"Developing Cultures for Safety & Reliability in Manufacturing Organizations"

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Abstract

The level of safety and reliability achieved by an organization is typically related to its culture and associated organizational, work-unit, and job level factors. This chapter will describe the development and utilization of a diagnostic survey designed to measure variables associated with safety and operating reliability. This chapter profiles results of a multi-year study of approximately 4900 respondents representing sixteen organizations in the wood products, petroleum, pharmaceutical, construction, and chemical industries. Using discriminant analysis, the author describes the development of a predictive model that forecasts the probability of accidents and injuries as a function of six predictive variables.

Safety/Reliability Diagnostics

Since the mid-1980's, The Reliability Group has conducted client studies designed to identify factors associated with industrial accidents, injuries, and losses. Safety performance and operating reliability result from the complex interaction of factors such as supervisory style, job design, communications, and group norms & expectations (the organizational culture).

The foundation for much of the work is the Human Systems Reliability Survey. It is based on research in occupational safety and health as well as more general research in the fields of organizational behavior and human resource management. Theoretical as well empirical work in these disciplines was reviewed in depth and synthesized to provide the framework for the survey.

The survey was originally developed with the following objectives in mind:

- Simple to use and interpret without special training.
- Objective, quantitative and scientifically valid
- Easily modified for specific industries and situations.

The instrument measures variables at multiple levels of analysis considered to be relevant to a culture of safety and reliability:

- Organizational variables including such factors as management's commitment to safety, vertical communication, the distribution of influence, inter-unit coordination and human resource management practices (e.g., training & development, performance appraisal);
- Work-unit characteristics including intra-group and inter-group factors (such as cooperation and teamwork, work group efficacy, and cross-job knowledge), supervisory dimensions (such as supportiveness and goal emphasis), and physical and ambient characteristics of the work place (such as physical conditions, psychological climate, quality and appropriateness of equipment);
- Job-level factors including task characteristics (e.g., variety and autonomy), role characteristics (e.g., overload, clarity, consistency), and affective reactions (e.g., involvement and challenge).
- Safety-related factors (incidence of "near misses" or "close calls," accident investigation procedures, and employee recognition).

Approximately 120 variables are measured. A typical survey takes about 30 minutes to complete. Respondents are asked to anonymously respond to written multiple-choice questions. Many of the survey 'scales' are created by using responses to a series of two or more questions. For instance, "job involvement" is measured by first asking respondents the degree to which their jobs are meaningful (positive question), and also asking them the extent to which money is their main interest for working (negative question).

The majority of the items and scales selected for the survey have been field tested and analyzed with respect to their basic psychometric properties. To the extent possible, each item and scale has been statistically analyzed to determine its reliability (internal consistency and/or inter-rater) and validity (concurrent criterion-related) with respect to safety, employee health and well-being, and other criteria of organizational effectiveness.

Analysis

The data set used in this analysis consists of 4872 respondents representing sixteen organizations in the wood products, petroleum, pharmaceutical, construction, and chemical industries. A key component in the analysis was that respondents were asked if they had experienced an on-the-job injury.

Approximately 12 percent of the respondents in this study reported experiencing a work-related injury in the three-year period preceding the administration of the survey.

Discriminant analysis was used to predict the likelihood of experiencing a job-related injury (the dependent variable) as a function of several independent variables. Linear combinations of the independent, or predictor, variables were formed and served as the basis for classifying cases into one of two groups: those who are at risk for job-related injuries and those who are not. Predictor variables are determined that are then used to classify cases whose group is unknown.

For the study data set, discriminant analysis yielded six predictor variables for injuries. The model classified cases correctly 86% of the time. The six variables were:

- the occurrence of 'near misses'
- the adequacy of equipment inspections
- job challenge
- job satisfaction
- the extent to which work groups have the authority to make decisions without consulting superiors (group autonomy)
- workload

Statistical results are detailed in Figure 1. For each of the six predictor variables, the mean value for respondents who sustained injuries was less positive than those who were injury-free. All variables (except near misses) were measured using a scale from 1 to 5 (5 is most favorable). The "F" value listed in Table One is the extent of variation within groups (injury and no injury) divided by the extent of variation across groups. The higher the "F" statistic, the less likely that the differences across these groups were due to chance. Significant statistical differences (at a .0001 level of significance) exist between the injury/no injury groups for all six predictor variables in Figure 1.

The output of the discriminant model is a value that can range from slightly over 4.0 (the most positive score) to minus 4.99 (the most negative score). These extreme values have never occurred in actual surveys. To date, the most positive respondent in the data set (considering only the six predictor variables) had a score of 3.04, which equated to a .0074% probability of being injured at work (less than one percent).

On the other hand, the most negative respondent had a score of -3.27, which equated to a 77% probability of injury! Thus the probability of injury ranges from under 1% to 77%, depending on the specific values of the predictor variables.

Discussion of Predictive Factors

"Near misses" or "close calls" – On average, respondents who experienced a near miss (an accident or injury that almost happened) were two and one-half times as likely to also be injured at work (the probability of sustaining an injury increases from 10% to 25% for respondents who experienced a near miss).

The occurrence of near misses is typically the single most-important predictor of injuries in studies conducted to date. In this analysis, near misses exhibited the highest correlation of any predictor variables with the output of the model (0.61).

Job Satisfaction – Respondents who sustained job-related injuries reported significantly lower levels for job satisfaction (3.1) than did injury-free respondents (3.7). This scale is determined in part by asking workers if they would recommend their job to a close friend. Other factors being equal, the probability of job-related injury increases from 8% to 26% as job satisfaction varies from high to

low (respectively). Job satisfaction had the second-highest correlation of the predictive variables with the discriminant function (0.56).

While low levels of job satisfaction contribute to injuries, it is also possible that a percentage of injured respondents reported a lower level of job satisfaction as a result of being injured. From a practical viewpoint, the direction of the causality is less important than the level of job satisfaction – top-performing organizations (from a safety and reliability perspective) typically have significantly higher levels of job satisfaction than average organizations.

Job Challenge -- Respondents who sustained job-related injuries reported significantly lower levels for job challenge (3.0) than did injury-free respondents (3.6). The scale is determined in part by asking respondents if their job lets them use their skills and abilities. Other factors being equal, the probability of job-related injury increases from 10% to 17% as job challenge varies from high to low (respectively).

Equipment Inspections -- Respondents who sustained job-related injuries reported significantly lower levels for the adequacy of equipment inspection (2.8) than did injury-free respondents (3.1). Other factors being equal, the probability of job-related injury increases from 3% to 47% as the scale varies from 'frequently inspected' to 'ignored unless broken.'

Work Load Appropriateness – Work load appropriateness is the extent to which the employee receives the proper amount of work so that he/she can do everything well and carefully. Respondents who sustained job-related injuries reported significantly lower levels for the appropriateness of their work load (3.3) than did injury-free respondents (3.5). Holding other factors constant, the probability of job-related injury increases from 11% to 16% as work load appropriateness varies from high to low (respectively).

Work Group Autonomy – Work group autonomy is the extent to which work group members have sufficient autonomy and authority to make necessary decisions. Respondents who sustained job-related injuries reported significantly lower levels for autonomy (3.3) than did injury-free respondents (3.4). On average, the probability of job-related injury increases from 7% to 28% as work group autonomy varies from high to low (respectively).

A Client Example

The model described in this paper demonstrates how risk levels can change dramatically as key predictor variables are changed. Various versions of the survey have been used in client organizations to promote reliability and reduce job-related injuries.

One case involved a major multi-state wood products company consisting of 7,000 workers in plywood, chip and saw mill operations. Prior to the intervention, the client reported 48 lost-time cases that resulted in about 2000 lost work days due to accidents.

A version of the survey was anonymously given to employees, supervisors, and managers. Although the results of the first survey were fairly positive, many of the responses indicated that the safety systems at the company were not working nearly as smoothly as managers believed. Approximately 46% of the workers reported that they had experienced a 'near miss' during the past three years.

In addition to differences across organizational level, researchers found significant differences between groups of employees at different locations. In one example, managers reported that they were careful to praise good work, while employees reported that their hard work was hardly noticed. Company leaders agreed that employees' perceptions were the bottom line. "If that's what the employees see, that's reality," remarked a company official. "We could argue all day about what our intent was, but this is reality." The following recommendations were reported to employees via newsletter:

- Individual and group recognition for good safety performance should be improved.
- Supervisors should spend more time helping subordinates complete their work, while also encouraging teamwork and communication.
- Management should develop ways to allow employees more authority and autonomy. Less

emphasis should be placed on authority and more on coaching.
- Equipment inspections should be improved.
- Employees should be encouraged to identify near miss situations.

A division vice-president remarked “the survey is an important tool to begin the process of reducing accidents and worker’s compensation costs. The consultant offered specific actions. We’re going to implement them all.”

A safety recognition program was developed. Management publicized safety accomplishments and held award dinners for individual and group safety accomplishments. In another example, a task force of workers addressed the common perception that injuries were inevitable. Workers designed and produced their own safety training video for their co-workers in which they showed how to minimize the chance of injury.

Work groups were given more job autonomy by allowing them to do things that were previously done by others, such as accident investigations and safety inspections. Rather than listening to presentations given by their supervisors, workers began conducting their own safety meetings. Revamped safety committees were created as volunteer groups comprised of both management and hourly workers. These groups help employees resolve issues that can’t be resolved at the work group level.

When the organization was re-surveyed a year later, employees reported improved scores across many of the survey dimensions. The number of ‘near misses’ was one-half the level reported a year earlier, and the accident rate had decreased significantly.

The concept of self-managing work teams was continued, and workers increased their confidence in their ability to make a difference. Hourly workers began taking an active role in planning for new equipment. They attended trade shows, visited other facilities, and forwarded recommendations to management.

Safety performance became a key objective for all supervisors and managers. Supervisors' overall ratings could be no higher than their rating for safety performance, regardless of how well they did in meeting production goals.

A hiring board comprised of hourly employees, supervisors, and personnel managers interviewed all prospective employees. New employees receive two weeks of on-the-job training. To keep their job, the worker needs the approval of his/her teammates.

Three years after the first survey, the number of lost time cases due to accidents decreased 76% while the number of lost work days decreased almost 90% over the same time period (Figure 2).

Conclusions

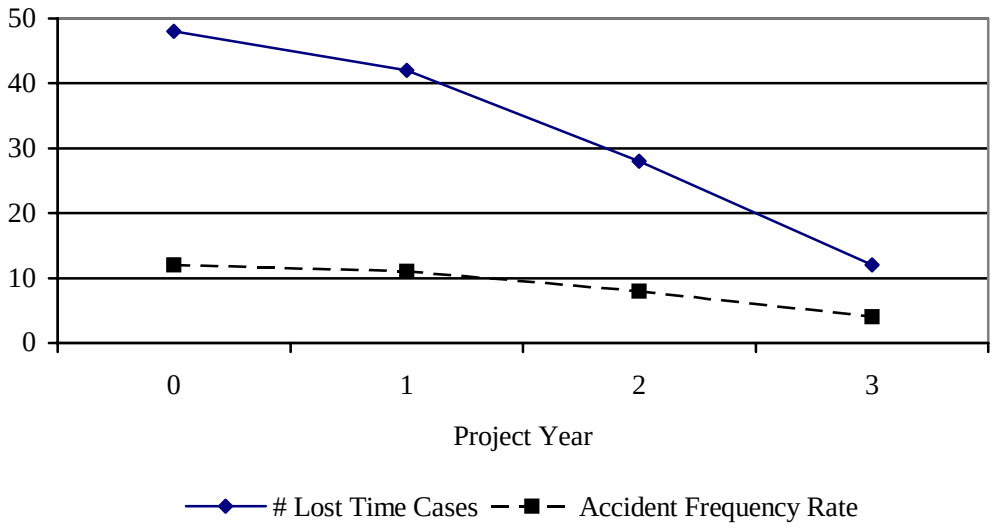
As this case study demonstrates, an organization’s safety and operating reliability can be significantly improved through change programs guided by diagnostic surveys. It should be further noted that predictor variables typically vary as a function of industry, organization, and product line. Further, it is not unusual for safety-related variables to change over a three to four year period at a specific site, as the culture of the organization evolves. The dynamics of these relationships dictate that a comprehensive re-evaluation occur periodically. In spite of the inherent complexity of human-based systems, the application of an appropriate quantitative diagnostic can yield positive results in both safety and operating reliability.■

Figure 1

Variable	Accidents (n=604)		No Accidents (n=4268)		F[3]	Correl.[4]
	Mean	Std. Dev.	Mean	Std. Dev.		
Near Misses[2]	2.06	1.0	2.59	.84	206.95	.605
Equipment Inspections[1]	2.83	.51	3.1	.55	134.50	.558
Job Challenge[1]	3.02	1.24	3.6	1.18	127.27	.513
Job Satisfaction[1]	3.05	1.17	3.37	1.08	44.45	.564
Autonomy and Authority[1]	3.3	.32	3.38	.38	27.85	.238
Workload Appropriateness[1]	3.29	1.15	3.48	1.11	14.63	.281

[1] Scale ranges from 1 to 5 (5 is most favorable)
[2] 1=near miss; 3=no near miss
[3] F-statistics for all ANOVAS are significant at p<.0001
[4] Correlation with the discriminant function

Figure 2
Number of Lost Time Cases & Accident Frequency Rate



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