	0.866	0.862	0.819	0.695	—	
	p-value	0.244	0.008	0.001	0.002	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001	—	
Avg_Q15	Spearman's rho	0.330	0.618	0.739	0.578	0.719	0.646	0.694	0.625	0.613	0.539	0.776	0.827	0.658	0.814	0.787	—
	p-value	0.092	<.001	<.001	0.002	<.001	<.001	<.001	<.001	<.001	0.004	<.001	<.001	<.001	<.001	<.001	—

Table 3

Correlation matrix between the average survey response and number of incidents in the 2020 calendar year.

Correlation Matrix

		Average Survey Response	Incidents
Average Survey Response	Pearson's r	—	
	p-value	—	
Incidents	Pearson's r	0.426	—
	p-value	0.027	—

Table 4

Questions that had significant correlations to Safety Measurement Culture and their anchors

Q6: My supervisor encourages employees to participate in decisions which affect safety (operating procedures, PPE…) I'm never asked to decide anything around safety. I never get asked but my supervisor tells us about safety decisions. I get asked for my opinion but I rarely give it. My supervisors encourage my opinion but am not involved in any final decisions. Me and my work team make decisions about our own safety.
Q11: I help investigate safety incidents and near misses. I avoid being involved in investigations because I am afraid I may get in trouble or look stupid.

I don't consider this part of my job. I cooperate with investigations when required. I voluntarily participate in investigations when I think I can help. I encourage my peers to also get involved in investigations of safety incidents.
Q15: When we report safety issues it helps prevent potentially serious injuries. There are serious close calls happening in my department and I have not seen a reduction. It is not something we talk about so I have no idea. I don't think reporting issues is helping one way or the other. In my team meetings, we get told that by reporting issues we have reduced potential serious injuries. My supervisor shows my team information on how our reporting is directly reducing injuries.

Table 5

Definitions, examples, and psychometric information for employee participation and management action.

Factor	Definition	Examples	# of questions in survey	Reliability
Employee Participation	The extent to which employees participate in the process and reporting of safety matters	Reporting of all minor injuries and near misses	5	α = .84
Management Action	Support and encourage employees to participate, includes transparency about the purpose of reporting	Improvements are made because of safety reporting	9	α = .69

(Compagnone, Young, Laske, Foreman, & Ludwig, 2020)

Figure 1:
Scatterplot showing the relationship between number of incidents recorded in the 2020 calendar year per employee's average survey response on the Safety Measurement Culture Survey in the 27 departments of companies A and B.

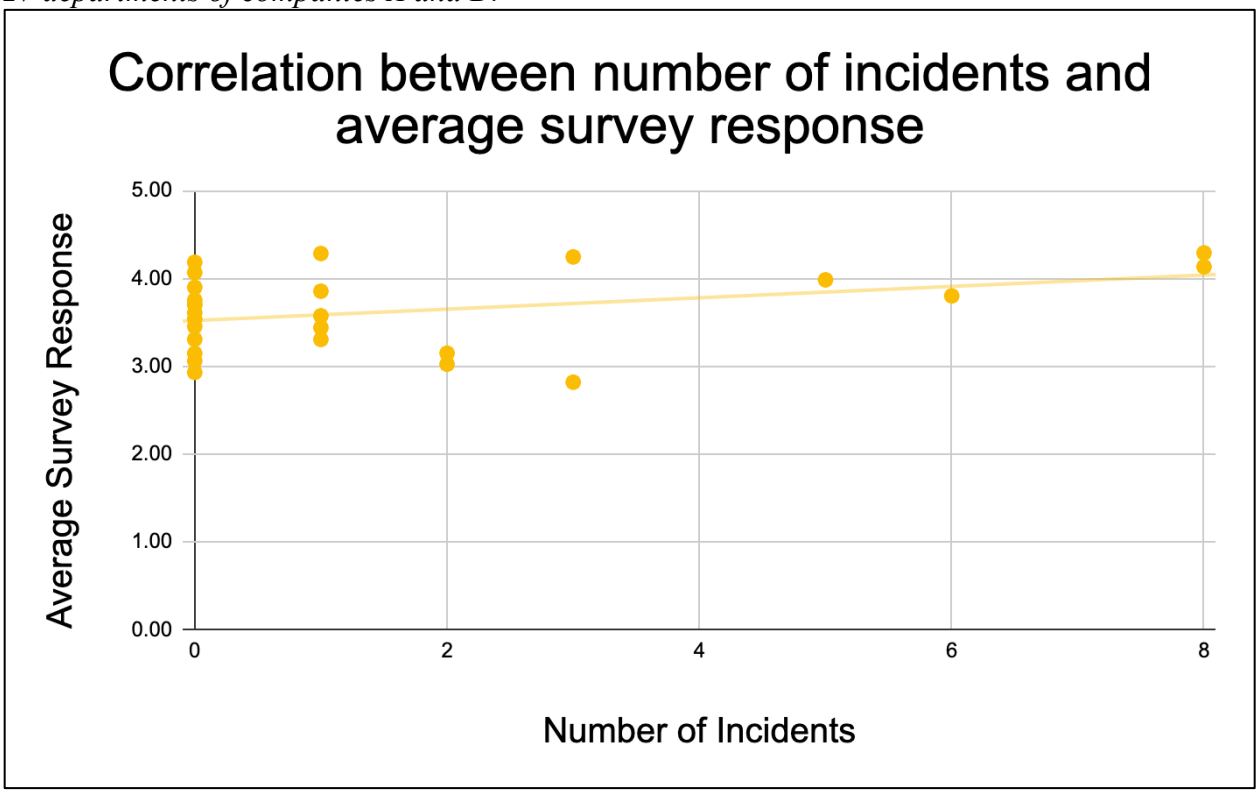

Figure 2:
Scatterplot showing employee reporting (i.e., near miss, first aid, and hazard reporting divided by number of employees) and the average response score for question 6 (i.e., supervisors encourage employees to participate in safety decisions).

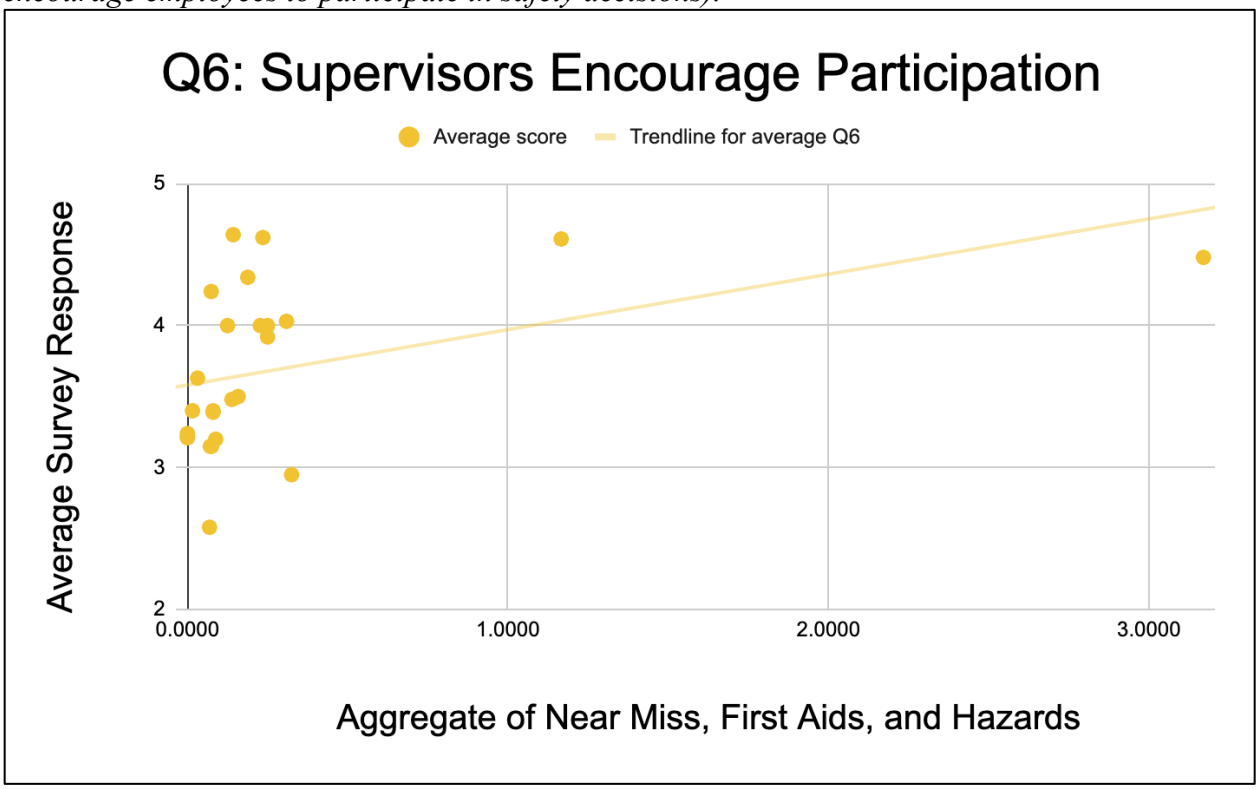

Figure 3:
Scatterplot showing employee reporting (i.e., near miss, first aid, and hazard reporting divided by number of employees) and the average response score for question 11 (i.e., I help investigate safety incidents and near misses).

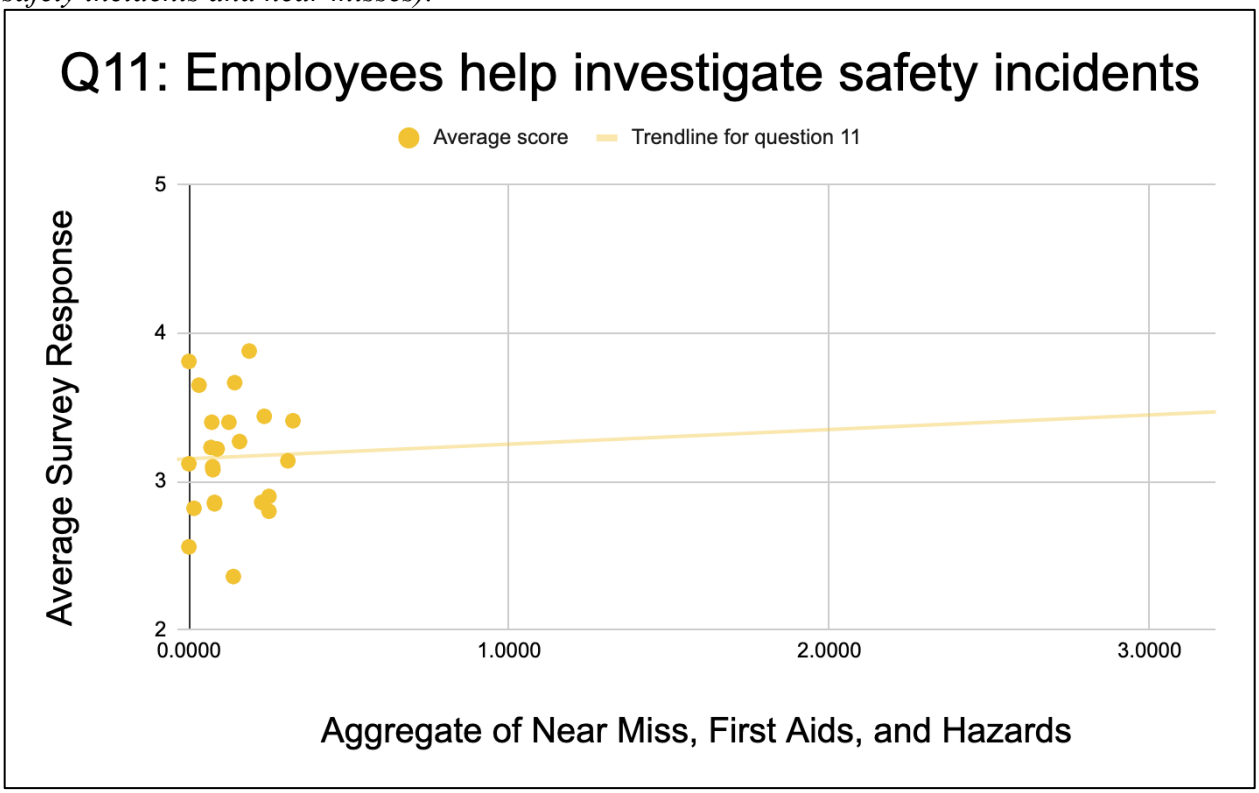

Figure 4:
Scatterplot showing employee reporting (i.e., near miss, first aid, and hazard reporting divided by number of employees) and the average response score for question 15 (i.e., When we report safety issues it helps prevent potentially serious injuries).