

THE INFLUENCE OF TRAINING, SAFETY AUDITS, AND DISCIPLINARY ACTION ON SAFETY MANAGEMENT

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ABSTRACT

This study examined crucial factors affecting industrial safety indicators. A survey was conducted to explore factors affecting total recordable incident rates and lost time incident rates. The number of safety audits and the natural log of safety infraction disciplinary action had a negative impact on the natural log of recordable incidents and the lost time incident rates while the number of training hours was an insignificant factor. Thus, the finding regarding training is contradictory to a belief that the number of training hours is an important factor in reducing recordable incident and lost time incident rates. These results should assist companies as they strive to focus on significant factors such as safety audits and disciplinary action in order to improve recordable incident and lost time incident rates, thus improving the safety performance of the organization.

INTRODUCTION

A safe workplace environment can improve labor productivity, reduce insurance premiums, and enhance the company's ability to compete in a global market. The U.S. Bureau of Labor Statistics-IIF (2006) provides data on workplace recordable injuries and fatalities via the Injuries, Illnesses, and Fatalities program. In 2006, fatalities in the U.S. totaled 5,703. Private sector cases accounted for 5,202 of these fatalities. Total recordable incidents tallied 4,085,400. Of these cases, 1,183,500 involved lost workdays. Workplace injuries and illnesses are costly in financial and human terms.

Safety professionals and supervisors experience frustration over the perceived conflict that exists in the organization between spending time on safety training and meeting production requirements. To fulfill required safety training requirements and to conduct safety audits, the organization in part or in total ceases production. Thus, there exists an opportunity cost to safety compliance and injury prevention. To achieve and attempt to sustain a competitive edge in today's global market, safety training (a cost of goods sold) falls under scrutiny.

This research specifically sought to answer whether safety audits, training hours, and disciplinary actions for safety infractions had a significant impact on the Total Recordable Incident Rate (TRIR) and Lost Time Incident Rate (LTIR). Identifying key factors that affect these rates enables organizations to enhance their safety management and to optimize the allocation of organizational resources.

REVIEW OF RELATED LITERATURE

According to Hurn (2007), a challenge remains for the organization in the area of safety management as even one fatality is too high. In recent years, many safety practitioners have adhered to a concept that the safety culture of an organization and its safety metrics are influenced by behavioral based safety. In practice, the behavioral theory of accident causation

and prevention has both proponents and critics (Goetsch, 2002). Agraz-Boeneker, Groves, and Haight (2008) concluded that no relationship had been found between observations of the behavioral based safety program and incidence occurrence.

A data-based evaluation of the relationship between occupational safety and operating performance (Veltri, Pagell, Behm & Das, 2007) confirmed that performance in safety can have a positive influence on the firms' overall performance. The results support anecdotal evidence that safety is good business. Therefore, the following sections of this paper will investigate determinants of safety indicators. Relevant literature is presented below.

The total number of injuries cannot be used alone as a safety metric as this does not account for size of business. Both the Occupational Safety and Health Administration (OSHA) and Bureau of Labor Statistics use TRIR and LTIR rather than numerical totals. Major corporations, such as BP Amoco, require contractors to have a TRIR of less than 2.0 in order to perform work for them (British Petroleum, 2008). Low TRIR results indicate safety management has successfully held serious incidents to a minimum. On the other hand, LTIR recognizes the absenteeism attributed to workplace injuries and illnesses. Illness in this regard means occupational illness due to workplace exposures. The TRIR and LTIR are reported in annual reports of companies across the globe as indicators to shareholders of organizational safety. Goetsch (2002) shows how these indicators are derived.

(1) $TRIR = N \times 200,000/T$, where:

N = the total annual number of incidents (work-related injuries, illnesses, and fatalities) that required more than first aid and were listed on the company's OSHA 300 log, and

T = the total hours worked by all employees.

(2) $LTIR = N \times 200,000/T$, where:

N = lost time incidents when employees must be off of work for treatment and recuperation, and

T = the total hours worked by all employees.

Safety audits. The Hartford Loss Control Department (1998) indicated that an effective safety audit is a tool that can be used by management to uncover safety and health problems before losses occur. In order to be effective, the audit must be supported by senior management. Audits should be continuous and aligned with the day-to-day operations of an organization. An ongoing audit process is a mechanism by which management can obtain measurable and meaningful data about the organization's safety and health programs. In contrast, a single audit is ineffective in that it only provides a snapshot of the overall status of safety and health programs. This link was established between aviation safety and human factors when the Line Operations Safety Audit of the U.S. Federal Aviation Administration was introduced in 1999 as the first safety audit program to derive all of its information from daily operations (Maurino, 2002).

Training hours. In the past, justification for safety training was not needed because most of the training that was conducted was required by law (Petersen, 1996). Safety training was a necessary burden a company must bear. According to Hart, Newmann, and Veltri (2008), rather than a burden, safety training is now viewed not only as the proper way to conduct business, but also as a method to enhance business. Goetsch (2002) stated one of the best ways to promote

safety in the workplace is to provide all employees with ongoing safety training. Initial training should be part of employee orientation and subsequent training should develop new, more specific, and more in-depth knowledge. In contrast, a study conducted by the American Transportation Research Institute in 2008 found no correlation between training duration and safety performance utilizing a logistic regression model. The findings indicate the need for further research on training hours and safety.

Safety infractions and disciplinary action. According to Johnson (2004), safety professionals still agree with the federal OSHA's voluntary guidelines for safety adherence. These guidelines stated that a clearly communicated disciplinary system is an indispensable piece of a whole approach to safety and health protection. However, organizations may be reluctant to doll out discipline for safety infractions. Legal and image issues persist, as well as the existence of some safety professionals who now believe in positive strokes rather than punitive discipline.

HYPOTHESIS

Based on the above discussion, it seems plausible to expect a relationship that industrial safety indicators such as Total Recordable Incident Rate (TRIR) and Lost Time Incident Rate (LTIR) are affected by the number of safety audits conducted in a year, number of training hours provided by the company and the disciplinary action against an employee's safety infraction. Furthermore, the number of safety audits, training hours, and safety infraction disciplinary actions are expected to have a negative impact on both safety indicators. This means an increase in the number of safety audits, training hours, and safety infraction disciplinary actions reduces the total recordable incident rates and lost time injury rates, and vice versa.

For empirical analysis, the models have been constructed as shown below:

$$\text{Model 1: TRIR} = \text{CONSTANT} + b_1 \text{SAFEAUDI} + b_2 \text{TRNGHRS} + b_3 \text{SAFDISP1} + b_4 \text{SAFDISP2} + b_5 \text{SAFDISP3} + u_i$$

$$\text{Model 2: LTIR} = \text{CONSTANT} + b_1 \text{SAFEAUDI} + b_2 \text{TRNGHRS} + b_3 \text{SAFDISP1} + b_4 \text{SAFDISP2} + b_5 \text{SAFDISP3} + u_i$$

Description of the variables is summarized in Table 1. u_i is a stochastic error term or disturbance term.

[Insert Table 1 about here]

DATA AND METHODOLOGY

According to Frazee, Hardin, Brashears, Smith & Lockaby (2002), researchers should be encouraged to incorporate computer technology into their surveys. Data was obtained from a survey conducted in late 2007 utilizing an online survey tool, QuestionPro™. The survey was completed by safety professionals across the United States through national and regional websites of the American Society of Safety Engineers (ASSE). In addition, the survey was also distributed to companies listed on ISNetworld's national database where contractors store safety program information. The respondents in this sample emanated from nearly all states

representing major industry groups such as construction, energy, manufacturing, scientific professional and petroleum refining. Because respondents were widely dispersed, no geographical bias is expected. The survey completion rate was about 38 percent or 309 out of 814 contacts.

Researchers have determined that, while there were no significant differences in reliability of responses, there were significant differences in response rates based on mode of collection. Traditional paper surveys yielded the high response rate at 60 percent with a significant drop to the web surveys at 43 percent, along with another significant decline to the e-mail surveys at 27 percent (Fraze, Hardin, Brashears, Smith & Lockaby, 2002). Furthermore, Zoomerang (2008), A MarketTools Inc. Company, provides a chart of 10,000 sample size requiring 370 responses for a 95 percent confidence level. Based on this fact and with a sample size substantially less than 10,000 potential respondents, the 309 responses in this study are sufficient.

Table 2 provides descriptive statistics of the Total Recordable Incident Rate (TRIR), Lost Time Incident Rate (LTIR), and training hours. These are scale variables where differences between values are comparable. The table shows a mean TRIR of 1.3. For comparison, the Bureau of Labor Statistics Table Q1 (2006) reported total incident rate of 5.9 for the construction industry while large petroleum and petroleum products wholesalers averaged 2.7. The LTIR mean is relatively low at 0.43. The maximum annual training hours reported was 670 with an overall average of about 50 hours. Potential huge outliers that may cause problems in the regression model are detected. For example, t-values are calculated for training hours. Histogram chart, skewness and kurtosis statistics are obtained. There are only three omitted outliers out of 14 expected candidates based on the five percent confidence level and standard deviation greater than or equal to plus or minus five.

The number of safety audits and safety infraction disciplinary action are continuous ratio variables which make them ordinal variables with natural order (see descriptions in Table 1). Their frequencies are reported in Table 3. When asked how many safety audits were conducted in a year, 37.08 percent or 109 out of 294 valid cases indicated 21 or more. Regarding disciplinary action for safety infractions, 55.83 percent or 158 out of 283 manufacturers terminated employment after an employee committed the third safety infraction.

[Insert Table 2 & 3 about here]

The Ordinary Least Square (OLS) method was employed to test the above hypotheses. One of the tasks in performing regression analysis with several independent variables was to calculate a correlation matrix for all variables. There were no particularly large intercorrelations among independent variables. However, a measure of multicollinearity among independent variables would be performed.

EMPIRICAL RESULTS

The assumption of linear multiple regression and the fitness of the model was tested. According to the computed values of a multiple regression model, the null hypothesis was rejected at a significant level of less than 0.01 (F test) in Total Recordable Incident Rate model (TRIR). This means that there existed a relationship between TRIR and the explanatory variables; the number of safety audits, training hours and safety infraction disciplinary actions.

The coefficient of multiple determination (R Square) in Table 4 was relatively low. Note that R Square is a measure of goodness of fit. R Square of zero does not mean that there is no association among the variables (Norusis, 1993). It simply indicates no linear relationship. The logarithmic transformation is useful to linearize the regression relation (Neter & Wasserman, 1974). Therefore, variables were transformed into natural logarithm which improves the value of the R Square. Training hours and the first two safety infraction disciplinary actions had no significant influence on both industrial safety models. As a result, they were omitted from the logarithmic models. The final results are shown in Table 5. The value of the R Square is improved when recordable incidents (dependent variables) and the third safety discipline were transformed into natural logarithm. For example, the R Square of TRIR model increases 200 percent from 0.04 to 0.12. Other similar published articles that show low R Squares are from Brahmairene and Smith (2008) at 0.1, and Lampert (2007) at 0.05. The F test shows significant level of less than 0.01 in all models. The Variance Inflation Factor (VIF) is also presented to detect multicollinearity among independent variables. A value of VIF less than 10 generally indicates no presence of multicollinearity. It appears that the observed dependencies did not affect their coefficients.

Furthermore, the significant test (t-test) for both industrial safety models in Table 5 indicated that the number of safety audits was significant ($\alpha < 0.05$) for the natural log of total recordable incident rates (LNTRIR) and on lost time injury rates (LNLTRIR), all with expected negative signs. The natural log of the third safety infraction disciplinary action (LNSAFDISP3) had a highly significant t-value ($\alpha < 0.01$) on LNTRIR and significant at $\alpha < 0.05$ on LNLTRIR, all with expected negative signs.

[Insert Table 4 & 5 about here]

DISCUSSION

The variable training hours (TRNGHRS) proved to be in conflict with a common industry perception that if an organization invests in training, they should experience organizational benefits (McCardle, 1999). In this application, safety training should have reduced the recordable incident rate. Many Occupational Safety and Health (OSH) standards require annual training in the industrial environment. Thus, to meet regulatory requirements, a facility schedules a significant amount of safety training that is based on compliance, not on business justification or needs assessment. This precipitates the reaction of organizations to train, for training sake and diminishes optimal resource allocation (investment in training).

Safety audits (SAFEAUDIT), are encouraged by insurance companies, risk management groups and the Occupational Safety & Health Administration (OSHA). Audits are significant with respect to a reduction in recordable incidents. This means that an increase in the number of safety audits has a propensity to reduce total recordable incident rates and lost time injury rates for a firm. Many companies evolve their safety audit practices over time, as they build their knowledge base and comfort level with the auditing process. When recordable incidents occur, organizations audit post-event to prevent future occurrences. Thus, when a company implements a proactive safety auditing program in addition to reactive safety audits, the recordable incident rates may further decline.

When employees commit a safety infraction, companies take disciplinary action whether it is the first (SAFDISP1), second (SAFDISP2) or third (SAFDISP3) safety infraction. Only the

third safety infraction disciplinary action is highly significant and inversely related to recordable incidents. Disciplinary actions varied from do nothing, verbal warnings, or written warnings to more severe actions such as time off and termination. This finding confirmed that disciplining employees for safety infractions is an effective tool to reduce incident rates at the third occurrence. This may be because 34 percent of surveyed companies indicated time off while 56 percent of the organizations terminated employment in the third safety infraction (Table 3).

CONTRIBUTIONS

This paper makes important contributions in the literature of industrial safety management. Contradictory to a popular belief that the number of training hours is an important factor in reducing recordable incident and lost time incident rates, this study found training hours to be an insignificant factor. This supports the finding of the American Transportation Research Institute in 2008. The number of safety audits had a negative impact on recordable incident rates as well as safety infractions at the third occurrence of disciplinary action. These results should affirm the importance of safety audits and disciplinary actions for safety infractions. In light of this research, organizations are encouraged to scrutinize their safety training program for content, time dedicated for topic delivery, and business justification.

MANAGERIAL IMPLICATIONS

In regard to safety audits, it is important for organizations to realize that an increase in the number of audits significantly reduces recordable incident rates. Thus, safety audits remain a critical component of effective safety management. The third stage of employee discipline was a significant factor with heavy emphasis on time off and termination (90 percent of surveyed companies). As a result, an organization that implements a discipline policy which includes time off or termination for safety infractions should realize a reduction in total recordable incident and lost time incident rates.

CONCLUSIONS

Enhancing organizational performance is a cornerstone of achieving global competitiveness. The implementation, maintenance, and improvement of safety, health, and environmental programs are of significant importance to this country as the economy of the United States moves toward a more global perspective. American Society of Safety Engineers (2002) affirms that such programs positively impact all Americans. As an organization adopts a comprehensive and strategic approach to safety management and moves away from training for compliance, strategic business advantages should be realized. The firm, which understands the importance of safety auditing and implements an aggressive discipline policy for safety infractions, should realize substantial reductions in total recordable incidents and lost time incident rates in the workplace. Obtaining a global competitive edge is a challenge. Maintaining this position is subsequently more difficult. Companies which implement the findings determined within this study have an opportunity to link safety audits and discipline actions to strategic organizational goals, thus, optimizing the profitability and sustainability of the firm.

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REFERENCES

Agraz-Boeneker, R., W. Groves, & J.M. Haight (2008). An Examination of Observations and Incidence Rates for a Behavior Based Safety Program. *Journal of SH&E Research*, 5(1).

American Society of Safety Engineers (2002). *White Paper Addressing the Return of Investment for Safety, Health, and Environmental Management Programs*. Des Plaines, IL: ASSE.

American Transportation Research Institute (2008). *A Technical Analysis of Driver Training Impacts on Safety*. Arlington, VA: ATRI.

Brahmasrene, T. & S. Smith (2008). Empirical Evidence of Factors Affecting Experience Modification Rate Used by the U.S. Insurance Industry. *Journal of Transnational Management*, Volume 13, Issue 3, 2008.

British Petroleum (2008). *Health, Safety, Security & Environment Resources for BP Suppliers*. Retrieved October 16, 2008, from <http://gomcontractors.bp.com/html/common/trir.html>.

Bureau of Labor Statistics, IIF Program, *Injuries, Illnesses and Fatalities (2006)*. Retrieved February 14, 2008, from <http://www.bls.gov/iif/home.htm#tables>.

Bureau of Labor Statistics, *TABLE Q1: Incidence Rates of Total Recordable Cases of Nonfatal Occupational Injuries and Illnesses by Quartile Distribution and Employment Size, Private Industry (2006)*. Retrieved February 29, 2008, from <http://www.bls.gov/iif/oshwc/osh/os/ostb1769.txt>.

Fraze, S., K. Hardin, T. Brashears, J. H. Smith, J. Lockaby. (2002). The Effects of Delivery Mode Upon Survey Response Rate and Perceived Attitudes of Texas Agri-Science Teachers. Retrieved October 14, 2008, from <http://www.depts.ttu.edu/aged/research/frazesurvey.pdf>.

Goetsch, David (2002). *Occupational Safety and Health for Technologists, Engineers, and Managers*. Upper Saddle River, NJ: Pearson Education.

Hart, M., C. Newmann, & A. Veltri (2008). Hand Injury Prevention Training: Assessing Knowledge, Attitude and Behavior. *Journal of SH&E Research*, 5 (1).

Hartford (1998). *The Safety Audit: A Management Tool*. The Hartford Loss Control Department. Retrieved October 16, 2008, from <http://www.relmark.net/losscontrol/workerscomp/The%20Safety%20Audit%20-%20A%20Management%20Tool.pdf>.

- Hurns, D. (2006). President's Comments on 2006 Fatal Workplace Injury Statistics. *American Society of Safety Engineers*. Retrieved February 17, 2007 from <http://www.asse.org/newsroom/presskit/docs/fatality2006statsnews8907.doc>.
- Johnson, D. (2004). In Search of Discipline. *Industrial Safety & Hygiene News (ISHN)*, Retrieved October 16, 2008, from http://www.ishn.com/Articles/Feature_Article/1db8b216b70c7010VgnVCM100000f932a8c0.
- Lampert, N. (2007). Critical Thinking Dispositions as an Outcome of Undergraduate Education. *Journal of General Education*, 56 (1), 21-28.
- Maurino, D. (2002). The LOSA Experience: Safety Audits on the Flight Deck. *International Civil Aviation Organization Journal*, 57(4), 5-31.
- McCardle, Geri (1999). *Training Design and Delivery*. Alexandria, VA: American Society of Training and Development Press.
- Neter, John & William Wasserman (1974). *Applied Linear Statistical Models*, Homewood, IL: Richard D. Irwin, Inc.
- Norusis, Marija J. (1993). *SPSS for Windows Base System User's Guide Release 6.0*. Chicago, IL: SPSS Inc.
- Petersen, D. (1996). *Analyzing safety system effectiveness*. New York: International Thomson Publishing Company.
- Veltri, A., M. Pagell & M. Behm (2007). A Data-Based Evaluation of the Relationship between Occupational Safety and Operating Performance. *Journal of SH&E Research*, 4(1).
- Zoomerang (2008), *Pro Online Surveys from A Market Tools Inc. Company*, Retrieved October 14, 2008, from, <http://www.zoomerang.com/online-panel/sample-size.htm>.

Table 1 Description of Variables	
<i>Dependent variables</i>	
TRIR	Total Recordable Incident Rate
LTIR	Lost Time Incident Rate
<i>Independent variables</i>	
SAFEAUDIT	Number of safety audits conducting in a year 1 = 0 2 = 1-5 3 = 6-10 4 = 11-15 5 = 16-20 6 = 21 or more
TRNGHRS	Number of training hours provided by the company
SAFDISP1 SAFDISP2 SAFDISP3	The first, second and third disciplinary action companies took against an employee when they committed a safety infraction. 0 = Do nothing 1 = Verbal warning 2 = Written warning 3 = Time off 4 = Termination

Table 2 Descriptive Statistics					
	N	Minimum	Maximum	Mean	Standard Deviation
TRIR	297	0	13	1.30	2.414
LTIR	275	0	14	.43	1.262
TRNGHRS	276	0	670	49.83	71.125

Table 3 Frequency						
	SAFEAUDIT	SAFDISP1		SAFDISP2	SAFDISP3	
Valid	1	17	.00	4	2	2
	2	105	1.00	220	15	3
	3	24	2.00	66	202	23
	4	29	3.00	1	56	97
	5	10	4.00	2	12	158
	6	109				
	Total	294	Total	293	287	283
Missing	System	15	System	16	22	26
Total		309		309	309	309
Notes	Variables in this frequency table are ordinal variables with natural order. See description in Table 1.					

Table 4 TRIR Model Coefficients		
Coefficients	TRIR	VIF
CONSTANT	2.411*** (.746)	
SAFEAUDIT	.185** (.080)	1.061
TRNGHRS	-.001 (.002)	1.036
SAFDISP1	-.119 (.358)	1.467
SAFDISP2	-.084 (.360)	2.198
SAFDISP3	-.431* (.248)	1.620
R Square	0.04	
F Statistics	2.12*	
Note: t statistics are in parentheses. Significant level : * 0.10, ** 0.05, ***0.01 VIF = Variance inflation factor, a measure of collinearity		

Table 5 Safety Model Coefficients				
Coefficients	LNTRIR	VIF	LNLTR	VIF
CONSTANT	2.388*** (.551)		1.999*** (2.645)	
SAFEAUDIT	-.110** (.050)	1.012	-.163** (-2.165)	1.004
LNSAFDISP3	-1.101*** (.417)	1.012	-1.227** (-2.163)	1.004
R Square	0.12		0.12	
F Statistics	5.37***		5.003***	
Notes: t statistics are in parentheses. Significant level : * 0.10, ** 0.05, ***0.01 VIF = Variance inflation factor, a measure of collinearity				