ASSE ACADEMICS PRACTICE SPECIALTY

VOLUME 9, ISSUE 2 • 2013

Journal of Safety, Health & Environmental Research

THIS ISSUE

AMERICAN SOCIETY OF SAFETY ENGINEERS • www.asse.org

Journal of Safety, Health and Environmental Research ISSN 2168-1368

ASSE ACADEMICS PRACTICE SPECIALTY VOLUME 9, ISSUE 2 • 2013

Journal of Safety, Health & Environmental Research

Mission: The mission of the *Journal of Safety, Health and Environmental Research* (JSHER) is to peer review theoretical and empirical manuscripts, reviews and editorials devoted to a wide variety of SH&E issues and practices.

Scope: JSHER accepts theoretical and empirical papers committed to concepts, analytical models, strategy, technical tools and observational analyses that enhance the decision-making and operating action capabilities of SH&E practitioners and provide subject matter for academics. JSHER is an online journal intended to be of interest to SH&E academics and to field practitioners concerned with SH&E science, emergency and disaster preparedness, fire and homeland security, corporate sustainability and resiliency, economic evaluation of SH&E programs or policies, risk-loss control, engineering and other legal aspects of the SH&E field.

Submission Guidelines: Each submission to JSHER will be blind peer reviewed by at least two reviewers. Submission of a manuscript to JSHER indicates that the effort expressed has not been published previously and that it is not currently under consideration for publication elsewhere.

Manuscripts that are in agreement with the mission and scope of JSHER should be crafted carefully and professionally written. They should be submitted as an attachment within an e-mail message. Specifically, they should:

- be submitted as an MS Word file(s) with no author identifiers;
- be 8 to 20 double-spaced pages with 1-inch margins all around (approximately 3,000 to 8,000 words including references, but not including illustrations, tables or figures that are not included in the text);
- include a separate document indicating the title, coauthors and the person to whom correspondence should be directed, including that person's name, title, employer, phone number, fax number and e-mail address, and a short (50-word) bio of each author indicating at least the author's current position, highest degrees earned and professional certifications earned;
- include an abstract of no more than 200 words that states briefly the purpose of the research, the principal results and major conclusions, including a short list of key words;
- include a reference section at the end of the manuscript, using APA style to cite and document sources;
- number pages consecutively and clearly indicate new paragraphs;
- facts and figures should be documented and acknowledged;
- present tables and figure legends on separate pages at the end of the manuscript, but indicate where in the manuscript the table or figure should go;
- ensure that graphics, such as figures and photos, are submitted as separate files and are not embedded in the article text;
- for empirical research, at a minimum, the text should include introduction, methods, results and discussion sections in the main text;
- for all submission types, section headers, which describe the main content of that portion of the manuscript, are advisable.

All submissions should be sent an MS Word e-mail attachment to:

Sang Choi, Ph.D., CSP
JSHER Editor
Professor of OESH
University of Wisconsin-Whitewater
3509 Hyland Hall
Whitewater, WI 53190
Phone: (262) 472-1641
chois@uww.edu

Editorial

JSHER Welcomes New Editor

It is with great honor that I assume the role of editor of the *Journal of Safety Health and Environmental Research* (JSHER), an academic journal of ASSE. I would like to take this opportunity to thank my predecessor, Michael Behm, Ph.D., for his dedicated contributions and tireless endeavors during the last 3 years. I would also like to thank the JSHER Editorial Board and manuscript reviewers for their time and efforts to ensure the highest-quality publications through a rigorous review process.

In the first article, coauthors Withers and Freeman examine the issues of question design and exam difficulty within the context of chemical safety training conducted on a college campus. Safety training is an integral part of every organization's overall safety program, and assessing the overall effectiveness of the training is critical. A variety of delivery methods are used to conduct safety training with the most common learning outcome being performance on a written exam. A key challenge for the safety professional is establishing a meaningful passing level for the exam, which is one metric sometimes used to assess overall training effectiveness.

Using two populations of learners, computer- and classroom-based students, the authors examined question difficulty factors across three different versions of learning assessments used in chemical safety training. The results showed differing levels of difficulty across each of the three versions. Additionally, the order of administration of the exam was a factor relative to the amount of learning demonstrated.

Through this study, the authors hope to encourage other safety professionals to incorporate the assessment techniques discussed here to gain a more complete picture of learning and overall training effectiveness. They conclude that a simple evaluation of assessment techniques, including question difficulty and order of administration, can provide valuable information on the amount of learning demonstrated and can be applied to any safety training intervention.

In the second article, authors Gilkey, Lopez del Puerto, Rosecrance and Chen have presented their work investigating differences in risk perception and safety culture between Latino and non-Latino workers employed in three major construction industry sectors. The authors wanted to address a recognized problem of greater injury and fatality among Latinos engaged in construction. This study was designed to explore possible contributors to the problem of disproportionate injury and fatality burden currently experienced by this minority group compared to non-Latinos using qualitative assessment methods.

The authors adapted the Safety Culture and Risk Perception survey previously used to seek feedback from 341 workers employed in residential, commercial and heavy civil construction in the northern Colorado region. The robust sample included 219 Latinos and 122 non-Latino responses. Workers completed a 27-question self-report survey using a Likert scale of agreement and disagreement with statements that measured risk perception and domains of safety culture. Data were nonparametric and evaluated using the Mann-Whitney test statistic.

Authors identified potential contributors to the problem. Latino workers had increased concern about their safety yet reduced perceptions about their vulnerability. Latino workers also had difficulty understanding safety training compared to non-Latinos. The authors contend that effective safety training and communication require culture competence coupled with appropriate language. Data continue to show that improved safety climate and culture scores are inversely proportional to injury and fatality rates. The key messages from this research are for employers in construction to 1) develop positive safety cultures and 2) include culturally and language appropriate safety training and communication practices.

In the last article, research was prompted by Maxwell's and Veltri's observation that many times a disconnect exists between what manufacturing firms state their SH&E strategies are and how SH&E strategies are actually carried out at the worksite. From this idea, an SH&E strategy assessment and formulation theory was initially developed using exploratory research methods, which resulted in a multistakeholder view of SH&E strategies available to firms and used by firms.

Five manufacturing firms were chosen in the Pacific Northwest. All of these facilities had previously participated in research by Maxwell and Veltri. Their products ranged from particle board to emergency firefighting equipment to food. This sampling strategy was purposeful in that Maxwell and Veltri wanted to determine if the results would be consistent across a variety of manufacturing types, which it was. A developmental levels rating system (DLRS) model was constructed based on that previous research.

Maxwell and Veltri found that the results of this confirmatory research may provide SH&E managers with an empirically based decision-support guidance model for a) assessing their firm's level of SH&E strategy development and b) formulating new and advanced levels of SH&E strategy. The refined theory offers a series of prompts, rather than a definitive set of standards, when assessing and formulating SH&E strategy.

Case study methodology was used in this study (within case and cross-case analysis) to analyze the data. Consistent patterns were found in how SH&E strategies were assessed and formulated in the facilities studied, providing support for the future usefulness of the model in manufacturing settings. Moreover, important insights were uncovered regarding the relationship between the manufacturing facilities' levels of management strategy, organizational structure and financing strategy, as well the relationship between the firm's risk exposure and SH&E strategy. As a result, the refined theory and DLRS provide a new pathway for assessing, formulating and integrating SH&E management strategy within the larger context of the firm's overall operations strategy.

I look forward to serving as the new editor and to receiving your suggestions and ideas for making JSHER more valuable for SH&E academics and practitioners. ✪

Yours sincerely,
Sang D. Choi, Ph.D., CSP
Managing Editor, JSHER

Case Study: The Importance of the Assessment Technique in Chemical Safety Training on a College Campus

James H. Withers and Steven A. Freeman

Abstract

Safety training is an integral part of every organization's overall safety program. A variety of delivery methods are used to conduct training with the most common learning outcome being performance on a written exam. The safety professional must consider numerous issues when composing a written exam, including question design and exam difficulty, to establish a meaningful passing level and to assess overall training effectiveness. A research study was undertaken to further explore issues related to question design and exam difficulty relative to a chemical safety course offered in both classroom- and computer-based formats on a college campus. The objectives of this study were to 1) evaluate the potential impact of question difficulty as a part of an assessment technique that measures learning and 2) evaluate the potential impact of exam difficulty and sequence of exam administration as a part of an assessment technique that measures learning. An analysis of question difficulty factors across three different versions of learning assessments used showed differing levels of difficulty. Additionally, the order of administration of the exam was a factor in the amount of measured learning. The implications of these results are discussed. Nuances of assessment techniques, including question difficulty and order of administration, must be evaluated to truly evaluate the effectiveness of any safety training intervention.

Keywords
Safety training, assessment technique, training effectiveness

Introduction & Background

Safety training is conducted using a variety of delivery methods. In addition to traditional classroom offerings, safety professionals have been using new technologies, such as computer-based training, at an increasing rate since the 1980s. An International Data Corp. study projected that 80% of safety training would be conducted via computer by 2003 (Overheul, 2002). Accordingly, studies on training effectiveness began to emerge in the scientific literature that examined differences in learning between the two methods (Bowan, et al., 1995; Coppola & Myre, 2002; Hasselbring, 1986; Kulik & Kulik, 1991; Lawson, 1999; Robson, et al., 2010; Stephenson, 1991; Williams & Zahed, 1996).

Regardless of the delivery method for safety training, learning outcomes must first be defined. Once defined, training effectiveness can be evaluated relative to the success in achieving these learning outcomes. In a recent NIOSH-funded literature review, four categories of learning outcomes were identified: 1) knowledge (typically shown via a written exam covering a particular policy, procedure or hazard); 2) attitudes and beliefs (including perception of risk); 3) behaviors (meaning worker actions that could result in exposure to hazards); and 4) health (referring to early detection of illnesses/injuries) (Robson, et al., 2010). Of the four outcomes, the most common in safety training is showing knowledge via a written exam (Burke, 2006). At X University, the majority of current safety training offerings have a written exam component (R. Book, personal communication, Dec. 6, 2010).

The safety professional has numerous issues to consider when composing a written exam. What are the appropriate questions to ask? Are questions clear? Did the training course cover the topic in sufficient detail to allow the participant to answer the question correctly? At this point, the safety professional is faced with a dilemma. Weidner (2000) stated that while safety regulations with training requirements are based on known scientific principles related to hazards, they often lack the underpinnings of the principles of adult learning and assessment. This becomes increasingly important when considering the measure of success in exam-based safety training: achievement of a minimum passing score (percentage) on a postcourse test. In general, a 70% score is widely accepted as an indicator of "moderate" knowledge, 80% of "moderately higher" knowledge and so forth (Angoff, 1984). However, the safety professional must wrestle with issues related to question design and exam difficulty to establish a meaningful passing level. This is especially important given the prevalence of exam-based safety training. While the concept of this research is not new, the context has not appeared before in the literature. Many higher education institutions routinely provide chemical safety training that could benefit from a more systemic approach to their assessments processes.

Research Objectives

This research is part of a larger study looking at delivery methods of safety training and the resulting knowledge gained and retained over time consistent with NIOSH, OSHA and

James H. Withers is the environmental health and safety manager at Danfoss Power Solutions in Ames, IA. He may be contacted at jwithers@sauer-danfoss.com.

Steven A. Freeman is professor of occupational safety in the Department of Agricultural and Biosystems Engineering at Iowa State University in Ames, IA.

American National Standards Institute training paradigms. See Withers, et al. (2012) for the theoretical explanation behind the training framework and the details of the broader study. This study was undertaken to further explore issues related to question design and exam difficulty.

The study focused on a chemical safety training course offered at X University that is an example of exam-based safety training. The course is offered in both classroom and computer-based formats and is considered the backbone of the university's chemical safety program. The course provides basic chemical safety programmatic information to the learner and provides a "roadmap" by which a research group-specific safety program can be developed and implemented. Course topics covered include regulations, terminology, roles and responsibilities, exposure controls and prevention, recordkeeping, exposure monitoring, MSDSs, emergency preparedness, PPE and lab maintenance and inspection.

The first topic evaluated was question difficulty. A specific, associated research objective was as follows:

Evaluate the potential impact of question difficulty as a part of an assessment technique that measures learning.

The larger issue of overall exam difficulty was also explored in relation to question difficulty. The specific associated research objective was as follows:

Evaluate the potential impact of exam difficulty and sequence of exam administration as a part of an assessment technique that measures learning.

Data were collected from participants in a required university chemical safety training course. The 243 participants represented a broad cross-section of university employees and students [for a detailed description of the population and the objectives of the larger study see Withers, et al. (2012)]. Study results were used to identify lessons learned that could be applied to programmatic and course improvements. An additional purpose was to demonstrate simple techniques that other safety professionals can use or adapt for use when evaluating the issue of question and exam difficulty relative to an exam-based safety training course.

Research Methods

The data collection mechanism used was a learning assessment tool (LAT). The LAT consisted of 16 multiple-choice questions, each testing knowledge of a specific topical area. To measure knowledge gained and knowledge retention, LATs were given to participants prior to training, after training and 1 year after training (Withers, et al., 2012). Three versions of the LAT were developed in consultation with a panel of experts with extensive chemical safety and regulatory experience with responsibilities for managing all aspects of chemical safety in a university environment. Question consistency across the three versions of the LAT was tested using a Wilk's Lamda calculation to determine how well each of the three questions tested the student on a particular learning outcome (Hinkel, et al., 2003). In other words, if the three questions were clearly written and the participant had salient knowledge of the topic, all questions should be answered correctly. Conversely, in a situation in which the participant did not have knowledge of the concept, all three questions would be answered incorrectly.

To measure knowledge gained as a result of the training experience, the LAT was administered prior to and after training. In classroom sessions, the pretest and posttests were handed out to participants. In computer-based sessions, the pretests and posttests were presented to the participant automatically on the computer. In each case, the version (1, 2 or 3) was randomly selected by the instructor or computer program. Upon completion of the course, a second and different version of the LAT was administered. Upon completion, each LAT was scored for number of questions correct. In addition, the number of individuals getting a particular question correct (or not) was also collated for each question on the three versions of the LAT.

Results & Discussion

Question set analysis via Wilk's Lambda test statistic revealed three of the 16 topical areas had one of three questions that was not consistently answered correctly relative to the other two. The three discrepancies were in the areas of training records, regulations and laboratory audits. A review of the individual questions did not reveal any apparent issues with clarity (as described before) that would warrant restructuring of the question. This information was used to review the content of both versions (computer and classroom) to ensure that it was delivered clearly prior to the study's commencement.

A common method for evaluating question difficulty is by evaluating the "difficulty factor" (DF) (Knauper, et al., 1997). DF is calculated by taking the number of individuals answering the question correctly divided by the total number of participants answering the question. In general, a calculated DF of > 0.7 is considered to be an "easy question"; a DF of < 0.3 is generally regarded as a difficult question. If a test's purpose is to discriminate between different levels of achievement, items with difficulty values between 0.3 and 0.7 are most effective. The optimal level should be 0.5 (Arizona State University, 2004). For the purpose of assessing exam question difficulty, a DF was calculated for each question on each LAT when taken as a pretest. The pretest was chosen so as to minimize any learning effect caused by participation in the training. Results are shown in Table 1.

An analysis of the data for each LAT shows that each version had a majority of questions that had a DF > 0.7 (denoted in green). Specifically, LAT Version 1 had 11 of 16, LAT Version 2 had 9 of 16 and LAT Version 3 had 10 of 16 questions with calculated DFs that were greater than 0.7. Conversely, each LAT also had some questions that fit the difficult criteria (< 0.3) (denoted in red). Specifically, LAT Version 1 had 2 of 16, LAT Version 2 had 3 of 16 and LAT Version 3 had 2 of 16. Data tend to support an overall conclusion that the exams are weighted on the "too easy" side. Given that data were generated by a group of participants who had no prior work experience with chemicals or any prior chemical safety training further supports that conclusion.

To further evaluate the issue of LAT difficulty, an analysis was conducted of overall pass rate for each LAT for the

TOPICAL AREA	LAT 1	LAT 2	LAT 3
Regulations	1.0	.23	.37
Laboratory Practices	.58	.46	1.0
Emergencies	.50	.38	.50
Exposure Control	.92	.15	.50
Training	.75	.38	.75
Material Safety Data Sheet	.25	.92	1.0
Personal Protective Equipment	.92	1.0	.75
Inspections	1.0	.92	.13
Postings	.58	.92	.75
Lab Procedures	.92	.15	.75
Labels	.83	.58	.63
Transportation	1.0	.92	.75
Behaviors	1.0	1.0	.88
Spills	.92	.85	.88
Standard Operating Procedures	.98	1.0	.25
Waste Disposal	.17	1.0	.88

NOTES: LAT = Learning Assessment Tool; values >0.7 denoted in green; values <0.3 denoted in red.

Table 1 Pretest Difficulty Factor Data: Participants With No Prior Work Experience or Previous Chemical Safety Training

same group, participants with no prior work experience with chemicals or any prior chemical safety training. For LAT Version 1 taken as a pretest, 83% of participants achieved a 70% or greater; the passing rates were 54% for LAT Version 2 and 75% for Version 3. These data suggest that the difficulty of each version might be different (i.e., Version 2 is more difficult that the other two). The implications of question and LAT difficulty are discussed in the Summary and Conclusions sections.

Order of assessment of the LAT was also explored. Inherent in the development of the three versions of the LAT was an assumption that all three were of equal difficulty. Given the previously described methodology, there were several possible combinations of administering the three versions of the LAT as pretests and posttests.

To evaluate the question of whether or not all LAT versions were equivalent in terms of difficulty, all possible combinations of the three versions were evaluated for amount of learning (defined as Delta 1). This evaluation was completed using an analysis of variance (ANOVA) model where Delta 1 was defined as the dependent variable and LAT order (Version Group) and computer or classroom (Delivery Method) were defined as the independent variables. Table 2 shows the results.

The *p-value* data show that both the version group and delivery method are significant in terms of explaining differences in learning.

The calculated value of R^2 was 0.397, which indicates a strong model [defined as: Learning (Delta 1) = Version Group + Delivery Method]. The least squares mean data indicate two interesting trends. Study participants taking Version 2 as a pretest and Versions 1 or 3 as a posttest showed the greatest increase in learning of all possible combinations. A possible explanation of this result is that participants scored low initially on Version 2 because of increased difficulty. When Versions 1 or 3 were taken as the posttest, the amount of measured learning was greater than the other combinations.

Conversely, study participants who took Versions 1 or 3 as a pretest may have scored higher initially because they were easier and then showed less learning (or even a decrease) due to Version 2, as the posttest, being more difficult. The combination of these two observations suggests that Version 2 is a more difficult LAT than Versions 1 or 3. The implications of this finding are discussed in Summary and Conclusions.

Summary

When considering the previous data, it should be obvious that the safety professional needs to consider assessment technique early in the training development process. Reliability

Source	Degrees of Freedom	Sum of Squares	Mean Square	F-Statistic	Probability > F
Version Group	5	589.387	117.877	28.88	<0.0001
Delivery Method	1	20.392	20.392	5.00	0.026
R-Square	0.397				

NOTES:

Version Group 1 = LAT 1 then LAT 2
Version Group 2 = LAT 1 then LAT 3
Version Group 3 = LAT 2 then LAT 1
Version Group 4 = LAT 2 then LAT 3
Version Group 5 = LAT 3 then LAT 1
Version Group 6 = LAT 3 then LAT 2

LEAST SQUARES MEAN:

Version Group 1 = -0.233
Version Group 2 = 0.265
Version Group 3 = 3.538
Version Group 4 = 3.466
Version Group 5 = 2.182
Version Group 6 = -0.020

Table 2 ANOVA for LAT Order

testing conducted during the development of the LAT provided valuable feedback that was a catalyst for a review of training content. An analysis of difficulty factor data, the overall pass rate for each LAT and the influence of exam order suggested that Version 2 of the LAT was more difficult than the other two.

However, at this juncture, the safety professional must consider another issue: establishing a passing level. As mentioned, 70% is a commonly used passing level in safety training, but how can the safety professional establish a passing level without consideration of question and exam difficulty as well as order of administration?

In the example, a majority of questions had a DF > 0.7 (LAT Version 1: 11 of 16, LAT Version 2: 9 of 16, LAT Version 3:10 of 16). Conversely, each LAT also has several questions that fit the difficult criterion (< 0.3) (LAT Version 1: 2 of 16, LAT Version 2: 3 of 16, LAT Version 3: 2 of 16). Without an understanding of LAT composition, in terms of the distribution of difficult or easy questions, the safety training's impact and value are difficult to determine. Organization management might look at the high rate of safety training completion and falsely conclude that workers, because of participation in safety training, are now "qualified" when, in reality, the assessment technique did not have sufficient rigor. Conversely, the safety professional might look at low pass rates for a given safety course and conclude that some aspect of the course (e.g., content) needs improving when, in reality, the assessment technique used was too difficult.

A similar discussion is necessary related to exam difficulty and order of administration. As was shown in this study, both exam difficulty and order of administration played a key role in the measured amount of learning. A false assumption was made that each exam had the same amount of difficulty when, in fact, one version was more difficult than the other two. A training participant who took the more difficult version of the exam as a pretest and then showed a significant gain in knowledge on a posttest might lead the safety professional to conclude that the training intervention was highly effective. Conversely, if the participant took the more difficult version of the exam as the posttest, the false conclusion would be that the training intervention was not effective (i.e., the participant did not learn much).

It should be obvious that data related to question and exam difficulty are necessary for the safety professional to evaluate safety training course effectiveness. Data generated in this study indicate a need to further evaluate the composition of LAT Version 2. Any changes made in individual questions would necessitate the need to reevaluate issues related to pass rate, etc. If the safety professional can show equivalent difficulty with each version of the LAT, then improvements in the assessment technique can be made. For example, raising the passing rate to 80% or higher might be evaluated as an option. However, what additional issues will that present in terms of ensuring the adequacy of content, length of course and other variables related to delivery methods? Will the safety professional spend more time with participants who do not achieve a passing grade outside of class and, therefore, devote more of his/her limited time to supporting the overall training program?

Developing an effective safety training program is challenging in any work environment. Clearly, many complexities are associated with evaluating safety training effectiveness. Sugure and Rivera (2005) reported that only about 50% of companies measure learning outcomes from training, and less than 25% make any attempt to assess potential programmatic improvements resulting from training. Today, the predominate type of safety training includes administration of a written exam and the achievement of a minimal score as a measure of success. To properly evaluate this type of assessment technique, it is imperative that the safety professional have the necessary data collection mechanisms in place. Evaluation of these data and resulting training enhancements will be an ongoing and iterative process.

Conclusions

This study has demonstrated the usefulness of several straightforward analytical techniques that can be used to assess issues related to both question and exam difficulty. It should be noted that the issue of exam difficulty was done within a specific chemical safety course. The results presented and discussed in this study cannot be used to predict potential outcomes of evaluations of other courses. The only way to truly shed light on issues related to the value of the assessment technique used is to implement a process by which course and exam-specific data can be collected and analyzed. The need to include this important step in the developmental process is directly related to the significance of the training course subject matter and the intended learning outcomes. Finally, there must be a clear indication of learning that results from the training experience that is not influenced by nuances (e.g., exam difficulty and exam order) associated with the assessment technique. ✪

References

Angoff, W. (1984). Scales, norms and equivalent scores. In A. Ward, H. Stoker, & M. Murray Ward (eds.), *Educational Measurement: Theories and Applications*. Princeton, NJ: Educational Testing Service. Retrieved from http://books.google.com/books?hl=en&lr=&id=dWTx7RXc028C&oi=fnd&pg=PA121&dq=Angoff++scales+norms+and+equivalent+scores&ots=hZGUHA236m&sig=6KR4CakpIWkqTsWmMa3a_99MFgc#v=onepage&q=Angoff%20%20scales%20norms%20and%20equivalent%20scores&f=false

Arizona State University, University Testing and Scanning Services. (2004). Exam scores: How to interpret your statistical analysis reports. Retrieved from https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCkQFjAA&url=https%3A%2F%2Fuoeee.asu.edu%2Fsites%2Fdefault%2Ffiles%2Fdocs%2FGuide_stat_analy_exam_scores.pdf&ei=tE15UuTdBKecyQHurYC4Aw&usg=AFQjCNH6FXqlmZP-NEHf-nEr3FypKw9Pgw&bvm=bv.55980276,d.aWc&cad=rja

Bowman, B.J., Grupe, F.H. & Simkin, M.G. (1995). Teaching end-user applications with computer-based training: Theory and an empirical investigation. *Journal of End User Computing, 7*(2), 12-18.

Burke, M.J. (2006). Relative effectiveness of worker safety and health training methods. *American Journal of Public Health, 96*(2), 315-324.

Coppola, N. & Myre, R. (2002). Corporate software training: Is web-based training as effective as instructor-led training? *IEEE Transactions of Professional Communication, 45*(3), 170-184.

Hasselbring, T. (1986). Research on the effectiveness of computer-based instruction: A review. *International Review of Education, 32*(3), 313-324.

Hinkel, D., Wiersma, W. & Jurs, S. (2003). *Applied statistics for the behavioral sciences.* Boston, MA: Houghton Mifflin Co.

Knauper, B., Belli, R., Hill, D. & Herzog, R. (1997). Question difficulty and respondent's cognitive ability: The effect on data quality. *Journal of Official Statistics, 13*(2), 181-199.

Kulik, C.-L.C. & Kulik, J.A. (1991). Metaanalytical studies of findings on computer-based instruction. In E. Baker & H. O'Neil (eds.), *Technology assessment in education and training.* New Jersey: Lawrence Erlbaum Associates Inc. Retrieved from http://books.google.com/books?hl=en&lr=&id=7spWIqyYdVIC&oi=fnd&pg=PA9&dq=kulik+1991&ots=UKakOb2h-f&sig=Le5fK6-YI08kaDKxGctnF8c-Nec#v=onepage&q=kulik%201991&f=false

Lawson, S.R. (1999). Computer-based training: Is it the next wave?. *Professional Safety, 44,* 30-33.

Overheul, V. (2002). Does online training live up to its promises? *Occupational Health & Safety, 71*(6), 100.

Robson, L., Stephenson, C., Schulte, P., Amick, B., Chan S., Bielecky A., . . . Grubb, P. (2010). A systematic review of the effectiveness of training & education for the protection of workers. Toronto: Institute for Work & Health. Cincinnati: NIOSH.

Rudman, W.B. (2003). *Emergency responders: Drastically under-funded, dangerously unprepared.* New York, NY: Council on Foreign Relations.

Stephenson, S.J. (1991). *The effect of instructor-student interaction on achievement in computer-based training* (AL-TP-1991-0002). Brooks Air Base, TX: Armstrong Laboratory, Technical Training Research Division.

Sugure, B. & Rivera, R.J. (2005). 2005 state of the industry: ASTD's annual review of trends in workplace learning and performance. Alexandria, VA: American Society for Training and Development.

Thalheimer, W. (2006). *Practical wisdom from learning research.* Somerville, MA: Work-Learn Research.

Wiedner, B. (2000). Testing as a measure of worker health and safety training: Perspectives from a hazardous materials program. *American Journal of Industrial Medicine, 37,* 221-228. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/%28SICI%291097-0274%28200002%2937:2%3C221::AID-AJIM8%3E3.0.CO;2-W/pdf

Williams, T.C. & Zahed, H. (1996). Computer-based training versus traditional lecture: Effect on learning and retention. *Journal of Business and Psychology, 11*(2), 297-310.

Withers, J.H., Freeman, S.A. & Kim, E. (2012, Sept.-Oct.). Learning and retention of chemical safety training information: A comparison of classroom versus computer-based formats on a college campus. *Journal of Chemical Health & Safety,* 47-55.

Comparative Analysis of Safety Culture & Risk Perceptions Among Latino & Non-Latino Workers in the Construction Industry

David Gilkey, Carla Lopez del Puerto, John Rosecrance and Peter Chen

Abstract

Construction job sites are among the most dangerous workplaces within all types of industries. There is growing evidence that safety culture and risk perception have a direct influence on worker perceptions about company priorities, safe work behaviors and resulting injury and death. This study investigated 341 construction workers using the Safety Culture and Risk Perception Survey to measure safety culture and risk perception among Latino and non-Latino workers in residential, commercial and heavy civil sectors in the Denver, CO, metropolitan area. Investigators compared the responses by ethnicity and construction sector. Results by ethnicity indicated that Latino workers were more concerned about the risk of injury and have more difficulty understanding safety rules and procedures than their non-Latino counterparts. Results by sector indicated that residential construction workers are younger and have higher levels of concern for injury risk than workers in the commercial and heavy civil sectors.

Keywords
Safety culture, residential construction, commercial construction, heavy civil construction, Latino construction workers, cultural differences

Introduction

It has been projected that Latinos are among the fastest-growing work groups in the U.S. through 2016 (Franklin, 2007). The 2011 census indicated that 23 million Latinos were employed in the U.S. (Department of Labor, 2012) and that the ethnic group had grown to 50.5 million (U.S. Census Bureau, 2011).

This article uses the federal definition of ethnicity as "Hispanic or Latino. A person of Cuban, Mexican, Puerto Rican, South or Central American or other Spanish culture or origin, regardless of race. The term, 'Spanish origin,' can be used in addition to Hispanic or Latino" (U.S. Census Bureau, 1977).

Between 1992 and 2006, it was reported that 11,303 Latino workers were killed performing their jobs in the U.S. with 34% working in construction (MMWR, 2008). Death rates for Latino workers during the same period were 20% higher than their non-Latino counterparts and 26% higher than black workers. Between 2003 and 2006, it was found that 67% of Latinos were foreign-born, an increase of 52% since 1992. The Center for Construction Research and Training (CPWR, 2009) reported that the number of Latino workers in construction had increased from 705,000 in 1990 to nearly 3 million by 2007.

Latino immigrant workers may not receive equal safety and health training on the job due to language barriers (Ruttenberg, 2004). Vazquez (2004) found that approximately 50% of Latinos workers employed in the western U.S. had earned a high school diploma. Beyond lack of formal education, other factors, such as undocumented status, relative youth and lack of construction experience, may also impact risk-taking behaviors and vulnerability on construction sites (Williams, et al., 2010).

Cultural diversity is common on today's construction sites with high numbers of foreign-born Latinos and other races comprising an ever-increasing proportion of workers. Research has found that immigrant workers bring with them varied life histories, work experiences, cultural sensibilities, health beliefs and cultural backgrounds that are different from U.S.-born Latino and non-Latino workers (Brunette, 2004). One such cultural difference is the view held by immigrant Latinos that authoritative figures are to be respected and not confronted or challenged by subordinates, even when the authority figure is clearly wrong (Vazquez, 2004). Latino workers revere their job and resist the notion of destabilizing their jobs or "rocking the boat" for fear of employer reprisals (Canales, et al., 2009).

Safety culture may be defined as the employee's perceptions and assumptions about company's real priorities for day-to-day business and the consistency of management actions to enforce policies and procedures that support safe work behaviors, actions and operations (Choudhry, 2007; Cooper, 2000; Glendon & Stanton, 2000). Significant evidence supports the assertion that key aspects of safety culture, such as management policies, procedures and commitment to safety, greatly influence the safety culture on worksites and that positive culture is inversely proportional with injury and illness rates (Abudayyeh, et al., 2005; O'Toole, 2002; Zohar, 2010).

Prior research was carried out investigating safety culture

David Gilkey is an associate professor in the Department of Environmental and Radiological Health Sciences at Colorado State University in Fort Collins, CO. He may be contacted at dgilkey@colostate.edu.

Carla Lopez del Puerto is an assistant professor in the Department of Construction Management at Colorado State University.

John Rosecrance is professor of ergonomics and human factors at Colorado State University and the Colorado School of Public Health.

Peter Chen is a professor of management at the International Graduate School of Business at the University of South Australia in Adelaide, South Australia, Australia.

and risk perception among 183 construction workers employed by 67 small companies in the Denver metropolitan area of Colorado. Investigators found that significant differences existed between management and workers but did not evaluate possible differences due to ethnicity. A continuing influx of immigrant Latino workers into the region has resulted in a major Latino presence in all three construction sectors: residential, commercial and heavy civil. Arcury, et al. (2012) found differences in safety culture scores among Latinos working in construction. They identified significant differences between various trades with roofers having the lowest overall mean scores compared to framers and general construction workers.

The present study was designed to evaluate differences in safety culture and risk perception scores between Latino and non-Latino workers among three construction sectors: residential, commercial and heavy civil. The purpose of the present study was to identify differences in safety culture and risk perception among these Latino and non-Latino construction workers. There is a great need to understand the multicultural dimensions of the workplace to identify cultural specific barriers and facilitators to strong safety culture, develop more effective safety training and prevent the disproportionate burden of injury and death suffered by Latino construction workers.

Study Methods

The present study used the Safety Culture and Risk Perception Survey developed by researchers for the HomeSafe Pilot Study as the primary tool for measuring safety culture and risk perception (Bigelow, et al., 1998; Gilkey, et al., 1998; Gilkey, et al., 2012). The survey instrument adapted from the Safety Culture Survey was developed by Safety Performance Solutions, Inc. (Geller, 1990) and translated into Spanish by a bilingual physician and then translated back into English by a bilingual academic faculty member to ensure accuracy of language, content and meaning (Gilkey, et al., 2012). The Safety Culture and Risk Perception Survey has been used for more than a decade in numerous workplaces and environments, including construction.

The instrument included 27 questions framed as statements regarding perceived risk level, management commitment to safety, safety policy, availability of safety equipment, communication, worker caring, safe work conduct, safety training effectiveness and priority for productivity compared to safety. For example, "The risk level at my company concerns me quite a bit" or "Compared to other companies, I think mine is rather risky." Respondents were asked their level of agreement with the statement using the Likert scale. Some statements were positively stated while others were negatively stated, such as "The dangers present on the construction site cannot cause my death or the death of others." The instrument included both English and Spanish side-by-side text boxes designed for ease of use by Spanish-speaking or English-speaking construction workers.

Responses were recorded as levels of agreement with statements using a Likert scale 1 to 5 where, 1 = Highly Disagree, 2 = Disagree, 3 = Neither Agree nor Disagree, 4 = Agree and 5 = Highly Agree. Respondents were also asked to identify their construction sector: Residential, commercial and heavy civil and their primary ethnicity as Latino or non-Latino and if they had suffered a work-related injury.

Age was classified into four categories where 1 = < 30 years, 2 = 31 to 40 years, 3 = 41 to 50 years and 4 = > 51 years. Year worked in construction were classified into 1 to 4 categories as well with 1 = < 5 years, 2 = 6 to 10 years, 3 = 11 to 15 years and 4 = > 15 years. Education attainment level was classified into 1 to 6 categories where 1 = < 6 years of school, 2 = some high school, 3 = high school graduate, 4 = some college, 5 = college graduate and 6 = technical or trade school. Hours of safety training in the past year were recorded as 0, 1, 2, 3, 4 or 5 or more.

The study protocol was submitted and approved by the university Human Research Board (IRB/HRB). Subjects were recruited using convenience sampling through companies in the Denver metropolitan and northern Colorado area that had developed working relationships with the university. The field investigator contacted the company's project manager to schedule a time to administer the survey. Upon entering the worksite, the field investigator explained to workers that participation on the survey was voluntarily and invited workers to participate by completing the survey. No personal identifiers were obtained on the Safety Culture and Risk Perception Survey. Respondents were told that their answers would remain anonymous and would not be shared with the employer. Upon completing and submitting the survey, respondents received ten dollars cash for compensation.

Completed surveys were returned to the university, coded and entered into a computer database for analysis using the Statistical Package for Social Sciences (SPSS™) version 17.0. Analytic methods included univariate, descriptive and frequency statistics. Comparisons of means were made between Latino and non-Latino respondents within and between the study population as a whole and for each of the three subgroup sectors using Mann-Whitney test statistic. The data were ordinal and did not meet all assumptions usually associated with a parametric data set (Pell, 2005); therefore, the non-parametric Mann-Whitney test statistic to compare ranking averages (means scores) between Latino and non-Latino workers as a whole population and subpopulations within sectors.

Results

The Safety Culture and Risk Perception Survey was administered to 341 construction workers in the residential, commercial and heavy civil sectors in the Denver metropolitan area of Colorado. Among the workers sampled, 219 respondents (64%) identified themselves as Latino, and 122 respondents (36%) identified themselves as non-Latino. There were 124 respondents from residential construction, 105 respondents from commercial construction and 110 respondents from heavy civil construction. Of the 124 respondents who worked in residential construction, 95 (77%) identified themselves as Latino. Of the 105 respondents who work in commercial construction, 67 (64%) identified themselves as Latino and of the 110 respondents who worked in heavy civil construction, 56 (51%) identified themselves as Latino. Ages ranged from < 30 years to > 51 years.

Sector	n	Latino	Non-Latino	Age	Years in Construction	Suffered Injury
Residential	124	95	29	88% < 41 yrs.	24% < 5 yrs.	17%
Commercial	105	67	38	86% < 41 yrs.	23% < 5 yrs.	12%
Heavy Civil	110	56	54	54% < 41 yrs.	8% < 5 yrs.	22%

Table 1 Study Population Characteristics

Subjects were classified into one of four possible age categories: 1 = < 30 years, 2 = 31 to 40 years, 3 = 41 to 50 years and 4 = > 51 years. Worker responses were classified into age distributions by proportions of the whole group as follows: 1 = 27%, 2 = 38%, 3 = 13% and 4 = 9% and 13% not reporting. Years of work in construction work were classified into four categories: 1 = < 5 years, 2 = 6 to 10 years, 3 = 11 to 15 years and 5 = > 16 years. Worker responses by proportions of the whole group were reported as follows: 1 = 19%, 2 = 27%, 3 = 19% and 4 = 21% and 14% not reporting. Educational levels were classified into six categories: 1 = < 6 years, 2 = some high school, 3 = high school graduate, 4 = some college, 5 = college graduate, 5 = technical, and 6 = trade school. Analysis revealed the following categorical proportions: 1 = 17%, 2 = 23%, 3 = 22%, 4 = 12%, 5 = 6%, 6 = 4% and 15% provided no response.

In residential construction, 12% of respondents reported they were older than 41 years of age, 76% had been working in construction more than 5 years, 64% had a high school education or less and 83% had not suffered a work-related injury (Table 1). In commercial construction, 14% of respondents reported they were older than 41 years of age, 76% had been working in construction more than 5 years, 70% had a high school education or less and 88% had not suffered a work-related injury. In heavy civil construction, 46% reported they were older than 41 years of age, 92% had been working in construction more than 5 years, 34% had high school or less education and 78% has not suffered a work-related injury. Latino construction workers as a group were younger than non-Latino construction workers, 75% reported they were younger than 41 years of age compared to 65% of non-Latino workers. No Latino workers reported their age greater than 50 years.

Latino workers reported having less construction experience than non-Latino workers; 19% responded they had 16 years' or more construction experience compared to 36% of non-Latino workers. Differences in the level of education were observed between the two groups related to years of formal education, *p-value* < 0.01. Sixty-six percent of Latino workers reported having earned a high school diploma compared to 90% of non-Latino workers. Seventeen percent of the total group reported they had suffered a work-related injury. Among Latino construction workers, it was reported that 11% had suffered a work-related injury compared to 9% of non-Latinos, *p-value* < 0.01.

The Safety Culture and Risk Perception Survey results for the entire study population are summarized in Table 2. Latino and non-Latino worker responses differed significantly, *p-value* < 0.05, in 11 items. Latino workers reported higher scores for 24 of the 30 questions compared to the non-Latino workers, which had higher overall mean scores for only 2 of the 30 questions. Latino workers had the highest mean score (4.8) for the statement, "I have the PPE I need to do my job safely."

Data analysis with Mann-Whitney test procedure was performed to compare the average rankings of Latino with non-Latino for the item, "The risk level of my job concerns them quite a bit." The average ranking (mean score) was 3.87 for Latino and 3.1 for non-Latino was found to be significantly different, *p-value* < 0.01. Nearly two thirds (67%) of Latinos agreed or highly agreed with the statement compared to 40% of non-Latino workers.

The average rankings were compared for the item, "At my company, work productivity and quality have a higher priority than safety." The Latino mean score was 3.1 compared to the non-Latino mean score of 2.6 revealing significant difference, *p-value* < 0.01. Thirty-eight percent of Latino workers highly disagreed or disagreed with the statement compared to 64% of non-Latino workers. When comparing mean ranking for the item, "Management places most of the blame for an accident on the injured employee," the Latino mean score was 3.22 with 42% for those who agreed or highly agreed with the statement compared to 23% of non-Latino workers with a mean ranking of 2.70. The comparison revealed that the differences were significant, *p-value* < 0.01. Evaluation of the rankings for the item, "Near misses are consistently reported and investigated at our company," revealed that the mean Latino ranking was higher with a mean score of 3.69 compared to the non-Latino average ranking of 3.30. The difference was significant, *p-value* < 0.01, with 64% of Latino workers agreed or highly agreed compared to 47% of non-Latinos.

Evaluation of the item, "Many first-aid cases in their company go unreported," found that the mean ranking for Latinos was 2.81 compared to non-Latinos with an average ranking of 2.3. These differences were significant, *p-value* < 0.01, and 38% of Latino workers agreed or highly agreed with the statement compared to 19% of non-Latinos. When evaluating the item, "Some safety rules and procedures are difficult to understand," the mean Latino ranking was 3.1 compared to the non-Latino ranking of 2.6. The difference was significant, *p-value* 0.01, with 45% of Latino workers agreed or highly agreed with the statement compared to 30% of non-Latinos.

When comparing responses to the statement, "The dangers present on a construction site cannot cause my death or the death of others," the Latino mean ranking was 2.90 compared to the non-Latino ranking 2.30 and that 43% of Latino workers agreed or highly agreed with the statement compared to 25% of non-Latino workers. Additional items had significant differences and can be seen in Table 2.

Safety Culture and Risk Perception responses with average rankings are summarized by construction sectors in Tables 3, 4 and 5. Data include mean scores (average rankings) for Latino and non-Latino workers with the number of responses and percentages for each possible response. Differences are identified by corresponding *p-value,* those < 0.05 are statistically significant.

Residential Sector

Significant differences were found in ten items when comparing Latino to non-Latino responses to statements within this sector (Table 3). Of interest are two items, first that Latino workers reported a higher mean ranking of 4.0 when responding to the statement, "The risk level of my job concerns me quite a bit," compared to non-Latinos with a mean ranking of 3.2. The differences were significant, *p-value* < 0.01, with 62% of Latino workers agreed or highly agreed compared to 38% of non-Latinos. When evaluating the item, "Immigrant workers make the worksite unsafe for all workers," the average response ranking for Latino workers was 2.5 compared to non-Latino workers 3.0. This difference was significant, *p-value* 0.04, and that 30% of Latino workers agreed or highly agreed with the statement compared to 38% of non-Latinos. Additional items had significant differences in rankings and can be seen in Table 3.

Latino					Non-Latino					
Highly Disagree	Disagree	Neither Agree or Disagree	Agree	Highly Agree	Highly Disagree	Disagree	Neither Agree or Disagree	Agree	Highly Agree	Mann Whitney P-Value
The risk level of my job concerns me quite a bit.										< 0.00
17	11	36	47	96	19	20	33	23	26	
8%	5%	17%	22%	45%	16%	16%	27%	19%	21%	
Mean: 3.87					Mean: 3.10					
When told about safety hazards, supervisors are appreciative and try to correct them quickly.										0.56
5	4	12	41	141	3	4	11	36	66	
2%	2%	6%	19%	67%	2%	3%	9%	30%	54%	
Mean: 4.33					Mean: 4.30					
My immediate supervisor is well informed about relevant safety issues.										0.10
7	1	11	44	144	3	3	10	32	72	
3%	0.40%	5%	21%	68%	2%	2%	8%	26%	59%	
Mean: 4.45					Mean: 4.30					
It is the responsibility of each employee to seek out opportunities to prevent injury.										0.61
6	3	4	35	158	4	2	6	20	89	
3%	1%	2%	17%	75%	3%	2%	5%	16%	73%	
Mean: 4.55					Mean: 4.50					
At my company, work productivity and quality usually have a higher priority than work safety.										<0.01
46	34	28	33	65	32	34	18	21	16	
22%	16%	13%	16%	53%	26%	28%	15%	17%	13%	
Mean: 3.10					Mean: 2.60					
The managers in my company really care about safety and try to reduce risk levels as much as possible.										0.11
7	3	6	56	131	4	3	6	44	63	
3%	1%	3%	26%	62%	3%	2%	5%	36%	52%	
Mean: 4.32					Mean 4.30					
When I see a potential safety hazard (e.g., oil spill), I am willing to correct it myself if possible.										0.34
12	5	10	51	124	6	8	8	42	63	
6%	2%	5%	24%	59%	5%	7%	7%	34%	52%	
Mean: 4.16					Mean: 4.20					
Management places most of the blame for an accident on the injured employee.										<0.01
21	37	60	40	48	24	21	48	16	12	
10%	18%	28%	19%	23%	20%	17%	39%	13%	10%	
Mean: 3.22					Mean: 2.70					
Near misses are consistently reported and investigated at our company.										<0.01
17	20	32	60	77	11	21	32	27	30	
8%	9%	15%	28%	36%	9%	17%	26%	22%	25%	
Mean: 3.69					Mean: 3.30					
I am willing to warn my coworkers about working unsafely.										0.16
8	2	3	41	153	3	6	3	29	80	
4%	0.9%	1%	19%	73%	2%	5%	2%	24%	66%	
Mean: 4.53					Mean: 4.50					
Employees seen behaving unsafely in my company are usually given corrective feedback by their coworkers.										0.22
11	5	16	71	103	4	8	12	46	51	
5%	2%	8%	34%	49%	3%	7%	10%	38%	42%	
Mean: 4.14					Mean: 4.10					

Table 2a Responses for Combined Sectors, Latino vs. Non-Latino

Commercial Sector

In the commercial sector, significant differences ($p < 0.05$) were found in seven items related to safety culture and risk perception with three items of interest. When responding to the statement, "The risk level in my job concerns me quite a bit," Latinos had a mean ranking of 3.8 compared to non-Latinos 3.0, ($p < 0.01$). Forty-six percent of Latino workers reported they agreed or highly agreed with the statement compared to 34% of non-Latino workers.

Latinos also reported higher agreement, mean ranking 3.0, with the statement that, "The near misses are consistently reported and investigated at my company" compared to non-Latinos with a mean score of 2.6. The difference in average ranking was significant, *p-value* < 0.01 with 67% of Latinos agreed or highly agreed with the statement compared to 31% of non-Latinos. When evaluating the item, "I always follow the safety rules and procedures when doing my job," the average ranking for Latinos was 4.50 compared to 3.90 for non-Latinos. This difference was significant, *p-value* < 0.01 with 89% of Latino workers agreed or highly agreed with the statement compared to 71% of non-Latino workers.

Heavy Civil Sector

In the heavy civil sector, rankings were significantly different for five safety culture and risk perception items. Latinos had an overall mean ranking of 3.8 to the statement, "The risk level at my job concerns me quite a bit," compared to the non-Latino workers with a 3.1 overall mean ranking, *p-value* < 0.01. When presented with the statement, "Management places most of the blame for an accident on the injured employee," Latino workers had an overall mean ranking of 3.5 compared to non-Latino workers with an overall mean of 2.6, $p < 0.01$. Latino and non-Latino mean rankings of 4.4 and 4.8 respectively, were generated when responding to the statement, "I know how to do my job safely," p 0.02. When responding to the statement, "Most employees in my company would not feel comfortable if their work practices were observed and recorded by a coworker," yielded mean scores of 4.0 and 2.7 for Latino and non-Latino workers respectively, *p-value* < 0.01. When presented with the statement, "The dangers on a construction site cannot cause my death or the death of others," the Latino overall mean score was 2.7 compared to non-Latinos with 1.6, *p* 0.03.

Discussion

The present study builds upon prior research and investigated perceptions of safety culture and risk among the Latino and non-Latino construction workers in the residential, commercial and heavy civil sectors. A literature search revealed no similar work had been published comparing Latino and non-Latino safety culture measures among the three construction sectors. The only study that was found investigating safety culture among Latino construction workers was only recently published (Arcury, et al., 2012). Arcury, et al. (2012) found differences in safety culture score between trades with roofers having the lowest overall mean scores compared to framers and general construction workers. The investigation team concluded that safety culture scores predicted safework behaviors verified by self-report 21-day diary account of work activities.

Investigators in the present study used a survey instrument similar to that developed by Bigelow, et al. (1998) to evaluate residential construction companies in the HomeSafe Pilot Program patterned after the Safety Culture Survey by Geller (1996). The workforce as a whole had some general differences. Latino workers tended to be younger with less experience in construction, lower levels of formal education and had received fewer hours of safety training in the prior year compared to their non-Latino counterparts. Residential construction had the youngest workers while heavy civil had the oldest and most experienced workers. Forty-six percent of residential workers reported being less than 31 years of age compared to 32% in commercial and 13% in heavy civil. CPWR (2009) reported the largest Hispanic age group working in construction was 25 to 29 years in 2005 but noted the trend for decreasing numbers of younger workers with an age shift to 30 to 34 years by 2008.

Latino workers reported less education than their non-Latino counterparts with a mean score of 1.9 (some high school) versus 3.0 (high school graduate), respectively. This finding is consistent with other investigators that identified approximately 50% of Latinos workers employed in the western U.S. had earned a high school diploma

Compared to other companies, I think mine is rather risky.										0.22
60	42	47	24	31	37	37	25	11	11	
28%	20%	23%	11%	15%	30%	30%	20%	9%	9%	
Mean: 2.56					Mean: 2.30					
Working safely is the Number One priority in my company.										0.09
5	6	10	46	135	9	6	13	25	68	
2%	3%	5%	22%	64%	7%	5%	11%	21%	56%	
Mean: 4.30					Mean: 4.10					
I have received adequate job safety training.										0.63
6	3	11	50	134	3	3	5	35	73	
3%	1%	5%	24%	64%	2%	3%	4%	29%	60%	
Mean: 4.34					Mean: 4.30					
Many first-aid cases in my company go unreported.										<0.01
56	41	29	33	46	40	34	22	13	11	
27%	19%	14%	16%	22%	33%	28%	18%	11%	9%	
Mean: 2.81					Mean: 2.30					
Information needed to work safely is made available to all employees.										0.25
4	2	11	49	136	3	6	6	33	71	
2%	0.9%	5%	24%	64%	3%	5%	5%	28%	60%	
Mean: 4.46					Mean: 4.40					
Management here seems genuinely interested in reducing injury rates.										0.54
6	2	16	58	119	4	5	7	28	74	
3%	0.9%	8%	28%	58%	3%	4%	6%	24%	62%	
Mean: 4.46					Mean: 4.30					
Safety audits are conducted regularly in my company to check the use of PPE.										0.40
5	7	19	44	124	4	7	13	29	66	
2%	3%	9%	22%	61%	3%	6%	11%	24%	55%	
Mean: 4.30					Mean: 4.20					
I know how to do my job safely.										0.23
3	2	3	49	141	3	1	1	24	90	
1%	0.90%	1%	24%	69%	3%	0.80%	0.80%	20%	76%	
Mean: 3.70					Mean: 2.90					
Employees in my company would not feel comfortable if their work practices were observed and recorded.										<0.01
19	11	33	65	71	24	22	30	25	17	
58%	5%	16%	32%	30%	20%	18%	25%	21%	14%	
Mean: 3.70					Mean: 2.90					
Teamwork and collaboration are encouraged to reduce safety hazards.										<0.01
5	1	8	47	140	2	2	14	41	60	
2%	0.4%	4%	23%	69%	2%	2%	12%	34%	50%	
Mean: 4.53					Mean: 4.30					
I always follow the safety rules and procedures when doing my job.										<0.01
2	2	12	46	135	2	3	16	46	52	
0.90%	0.9%	6%	23%	66%	2%	3%	13%	39%	44%	
Mean: 4.40					Mean: 4.20					
I have the PPE I need to do my job safely.										0.09
5	1	2	38	155	4	3	3	29	80	
2%	0.4%	0.9%	19%	76%	3%	2%	2%	24%	67%	
Mean: 4.60					Mean: 4.50					
Some safety rules and procedures are difficult to understand.										0.01
46	25	35	40	52	33	28	23	20	15	
23%	13%	17%	20%	25%	28%	24%	19%	17%	13%	
Mean: 3.10					Mean: 2.60					
Immigrant workers are more likely to suffer accidents than American workers.										0.83
65	26	31	29	48	29	21	29	22	18	
32%	13%	15%	14%	23%	22%	18%	24%	19%	15%	
Mean: 2.80					Mean: 2.80					
Immigrant workers make the worksite unsafe for all workers.										0.02
105	27	20	22	28	37	28	31	12	11	
51%	13%	10%	11%	14%	31%	24%	26%	10%	9%	
Mean: 2.20					Mean: 2.40					
Accidents can happen to anyone.										0.33
6	1	2	24	168	5	3	5	12	94	
3%	0.40%	0.9%	12%	82%	4%	3%	4%	10%	79%	
Mean: 4.70					Mean: 4.60					
I am willing to take more risks than my coworkers.										0.96
67	32	30	19	30	32	23	21	9	10	
37%	17%	16%	10%	16%	34%	24%	22%	9%	11%	
Mean: 2.40					Mean: 2.40					
The dangers present on construction sites cannot cause my death or the death of others.										<0.01
64	26	10	16	63	54	8	9	2	22	
35%	14%	5%	9%	34%	57%	8%	9%	2%	23%	
Mean: 2.90					Mean: 2.30					
I have control over the dangers I encounter on construction sites.										0.15
12	16	16	42	94	5	9	17	24	40	
7%	9%	9%	23%	52%	5%	9%	18%	25	42%	
Mean: 4.10					Mean: 3.90					

Table 2b Responses for Combined Sectors, Latino vs. Non-Latino

(Vazquez, 2004). The lack of formal education, coupled with language, cultural and other barriers, is an impediment to effective safety training (Menzel & Gutierrez, 2010; Roelofs, et al., 2011; Thompson & Siddiqi; 2007). Latino construction workers in the study reported they had suffered more work-related injury, 11% versus 9% of the population sampled. The published literature reports significantly higher levels of injury and death among the Latino workforce compared to non-Latinos (CPWR, 2009, 2010; MMWR, 2008).

The statistically significant differences of concern seen in the survey results included perceptions about risk, productivity priority, blame for injury, reporting of first-aid cases, understanding safety rules and awareness of lethal dangers on construction sites. Latino workers reported across all sectors combined 20% higher mean rankings (3.87 vs 3.11) than non-Latinos when responding to the statement, "The risk level at my job concerns me quite a bit." This finding is consistent with work by Roelofs, et al. (2011) and their investigation using focus groups to ascertain perceptions of safety and risk among Hispanic construction workers. They found that Hispanic workers recognized increased hazard exposure and risk levels but felt powerless to make changes for several reasons. The workers in their study reported not receiving proper PPE and/or equipment to do the job, being pressured to work faster and to take risks, inability to question supervisor authority, ineffective safety training, irrelevant safety training and being forced to accept the responsibility for safety without a full understanding of controls, available resources or authority to take action.

Roelofs and colleagues (2011) also reported that Hispanic workers felt intimidated and were fearful of retaliation by employers. Workers felt that the only option was to give up the job to avoid the risks experienced in construction. When looking at differences between the sectors, Latino workers reported a consistently higher level of concern for risk with mean scores ranging from 4.0 in residential construction to 3.8 in both commercial and residential sectors.

Latino workers appear to recognize hazards and risks but engage them as part of the job. It is possible that they do not feel confident addressing hazards and risks as reported by Roelofs and colleagues (2011) or they have become less concerned and underestimate the real threat of lethal danger for themselves or coworkers. Geller (1996) suggested that workers become desensitized to hazards and risks as they encounter them day after day and do not suffer adverse events.

When asked about the lethal dangers present on a construction sites, Latino workers reported higher agreement with the statement, "The dangers present on a construction site cannot cause my death or the death of others." Forty-three percent residential, 34% commercial and 28% heavy civil Latino workers agreed or strongly agreed with the statement. This finding suggests that Latinos may underestimate the real risks present on construction sites.

Thompson and Siddiqi (2007) reported that the "sissy factor" or machismo culture common to Latino men may play a role in denying vulnerability. Latino men are culturally conditioned to be "manly" and may avoid safety issues and not bring up concerns for risk to supervisors (Kalarao, 2004). Multiple factors influence accurate risk perception, including culture, immigration status, education level as well as effective culturally appropriate safety and health training (Gilkey & Lopez del Puerto, 2011).

Thompson and Siddiqi (2007) provided a list of best practices that includes increased training, Spanish-language training for supervisors, English-as-a-second-language training for workers, cultural awareness for supervisors, more emphasis on hands-on training, increased supervision and promotion of Hispanics to achieve overall success safety and health practices on the job. The authors support this integrated and well-rounded approach for enhanced effectiveness in safety and

Latino					Non-Latino					
Highly Disagree	Disagree	Neither Agree or Disagree	Agree	Highly Agree	Highly Disagree	Disagree	Neither Agree or Disagree	Agree	Highly Agree	Mann Whitney P-Value
The risk level of my job concerns me quite a bit.										< 0.01
4	2	17	26	39	1	7	9	4	7	
4%	2%	19%	29%	43%	3%	24%	31%	14%	24%	
Mean: 4.00					Mean: 3.20					
When told about safety hazards, supervisors are appreciative and try to correct them quickly.										0.05
3	0	6	20	58	0	0	6	9	13	
3%	0%	7%	22%	64%	0%	0%	21%	31%	45%	
Mean: 4.40					Mean: 4.10					
My immediate supervisor is well informed about relevant safety issues.										0.28
2	1	6	17	63	0	0	2	9	17	
2%	1.0%	7%	19%	70%	0%	0%	7%	31%	57%	
Mean: 4.50					Mean: 4.40					
It is the responsibility of each employee to seek out opportunities to prevent injury.										0.02
4	2	1	14	67	0	1	4	8	15	
4%	2%	1%	16%	74%	0%	3%	14%	28%	52%	
Mean: 4.50					Mean: 4.20					
At my company, work productivity and quality usually have a higher priority than work safety.										0.24
13	14	12	16	33	4	6	6	6	6	
14%	16%	13%	18%	37%	14%	21%	21%	21%	21%	
Mean: 3.40					Mean: 3.00					
The managers in my company really care about safety and try to reduce risk levels as much as possible.										< 0.01
3	1	2	20	62	0	1	1	17	9	
3%	1%	2%	22%	67%	0%	3%	3%	59%	31%	
Mean: 4.50					Mean 4.10					
When I see a potential safety hazard (e.g., oil spill), I am willing to correct it myself if possible.										0.59
8	2	6	26	44	0	3	3	10	12	
9%	2%	7%	29%	49%	0%	10%	10%	35%	41%	
Mean: 4.00					Mean: 4.00					
Management places most of the blame for an accident on the injured employee.										0.44
11	16	21	17	24	4	3	10	7	4	
12%	18%	23%	19%	27%	14%	10%	35%	24%	14%	
Mean: 3.30					Mean: 3.30					
Near misses are consistently reported and investigated at our company.										0.08
9	8	17	27	29	3	5	8	5	7	
10%	9%	19%	30%	32%	10%	17%	28%	17%	24%	
Mean: 3.70					Mean: 3.20					
I am willing to warn my coworkers about working unsafely.										<0.01
4	1	3	14	71	0	2	1	10	15	
4%	1.0%	0%	16%	79%	0%	7%	3%	35%	52%	
Mean: 4.70					Mean: 4.20					
Employees seen behaving unsafely in my company are usually given corrective feedback by their coworkers.										0.82
6	2	7	33	40	0	2	2	12	12	
7%	2%	8%	37%	44%	0%	7%	7%	41%	41%	
Mean: 4.10					Mean: 4.10					

Table 3a Responses for Residential Sector, Latino vs. Non-Latino

health training and teaching and learning for Latino workers.

The sample of Latino workers in the current study reported more difficulty understanding available safety and health information compared to non-Latino workers. When responding to the question, "Some safety rules and procedures are difficult to understand," 46% of all Latino workers highly agreed or agreed with the statement, compared to 26.6% of all non-Latino workers, *p-value* < 0.01. This finding suggests that language is a significant and persistent barrier to effective safety and health training using the traditional model of providing English or translated content to Spanish-speaking workers without regard for literacy or cultural nuances necessary for effective learning.

When looking closer at the three construction sector results, 50% of residential, 39% of commercial and 34% of heavy civil Latino construction workers indicated that they strongly agreed or agreed with the statement. This finding is likely to be a byproduct of the persistent barriers: language, cultural differences, immigration status, machismo, inability to question supervisor authority, ineffective safety training, irrelevant safety training and being forced to accept responsibility for safety without a full understanding of controls, available resources or authority to take action (Menzel & Gutierrez, 2010; Roelofs, et al., 2011). This finding is also supported by an OSHA directive to provide training in a manner and language that workers can understand (OSHA, 2010).

Latino workers in the current study also report higher levels of agreement about the "real" company priorities placed on productivity rather than safety. This finding is core to safety culture and must also be addressed if companies wish to drive down their injury and illness losses (Oakley, 2012; Zohar, 2010). The pressure to meet deadlines and goals is, in fact, a test of commitment by supervisors and managers that enforce company policy. The reporting and investigation of first-aid cases provide an opportunity to improve the safety program (Oakley, 2012). Companies that wish to build safety culture and profitability should exercise every opportunity to understand hazards and risks that pose injury to workers regardless of their origin or racial classification. Improved safety culture will benefit both Latino and non-Latino workers.

Oakley (2012) and others advocated that blaming workers for their injury consequence is not acceptable and is a poor practice. Fear of being blamed has been identified as a persistent barrier for Latino workers (Roelofs, et al., 2011). Study results found that 42.5% of Latino workers highly agreed or agreed with the statement, "Management places most of the blame for an accident on the injured

Compared to other companies, I think mine is rather risky.										
20	17	25	12	13	4	8	6	5	5	0.53
22%	19%	28%	13%	14%	14%	28%	21%	17%	17%	
Mean: 2.70					Mean: 2.90					
Working safely is the Number One priority in my company.										
3	0	3	22	58	2	2	4	5	15	0.09
3%	0%	3%	23%	64%	7%	7%	14%	17%	52%	
Mean: 4.40					Mean: 3.90					
I have received adequate job safety training.										
3	3	6	21	55	0	2	2	10	13	0.12
3%	3%	7%	23%	61%	0%	7%	7%	35%	45%	
Mean: 4.30					Mean: 4.40					
Many first-aid cases in my company go unreported.										
19	23	14	10	22	5	9	5	4	5	0.72
21%	26%	16%	11%	24%	17%	31%	17%	14%	17%	
Mean: 2.90					Mean: 2.70					
Information needed to work safely is made available to all employees.										
3	0	7	20	57	0	2	2	9	13	0.18
3%	0.0%	8%	23%	65%	0%	8%	8%	35%	50%	
Mean: 4.50					Mean: 4.30					
Management here seems genuinely interested in reducing injury rates.										
4	2	9	26	46	0	2	3	9	12	0.60
5%	2.0%	10%	30%	52%	0%	8%	12%	35%	46%	
Mean: 4.20					Mean: 4.20					
Safety audits are conducted regularly in my company to check the use of PPE.										
2	4	11	12	57	0	2	5	7	12	0.14
2%	5%	13%	35%	65%	0%	8%	19%	27%	46%	
Mean: 4.30					Mean: 4.10					
I know how to do my job safely.										
2	1	1	17	64	0	1	0	12	13	0.05
2%	1.00%	1%	19%	73%	0%	4.0%	0.0%	46%	50%	
Mean: 4.50					Mean: 4.40					
Employees in my company would not feel comfortable if their work practices were observed and recorded.										
5	5	16	31	30	3	5	5	8	5	0.03
6%	6%	18%	35%	34%	12%	19%	19%	31%	19%	
Mean: 3.90					Mean: 3.30					
Teamwork and collaboration are encouraged to reduce safety hazards.										
2	0	3	26	55	0	0	5	11	10	0.02
2%	0.0%	3%	29%	63%	0%	0%	19%	42%	39%	
Mean: 4.50					Mean: 4.20					
I always follow the safety rules and procedures when doing my job.										
2	2	4	22	55	0	1	3	10	12	0.17
2.0%	2.0%	5%	25%	63%	0%	4%	12%	39%	46%	
Mean: 4.40					Mean: 4.30					
I have the PPE I need to do my job safely.										
3	1	0	15	68	0	1	2	12	11	< 0.01
3%	1.0%	0.0%	17%	71%	0%	4%	8%	46%	42%	
Mean: 4.60					Mean: 4.30					
Some safety rules and procedures are difficult to understand.										
14	15	10	14	34	4	4	5	6	7	0.58
16%	17%	11%	16%	39%	15%	15%	19%	23%	27%	
Mean: 3.40					Mean: 3.30					
Immigrant workers are more likely to suffer accidents than American workers.										
25	13	11	15	23	3	4	4	9	6	0.23
28%	15%	13%	17%	26%	12%	15%	15%	35%	23%	
Mean: 3.00					Mean: 3.40					
Immigrant workers make the worksite unsafe for all workers.										
39	13	9	7	19	3	6	8	5	4	0.04
44%	15%	10%	8%	22%	12%	23%	31%	19%	15%	
Mean: 2.50					Mean: 3.00					
Accidents can happen to anyone.										
2	2	0	8	74	0	1	1	4	20	0.36
2%	0.0%	2.0%	9%	84%	0%	4%	4%	15%	77%	
Mean: 4.70					Mean: 4.70					
I am willing to take more risks than my coworkers.										
23	14	18	8	20	6	3	10	4	3	0.88
27%	17%	21%	9%	24%	23%	12%	39%	15%	12%	
Mean: 2.80					Mean: 2.80					
The dangers present on construction sites cannot cause my death or the death of others.										
21	13	8	6	35	10	3	2	2	9	0.42
25%	15%	9%	7%	41%	39%	12%	8%	8%	35%	
Mean: 3.30					Mean: 2.90					
I have control over the dangers I encounter on construction sites.										
4	10	2	22	46	1	3	5	5	12	0.35
5%	12%	2%	26%	54%	4%	12%	19%	19	46%	
Mean: 4.10					Mean: 3.90					

Table 3b Responses for Residential Sector, Latino vs. Non-Latino

employee," compared to 22.5% of non-Latino workers, *p-value* < 0.01. When looking at the sector results, investigators found that 50% of Latinos working in heavy civil, 43% in residential and 30% in commercial reported that blame falls on the employee. Experts have stated, "Experience in industry indicates that any undesirable outcome will have, on average, a series of 10 to 14 cause-and-effect relationships that queue up in a particular pattern in for the event to occur" (Latino & Latino, 2006). The shortsighted pattern for assigning blame to an accident is counterproductive to the development of a positive safety culture and a lost opportunity to identify the real underlying causes for human error and adverse outcomes.

Limitations

This investigation has many limitations. The study was conducted in the Denver metropolitan and northern areas of Colorado and may not represent multicultural worksites in other regions of the country. The sample was not random but recruited through convenience sampling using employers with active relationships with the university. The companies may not represent the "typical" employer and represent a "better" type of employer. This bias would be differential toward the null; there is no difference in safety culture and risk perception scores between Latino and non-Latino workers. The overall sample size is robust for the broader construction industry, but results have significant limitations when applied to any one sector. The sample size is small when classified by sector; larger samples are needed to accurately generalize to any one industry sector.

Using the domains of safety culture outlined by Zohar (1980), investigators have selectively applied measurement and evaluation techniques to construction companies without identifying or reporting differences between Latino and non-Latino workers. This investigation team chose to evaluate differences between Latino and non-Latino groups. This tool appears appropriate but was not designed with this broader multisector population as the original intent. Better methods may exist for investigating differences in safety culture and risk perception between Latinos and non-Latinos in construction. The survey tool had been originally developed and applied to the residential sector only. Investigators also recognized that self-report surveys have an inherent potential for recall and reporting bias. Individuals may provide truthful or spurious answers to questions or may not remember the facts as they have occurred in their work experience.

Latino					Non-Latino					
Highly Disagree	Disagree	Neither Agree or Disagree	Agree	Highly Agree	Highly Disagree	Disagree	Neither Agree or Disagree	Agree	Highly Agree	Mann-Whitney P-Value
The risk level of my job concerns me quite a bit.										< 0.01
5	4	12	14	30	6	8	11	7	6	
8%	6%	18%	21%	45%	16%	21%	29%	18%	16%	
Mean: 3.80					Mean: 3.00					
When told about safety hazards, supervisors are appreciative and try to correct them quickly.										0.34
1	2	4	13	45	2	1	3	11	21	
2%	3%	6%	19%	67%	5%	3%	8%	29%	55%	
Mean: 4.70					Mean: 4.30					
My immediate supervisor is well informed about relevant safety issues.										0.68
2	3	3	15	44	2	1	3	9	23	
3%	5%	5%	22%	66%	5%	3%	8%	28%	62%	
Mean: 4.30					Mean: 4.30					
It is the responsibility of each employee to seek out opportunities to prevent injury.										0.77
1	0	2	14	48	2	1	1	8	26	
2%	0%	3%	21%	72%	5%	3%	3%	21%	68%	
Mean: 4.50					Mean: 4.40					
At my company, work productivity and quality usually have a higher priority than work safety.										0.53
18	13	9	10	15	11	11	5	6	5	
27%	19%	13%	15%	22%	29%	29%	13%	16%	13%	
Mean: 2.80					Mean: 2.60					
The managers in my company really care about safety and try to reduce risk levels as much as possible.										0.99
4	1	3	21	35	3	1	3	10	20	
6%	1%	5%	31%	52%	8%	3%	8%	26%	53%	
Mean: 4.10					Mean 4.10					
When I see a potential safety hazard (e.g., oil spill), I am willing to correct it myself if possible.										0.03
2	2	2	13	46	0	2	5	14	17	
3%	3%	3%	19%	69%	0%	5%	13%	37%	45%	
Mean: 4.00					Mean: 4.00					
Management places most of the blame for an accident on the injured employee.										0.15
5	14	26	11	9	6	9	18	3	2	
8%	21%	39%	16%	13%	16%	24%	47%	8%	5%	
Mean: 3.00					Mean: 2.60					
Near misses are consistently reported and investigated at our company.										<0.01
2	8	9	10	26	5	8	13	7	5	
3%	12%	13%	28%	39%	13%	21%	34%	18%	13%	
Mean: 3.00					Mean: 2.60					
I am willing to warn my coworkers about working unsafely.										0.75
2	0	2	17	44	2	2	0	8	26	
3%	0.0%	3%	25%	66%	5%	5%	0%	21%	68%	
Mean: 4.40					Mean: 4.40					
Employees seen behaving unsafely in my company are usually given corrective feedback by their coworkers.										0.14
4	1	2	24	34	3	2	6	13	14	
6%	2%	3%	36%	51%	8%	5%	16%	34%	37%	
Mean: 4.10					Mean: 3.90					

Table 4a Responses for Commercial Sector, Latino vs. Non-Latino

Conclusions

This study successfully investigated perceptions about safety culture and risk among Latino and non-Latino construction workers in the residential, commercial and heavy civil sectors and found differences and similarities. Results indicated that Latino construction workers in all three sectors may experience a different safety culture and level of risk perception than non-Latino workers. Of most concern to the investigation team were findings that suggest Latinos perceive greater company-level risk, productivity priority, blame for injury, reporting of first-aid cases, understanding safety rules and awareness of lethal dangers on construction sites. Future research has been directed toward increasing data collection and evaluation of this apparent disparity between the groups as well as developing multifaceted interventions to address the persistent problem of Latino injury and death in construction. Solutions to address the many challenges will require a multifaceted approach as advocated by CPWR (2010) and Thompson and Siddiqi (2009) and may include formal cultural training for Anglo supervisors, Spanish-language training for supervisors, Spanish-language safety training for workers, promotion of Latino workers, English-as-a-second-language training for Latino workers, increased supervision, more emphasis on “hands on” training, health literacy and workers’ compensation. Materials and methods must be designed to target Latinos with culture in mind to be effective (Brunette, 2005). ✪

References

Abudayyeh, O., Frederick, T. Butt, S. & Shaar, A. (2005). An investigation of management’s commitment to construction safety. *International Journal of Project Management, 24,* 167-174.

Arcury, T.A., Mills, T., Marin, A.J., Summers, P., Quandt, S.A., Ruching, J., Lang, W. & Grzywacz, J.G. (2012). Work safety climate and safety practices among immigrant Latino residential construction workers. *American Journal of Industrial Medicine.* Retrieved Aug. 25, 2012, from http://www.ncbi.nlm.nih.gov/pubmed/22544480

Bigelow, P.L., D.P. Gilkey, S. Greenstein & Kirsch, M.P. (1998a). Evaluation of HomeSafe: An injury and illness prevention program in residential construction. *Work, 11,* 21-33.

Brunette, M.J. (2004). Construction safety research in the U.S.: Targeting the Hispanic workforce. *Injury Prevention, 10*(4), 244-248.

Bureau of Labor Statistics. (2003). Current population survey, 2006, and labor force, employment and unemployment from the current population survey. In *BLS handbook of methods.* Retrieved from http://www.bls.gov/cps/home.htm

Canales, A.R., Arbelaez, M., Vasquez, E., Aveiga, F., Strong, K., Walters, R., et al. (2009). Exploring training needs and development of construction language courses for American supervisors and Hispanic craft workers. *Journal of Construction Engineering & Management, 135*(5), 387-396. Retrieved from http://ascelibrary.org/doi/pdf/10.1061/%28ASCE%290733-9364-%282009%29135%3A5%28387%29

Carifio, J. & Perla, R. (2008). Resolving the 50-year debate around using an misusing Likert scales. *Medical Education, 42,* 1150-1152.

CDC. (2008). Work-related deaths among Hispanics, U.S., 1992-2006. *Morbidity & Mortality Weekly Report.* Retrieved from http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5722a1.htm

Center for Construction Research and Training (CPWR). (2009). Hispanic employment in construction. *CPWR, 1*(1). Retrieved from http://www.elcosh.org/record/document/1034/d000989.PDF

Choudhry, R., Fang, D. & Mohamed, S. (2007). The nature of safety culture: A survey of the state-of-the-art. *Safety Science, 45,* 993-1012.

Cooper, M.D. (2000). Toward a model of safety culture. *Safety Science, 36,* 111-136.

CPWR. Immigrant workers in U.S. constitution: Sharing lesson learned in our unions.

Franklin, J.C. (2007, Nov.). Employment outlook: 2006-16: An overview of BLS projections to 2016. *Monthly Labor Review,* 3-12. Retrieved from http://www.bls.gov/opub/mlr/2007/11/art1full.pdf

Geller, E.S. (1990). Overview of the Safety Performance Solutions Inc. safety culture survey. Blacksburg, VA: Safety Performance Solutions Inc.

Geller, E.S. (1996). *The psychology of safety.* Radnor, PA: Chilton Book Co.

Gilkey, D.P., Bigelow, P.L., Herron, R., Greenstein, S., Chadwick, B.R. & Fowler, J.K. (1998). The HomeSafe

Compared to other companies, I think mine is rather risky.										0.75
21	16	10	6	11	12	14	8	2	2	
31%	24%	15%	9%	16%	32%	37%	21%	5%	5%	
Mean: 2.40					Mean: 2.20					
Working safely is the Number One priority in my company.										0.06
2	5	4	11	43	6	2	5	8	17	
3%	8%	6%	16%	64%	16%	5%	13%	21%	45%	
Mean: 4.20					Mean: 3.70					
I have received adequate job safety training.										0.86
3	0	4	16	42	2	1	1	12	22	
5%	0%	6%	24%	63%	5%	3%	3%	32%	58%	
Mean: 4.30					Mean: 4.30					
Many first-aid cases in my company go unreported.										0.11
17	13	10	12	13	13	11	8	3	3	
25%	19%	15%	18%	19%	34%	29%	21%	8%	8%	
Mean: 2.80					Mean: 2.30					
Information needed to work safely is made available to all employees.										0.03
1	2	3	12	49	2	4	2	10	20	
2%	3.0%	5%	18%	73%	5%	11%	5%	26%	53%	
Mean: 4.60					Mean: 4.10					
Management here seems genuinely interested in reducing injury rates.										0.71
0	1	4	18	42	3	2	3	5	24	
0%	2.0%	6%	27%	63%	8%	5%	8%	13%	63%	
Mean: 4.40					Mean: 4.10					
Safety audits are conducted regularly in my company to check the use of PPE.										0.05
2	2	6	19	37	3	4	4	7	20	
3%	3%	9%	28%	55%	8%	11%	11%	18%	53%	
Mean: 4.10					Mean: 4.00					
I know how to do my job safely.										0.32
1	0	1	19	46	2	0	1	5	30	
2%	0.0%	2%	28%	69%	5%	0.0%	3.0%	13%	79%	
Mean: 4.60					Mean: 4.60					
Employees in my company would not feel comfortable if their work practices were observed and recorded.										0.06
11	4	13	21	17	7	7	11	8	5	
16%	6%	19%	31%	25%	18%	18%	29%	21%	13%	
Mean: 3.40					Mean: 2.90					
Teamwork and collaboration are encouraged to reduce safety hazards.										0.03
1	1	5	13	47	2	1	5	12	18	
2%	2.0%	8%	19%	70%	5%	3%	13%	32%	47%	
Mean: 4.50					Mean: 4.10					
I always follow the safety rules and procedures when doing my job.										< 0.01
0	0	6	15	45	2	1	8	14	13	
0.0%	0.0%	9%	22%	67%	5%	3%	21%	37%	34%	
Mean: 4.50					Mean: 3.90					
I have the PPE I need to do my job safely.										0.85
2	0	2	14	49	2	0	1	8	27	
3%	0.0%	3.0%	21%	73%	5%	0%	3%	21%	71%	
Mean: 4.60					Mean: 4.50					
Some safety rules and procedures are difficult to understand.										0.12
16	6	18	15	11	13	5	11	7	2	
24%	9%	27%	22%	16%	34%	13%	29%	18%	5%	
Mean: 2.90					Mean: 2.50					
Immigrant workers are more likely to suffer accidents than American workers.										0.89
17	11	14	9	14	12	5	10	5	6	
25%	16%	21%	13%	21%	32%	13%	26%	13%	16%	
Mean 2.70					Mean: 2.70					
Immigrant workers make the worksite unsafe for all workers.										0.23
35	11	8	8	5	14	8	9	4	3	
52%	16%	12%	12%	8%	37%	21%	24%	11%	8%	
Mean: 2.10					Mean: 2.30					
Accidents can happen to anyone.										0.36
1	1	0	9	56	4	2	1	2	29	
2%	2.00%	0.0%	13%	84%	11%	5%	3%	5%	76%	
Mean: 4.80					Mean: 4.30					
I am willing to take more risks than my coworkers.										0.31
22%	10%	9%	4%	7%	3	6	3	2	2	
42%	19%	17%	8%	13%	19%	38%	19%	13%	13%	
Mean: 2.30					Mean: 2.60					
The dangers present on construction sites cannot cause my death or the death of others.										0.55
26	5	2	4	15	8	2	4	0	2	
49%	9%	4%	8%	28%	50%	13%	25%	0%	13%	
Mean 2.60					Mean: 2.90					
I have control over the dangers I encounter on construction sites.										0.43
2	4	11	8	28	1	1	1	9	4	
4%	8%	21%	15%	53%	6%	6%	6%	56	25%	
Mean: 4.00					Mean: 3.90					

Table 4b Responses for Commercial Sector, Latino vs. Non-Latino

pilot program: A novel approach to injury prevention in residential construction. *Work, 10,* 167-180.

Gilkey, D., Lopez del Puerto, C., Keefe, T., Bigelow, P., Herron, R., Rosecrance, J. & Chen, P. (2012). Safety culture in residential construction: Managers vs. workers. *Journal of Construction Engineering and Management.*

Gilkey, D. & Lopez del Puerto, C. (2011). Building safety culture with Latino and non-Latino Construction Workers. ASSE Professional Development Conference & Exposition, Chicago, IL.

Glendon, A. & Litherland, D. (2001). Safety climate factors, group differences and safety behavior in road construction. *Safety Science,* 39, 157-188.

Jamieson, S. (2004). Likert scales: How to (ab)use them. *Medical Education, 38,* 1212-1218.

Kalarao, N. (2004, June). Breaching the language barrier. *Occupational Safety and Health, 73*(6), 60-65.

Latino & Latino. (2006). *Root-cause analysis.* Boca Raton, FL: Taylor & Francis.

Menzel, N.N. & Gutiérrez, A.P. (2010). Latino worker perception of construction risks. *American Journal of Industrial Medicine, 53,* 179-187.

Oakley, J. *Accident investigation techniques.* Des Planes, IL; ASSE.

OSHA. (2010). OSHA training standards policy statement. Retrieved from http://www.osha.gov/dep/standards-policy-statement-memo-04-28-10.html

O'Toole, M. (2002). The relationship between employees' perceptions of safety and organizational culture. *Journal of Safety Research, 33,* 231-243.

Pell, G. (2005). Use and misuse of Likert scales. *Medical Education, 39,* 970.

Roelofs, C., Sprague-Martinez, L., Brunette, M.N. & Azaroff, L. (2011). A qualitative investigation of Hispanic construction worker perspectives on factors impacting safety and risk. *Environmental Health Perspectives, 10,* 1-9.

Ruttenberg, R.M.L. (2004). Spanish-speaking construction workers discuss their safety needs and experiences. Silver Spring, MD: The Center to Protect Workers' Rights. Retrieved from http://www.cpwr.com/pdfs/pubs/research_pubs/krruttenbergreport.pdf

Thompson, P. & Siddiqi, K. (2007). Best practices for improving safety among Hispanic construction workers. 43rd Annual International Conference of Associated Schools of Construction at Northern Arizona University in Flagstaff, AZ. Retrieved from http://ascpro0.ascweb.org/archives/cd/2007/paper/CPRT116002007.pdf

U.S. Census Bureau. (1977, May 12). Directive No. 15: Race and ethnic standards for federal statistics and administrative reporting. Retrieved from http://wonder.cdc.gov/wonder/help/populations/bridged-race/Directive15.html

U.S. Census Bureau. (2011). The Hispanic population: 2010. The U.S. Census Bureau. Retrieved from http://www.census.gov/prod/cen2010/briefs/c2010br-04.pdf

U.S. Department of Labor. (2012). The Latino labor force at a glance. Washington, DC: U.S. Department of Labor, Author. Retrieved from http://www.dol.gov/_sec/media/reports/HispanicLaborForce/HispanicLaborForce.pdf

Vazquez, R.F., & Stalnaker, C. K. (2004). Latino workers in the construction industry overcoming the language barrier improves safety. *Professional Safety.*

Williams, Q., Ochsner, M., Marshall, E., Kimmel, L., & Martino, C. (2010). The impact of a peer-led participatory health and safety training program for Latino day laborers in construction. *Journal of Safety Research, 41*(3), 253-261.

Zohar, D. (1980). Safety climate in industrial organizations and applied implications. *Journal of Applied Psychology, 1,* 96-102.

Zohar, D. (2010). Thirty years of safety climate research: Reflections and future directions. *Accident Analysis & Prevention,* 42.

Latino					Non-Latino					
Highly Disagree	Disagree	Neither Agree or Disagree	Agree	Highly Agree	Highly Disagree	Disagree	Neither Agree or Disagree	Agree	Highly Agree	Mann-Whitney P-Value
The risk level of my job concerns me quite a bit.										< 0.01
8	5	7	7	28	12	5	13	12	12	
15%	9%	13%	13%	51%	22%	9%	24%	22%	22%	
Mean: 3.80					Mean: 3.10					
When told about safety hazards, supervisors are appreciative and try to correct them quickly.										0.48
2	2	2	8	38	1	3	2	15	32	
4%	4%	4%	15%	69%	2%	6%	4%	28%	59%	
Mean: 4.30					Mean: 4.30					
My immediate supervisor is well informed about relevant safety issues.										0.28
3	0	2	12	37	1	2	5	13	32	
6%	0%	4%	22%	69%	2%	4%	9%	24%	59%	
Mean: 4.50					Mean: 4.30					
It is the responsibility of each employee to seek out opportunities to prevent injury.										0.46
1	1	1	7	44	2	0	1	4	47	
2%	2%	2%	13%	82%	4%	0%	2%	7%	87%	
Mean: 4.70					Mean: 4.70					
At my company, work productivity and quality usually have a higher priority than work safety.										0.06
15	7	7	7	17	17	17	7	8	5	
28%	13%	13%	13%	32%	32%	32%	13%	15%	9%	
Mean: 3.00					2.40					
The managers in my company really care about safety and try to reduce risk levels as much as possible.										0.95
1	1	1	15	34	1	1	2	17	33	
2%	2%	2%	28%	63%	2%	2%	4%	32%	61%	
Mean: 4.40					Mean 4.50					
When I see a potential safety hazard (e.g., oil spill), I am willing to correct it myself if possible.										0.80
3	1	2	12	34	2	3	0	18	31	
6%	2%	4%	22%	63%	4%	6%	0%	33%	57%	
Mean: 4.20					Mean: 4.40					
Management places most of the blame for an accident on the injured employee.										<0.01
5	7	13	12	18	14	9	20	5	6	
9%	13%	24%	22%	29%	26%	17%	37%	9%	11%	
Mean: 3.40					Mean: 2.60					
Near misses are consistently reported and investigated at our company.										0.063
7	4	6	24	22	3	8	11	14	18	
13%	7%	11%	26%	41%	6%	15%	20%	26%	33%	
Mean: 3.60					Mean: 3.70					
I am willing to warn my coworkers about working unsafely.										0.88
2	1	1	10	39	1	2	2	11	38	
4%	2%	2%	19%	73%	2%	4%	4%	20%	70%	
Mean: 4.50					Mean: 4.50					
Employees seen behaving unsafely in my company are usually given corrective feedback by their coworkers.										0.38
1	2	13	25	54	1	4	4	21	24	
2%	4%	13%	26%	56%	2%	7%	7%	39%	44%	
Mean: 4.30					Mean: 4.20					

Table 5a Responses for Heavy Civil Sector, Latino vs. Non-Latino

Compared to other companies, I think mine is rather risky.										0.19
19	9	12	6	8	21	15	11	3	4	
35%	17%	22%	11%	15%	39%	28%	20%	6%	7%	
Mean: 2.50					Mean: 2.10					
Working safely is the Number One priority in my company.										0.83
1	1	3	13	34	1	2	4	12	35	
2%	2%	6%	24%	63%	2%	4%	7%	22%	65%	
Mean: 4.30					Mean: 3.70					
I have received adequate job safety training.										0.78
1	0	1	13	37	1	0	2	13	38	
2%	0%	2%	24%	69%	2%	0%	4%	24%	70%	
Mean: 4.50					Mean: 4.60					
Many first-aid cases in my company go unreported.										0.05
20	5	5	11	12	22	14	9	5	3	
37%	9%	9%	20%	22%	41%	26%	17%	9%	6%	
Mean: 2.70					Mean: 2.10					
Information needed to work safely is made available to all employees.										0.32
1	0	1	17	30	1	0	2	13	38	
2%	0%	2%	33%	59%	2%	0%	4%	24%	70%	
Mean: 4.30					Mean: 4.60					
Management here seems genuinely interested in reducing injury rates.										0.33
3	0	3	14	31	1	1	1	14	37	
6%	0%	6%	28%	61%	2%	2%	2%	26%	69%	
Mean: 4.40					Mean: 4.60					
Safety audits are conducted regularly in my company to check the use of PPE.										0.80
2	1	2	13	30	1	1	4	14	34	
4%	2%	4%	27%	61%	2%	2%	7%	26%	63%	
Mean: 4.30					Mean: 4.50					
I know how to do my job safely.										0.02
0	1	1	13	32	1	0	0	7	46	
0%	2%	2%	27%	65%	2%	0%	0%	13%	85%	
Mean: 4.40					Mean: 4.80					
Employees in my company would not feel comfortable if their work practices were observed and recorded.										<0.01
3	2	4	13	25	14	10	14	9	7	
6%	4%	8%	27%	51%	26%	19%	26%	17%	13%	
Mean: 4.00					Mean: 2.70					
Teamwork and collaboration are encouraged to reduce safety hazards.										0.02
2	0	0	8	39	0	1	4	18	31	
4%	0%	0%	16%	80%	0%	2%	7%	33%	57%	
Mean: 4.70					Mean: 4.50					
I always follow the safety rules and procedures when doing my job.										0.63
1	0	2	9	35	0	1	5	21	27	
2%	0%	4%	18%	71%	0%	2%	9%	39%	50%	
Mean: 4.40					Mean: 4.40					
I have the PPE I need to do my job safely.										0.97
1	0	0	9	38	2	2	0	8	42	
2%	0%	0%	18%	78%	4%	4%	0%	15%	78%	
Mean: 4.60					Mean: 4.60					
Some safety rules and procedures are difficult to understand.										0.59
16	4	7	11	8	16	19	7	6	6	
33%	8%	14%	22%	16%	30%	35%	13%	11%	11%	
Mean: 2.60					Mean: 2.40					
Immigrant workers are more likely to suffer accidents than American workers.										0.59
23	2	6	5	12	14	12	15	8	5	
47%	4%	12%	10%	25%	26%	22%	28%	15%	9%	
Mean 2.60					Mean: 2.60					
Immigrant workers make the worksite unsafe for all workers.										0.08
32	3	3	7	4	20	14	14	2	4	
65%	6%	6%	14%	8%	37%	26%	26%	4%	7%	
Mean: 1.90					Mean: 2.20					
Accidents can happen to anyone.										0.81
3	0	0	7	39	1	0	3	6	44	
6%	0%	0%	14%	80%	2%	0%	6%	11%	82%	
Mean: 4.60					Mean: 4.70					
I am willing to take more risks than my coworkers.										0.45
22	8	3	7	3	23	14	8	3	5	
49%	18%	7%	16%	7%	43%	26%	15%	6%	9%	
Mean: 2.00					Mean: 2.10					
The dangers present on construction sites cannot cause my death or the death of others.										0.03
17	8	0	6	13	36	3	3	0	11	
38%	18%	0%	13%	29%	68%	6%	6%	0%	21%	
Mean 2.70					Mean: 2.00					
I have control over the dangers I encounter on construction sites.										0.82
6	2	3	12	20	3	5	11	19	24	
14%	5%	7%	28%	47%	6%	9%	21%	19%	45%	
Mean: 3.90					Mean: 3.90					

Table 5b Responses for Heavy Civil Sector, Latino vs. Non-Latino

Refining a More Complete Theory of Environment, Safety & Health Management Strategy Through Confirmatory Research

Elisabeth Maxwell and Anthony Veltri

Abstract

Confirmatory research that employs case studies for testing theory initially developed through exploratory research methods is rarely published in environment, safety and health (ESH) management journals, despite increased interest. An ESH strategy assessment and formulation theory was initially developed using exploratory research methods, which resulted in a multistakeholder view of ESH strategies available to firms and used by firms. A Developmental Levels Rating System (DLRS) was constructed based on that previous research.

This article's purpose is to report the results of confirmatory research about the efficacy of DLRS in providing ESH managers with an empirically based decision-support guidance model for a) assessing their firm's level of ESH strategy development and b) formulating new and advanced levels of ESH strategy. The refined theory offers a series of prompts, rather than a definitive set of standards, when assessing and formulating ESH strategy. Case study methodology was used in this study with within case and cross-case analysis used to analyze the data.

Consistent patterns were found in how ESH strategies were assessed and formulated in the facilities studied, providing support for the future usefulness of the model in manufacturing settings. Moreover, important insights were uncovered regarding the relationship between the manufacturing facilities' levels of management strategy, organizational structure and financing strategy, as well the relationship between the firm's risk exposure and ESH strategy. As a result, the refined theory and the DLRS provides a new pathway for assessing, formulating and integrating ESH management strategy within the larger context of the firm's overall operations strategy.

Keywords
Environment, safety, health, management, operations, business

Contextual Background

The primary objective of this research was to refine a more complete theory for assessing and formulating ESH strategy within the larger context of the firms overall business/operational strategy and to validate the DLRS (Figure 1). This theory and rating system was developed as part of previous research by the current researchers. The current article is an extension of that original research (Veltri & Maxwell, 2008). Manufacturing was selected because it has traditionally experienced high rates of injury and illness, ranking similarly in days away from work, job transfer or restriction rate (DART) with other dangerous occupational settings, such as mining, agriculture and construction (Oregon OSHA, 2011). In 2011, manufacturing in Oregon had a DART rate of 2.9, compared with mining at 2.3, agriculture at 3.9 and construction at 2.3 (Oregon OSHA, 2011).

The DLRS was the model used to evaluate the ESH strategy process within manufacturing firms. The following elements of the framework were employed: a) management strategy, b) organizational structuring and c) financing arrangements. Each element was then assessed by a level of development. The lowest level is the Reactive level (1), which means the firm's strategic posture is to respond to ESH issues as they occur. The next level is Static (2) where the strategic posture is to respond to ESH issues based on the prevailing regulatory requirements. Next is the Active (3) level where the strategic posture is to accept and internalize ESH issues and to extend broad management and technical effort. The highest or best level is the Dynamic (4) level, which the strategic posture is to focus on the competitive value of ESH practices.

A series of case studies was employed in the manufacturing firms to confirm the theory. Two research questions related to the strategy assessment and formulation process were then empirically addressed.

RQ1: How efficacious is the theory in guiding the assessment and formulation of ESH strategy?

RQ2: What is the relationship between the relative levels of ESH risk within manufacturing sites studied compared to their developmental level of ESH strategy?

The aim of the research is to provide ESH managers with a research-based decision-support guidance model for a) assessing their firm's level of ESH strategy development and b) formulating new levels of ESH strategy. The scholarly merit of the research provides a more refined theory for assessing and formulating ESH strategy based on confirmatory research methods and offers a series of prompts, rather than a definitive set of standards.

Broader, more applied-type impacts of the research include the following. For ESH managers, the research provides a new pathway for assessing, formulating and integrating ESH

Elisabeth Maxwell is an instructor in the College of Public Health and Human Sciences in the School of Social and Behavioral Health Sciences at Oregon State University. She may be contacted at elisabeth.maxwell@oregonstate.edu.

Anthony Veltri is an associate professor in the College of Public Health at Oregon State University.

Model Development & Framework
Elements of a Firm's ESH Management Strategy:

1) Strategy Formulation: The manner in which the firm intends on confronting and managing ESH issues.

2) Organization Structure: The manner in which the firm structures ESH strategy within the organization of the firm.

3) Financing Strategy: The manner in which the firm funds ESH strategy.

Developmental Levels of ESH Management Strategy Within a Firm:

Level 1 (Reactive)	Strategic posture is to respond to ESH issues as they occur.
Level 2 (Static)	Strategic posture is to respond to ESH issues based on the prevailing regulatory requirements.
Level 3 (Active)	Strategic posture is to accept and internalize ESH issues and extend broad management and technical effort.
Level 4 (Dynamic)	Strategic posture is to focus on the competitive value of ESH practices.

Figure 1 Developmental Levels Rating System (DLRS)

strategy within the larger context of the firms overall business/operations strategy. For ESH educators, the research provides evidence-based research for educating students on the real-world applications of ESH strategy. For ESH researchers, the research provides a means to expand on the major insights gleaned from this research area. Specifically, the discovery of the linkages between ESH and the competitive performance of the firm could be explored. For students, the research provides a framework for enhancing their understanding of the functional strategies and technical practices of the field and to make informed strategic and tactical decisions for the firms they will eventually service. This article introduces the need for expanding this underrepresented research area. It provides a review of literature that shows how the research is grounded in previous research and how the authors went beyond the existing research in important ways. This is followed by the research methodology used, analysis, results and discussion.

Introduction

The ESH profession has historically conducted research in manufacturing firms to protect workers and the environment and has tied its outcomes to many significant priorities: illness and injury prevention, environmental sustainability, corporate social responsibility, regulatory compliance, fulfilling insurance requirements and responding to nongovernmental organization (NGO) pressures (Levy, et al., 2006). However, ESH research literature is weak in a critical priority that links strategy to the operational performance strategy of the firm (Walls, et al., 2011). Research rarely explicitly examines ESH strategy in the broader context of operations strategy. This oversight makes prescriptions for integrating ESH and operations strategies difficult with the possibility that key strategic relationships remain undiscovered. The operations management literature suggests that well thought-out operations management strategies could make improvements in meeting operational goals by emphasizing ESH strategies as part of an overall operations strategy (Corbett & Klassen, 2006; Das, et al., 2008; Porter, 1995; Tompa, et al., 2009). This suggestion could exploit an ESH perspective as a criterion for making operational decisions, and operational perspectives could become a criterion for making ESH decisions.

In recent years, an idea has emerged that discovering new and advanced levels of strategy for ESH, which are connected with operational strategies, could enhance the understanding of how to improve workplace ESH strategy, practices and outcomes (Menon & Menon, 1997). Moreover, in the ESH academic field, there has been discussion of this area as underrepresented in research (ASSE, 2002; European Agency for Safety at Work, 2004; Kleindorfer, et al., 2005; NIOSH, 2009; Ward, et al., 1995; World Resources Institute, 2011). As far back as 1996, Brown wrote a seminal paper highlighting the need for research on ESH strategy in operational settings.

Poorly designed ESH strategies clearly cost business and society dearly (including the individual impacts for workers, families and communities), but ESH is still often perceived to be in conflict with the goal of adding value or maximizing profit, making most managers wary of doing more than meeting regulatory requirements (Asche & Aven, 2004; Kleindorfer, et al., 2005). There is growing interest in investing in companies with better ESH records and in indexes that provide an assessment of ESH strategies and technical practices in operations (ASSE, 2002; Innovest, 2011; Investorideas, 2008). This may provide an incentive to laggards to improve their own ESH performance, but these indexes cannot provide insight into how to assess and formulate ESH strategy or how to link strategy within the larger context of the firms overall operational strategy. Figure 2 depicts what is generally known and unknown about ESH and operational strategies.

Literature Review

The literature review is focused on how this research is grounded in previous research and how the authors went beyond the previous research in important ways. The review of literature is organized around a central theme of linking ESH strategy assessment and formulation within the larger context of the firm's overall operational strategy. Other technical functions, such as

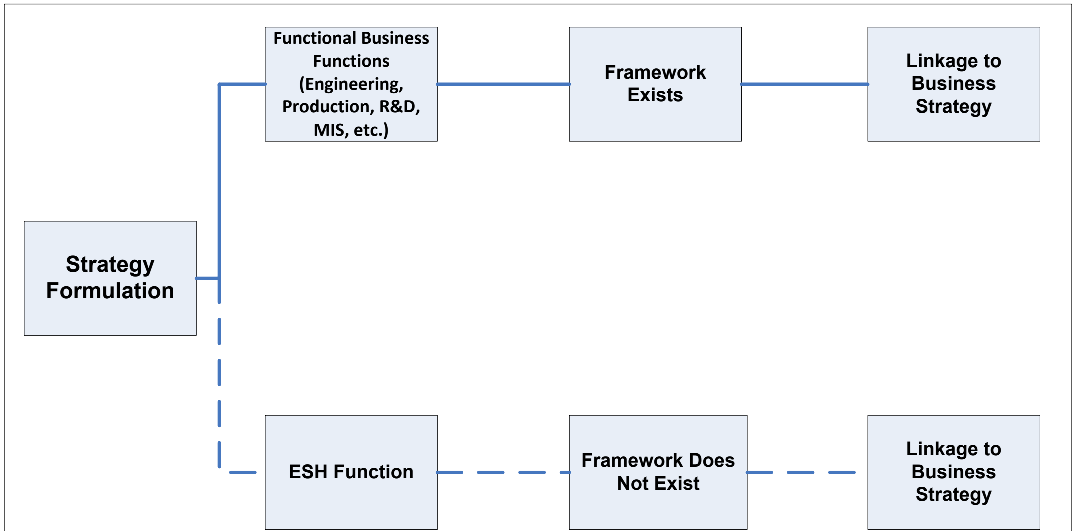


Figure 2 What Is Known & (Generally) Unknown About ESH & Business Strategy

operations management, design and process engineering, information systems and so on have professional guidance in the literature about assessing and formulating their strategy and linking it to the firm's overall operational strategy (Adam & Swamidass 1989, Adler, et al., 1992; Kiernan, 1993; Porter, 1998).

However, specialists in ESH have not received comparable guidance in the research literature despite increased interest in augmenting the prevailing regulatory compliance strategy with a more operational-driven strategy (Newman & Hanna, 1996; Simpson & Sampson, 2010). Because no empirically based models exist, ESH specialists who want to assess and formulate their function's overall management strategy have needed to satisfy themselves with piecemeal approaches. ESH managers must frequently juggle many issues (e.g., maintaining compliance with ESH regulations, assessing and controlling exposures, characterizing risk, minimizing contingent liability) usually without a means for setting strategic priorities or a method for assessing and integrating priorities into operational practices. A common rallying cry of many ESH specialists is that ESH strategy must be integrated into everyday operations management decisions, yet few specify what that means. One reason why so many firms have struggled to integrate ESH strategy into operations is that they are unsure what strategy and practices they should pursue and how to go about it.

Strategy Research in Operations & ESH

Both operations and ESH management researchers have studied the ESH implications of operations management strategy and whether increasing the operational performance of the firm always must be at the cost of social goods, such as environmental, occupational and community health (Hunt, 1999; Pagel & Gobili, 2011; Porter, 1985; Reinhardt, 1998; Reinhardt, 1999). In operations management, interest in assessing and formulating strategy and its link to competitive performance and which theories describe the linkage best has a long history of discussion, and researchers have developed strategy assessment and formulation frameworks (Adam, et al., 1988; Barney, 1986; Platts, 1994; Swink & Way, 1995; Voss, 1995). Theories have been proposed describing the different ways to structure operations management strategy, most notably the resource-based view of the firm, which focuses on the firm's internal resources and how to use them through strategy to achieve operational performance.

New theories and evidenced-based research continue to be conducted into how operations strategy is formulated, constructed and financed (Andrews, et al., 2009; Hart, 1995; Nath, et al., 2010; Sveiby, 2001). In recent years, there has been a new notion that strategy research in ESH should focus on the discovery of new routes of strategy that are connected with operations strategy, which could enhance the understanding of how to improve ESH practices and outcomes (Menon & Menon, 1997). One theory put forth by Hunt and Auster (1990) was a proposed stage system for evaluating corporate environmental management programs. A framework was developed to guide evaluation with stages ranging from Stage One ("no protection") to Stage Five ("maximum protection"). However, nowhere in the study do they report that they used any method for validating the system or for trying to describe any relationship to a performance outcome.

One study that attempted to validate the efficacy of ESH strategy assessment and formulation frameworks was by Henriques and Sadorsky (1999). However, this study focused solely on the firm's perceptions of a single managerial stakeholder and not on its link to operational strategy. Another study that investigated environmental strategies used by managers at small firms in Britain found that several approaches were used to address environmental issues, including strategic, piecemeal, accidental and omitted (Tilley, 1999). However, this study did not provide a usable framework or tool for further testing or use in the ESH field. Moreover, regarding safety management systems, a meta-analysis of 13 studies by Robson, et al. (2007) found insufficient evidence to recommend any safety management systems. They found that the studies were weak methodologically and, therefore, were limited in their generalizability.

As the literature suggests, the ESH function has a long history of assessing and formulating strategy; however, it has primarily been constructed around reacting to pressures from outside concerns (e.g., government agencies, insurance carriers, NGOs) with little attention to linking it to the firm's competitive operational strategy (Brown, 1994; Hunt & Auster, 1990; Roome, 1992; Sharma, 2000; Singh, 2000). The emphasis on formulating and linking ESH strategy to the firm's operational strategy should not be interpreted in this article to mean that there is an intention to deemphasize the importance of compliance with the pressures from outside concerns from communities, workers, NGOs and regulators (Hunt & Auster, 1990). Attention to outside concerns is a significant part of ESH strategy, and formulating an ESH strategy that is linked to the operational strategy of the firm is not intended to replace this critical consideration. However, a strategic focus only on maintaining compliance with ESH regulations should not be expected to yield positive financial returns (Sharma, 2000; Singh, 2000).

ESH Linkage to Operations

Recent recognition of the need to integrate ESH strategy into operations strategy does not seem to have translated into changes in how operations managers view ESH strategy within their own organizations. Part of the explanation for this may be that current research does not exist to shore up the idea, either in the ESH field or in the operations management field. The empirical evidence suggests that most organizations still view ESH from a regulatory compliance perspective rather than looking for ways to address ESH within the larger context of creating competitive advantage (Colbert, 2006).

Epstein and Roy (2003) found that most companies do not make a connection between ESH strategy and operational strategy. Yet, at the internal organizational level, the operative notion of an approach for linking ESH strategy to the firm's operations strategy is financially appealing. Internal finance specialists, design and process engineers and operational managers are extremely interested in being provided an ESH strategy that is most likely to contribute to the firm's business fundamentals (i.e., revenue and earnings growth, quality of management, free cash flow generation) and operating priorities (cost, quality, delivery and flexibility).

However, they are somewhat skeptical of the results of strategy assessments that provide data, such as the number of compliance audits performed, behavior-based training provided and climate perception surveys conducted. A stronger case can be made when actual data are collected, interpreted and linked to business fundamentals and with operating priorities. Externally, there is evidence that the business community is starting to notice the value of ESH. The external financial community, specifically, many investment bankers, view ESH performance as a proxy for other firm business performance behaviors that tend to enhance the overall competitive performance for a firm (Carter & Veltri 1999; Feldman & Soyka, 1997).

Although the evidence-based research results of this claim are not conclusive, a distinct group of firms are beginning to promote a more business and operationally based perspective when looking at how ESH strategy could be important for increasing competitiveness (Hoffman, 2000; López-Gamero, et al., 2010). It may be that assessments of ESH strategy linked to the firm's business fundamentals and operating priorities will become a standard part of the way a firm promotes its competitive business performance and may affect its attractiveness in the external financial marketplace. The investment community is beginning to understand the benefits of ESH strategy that is linked to competitive business performance and has developed stock indexes, such as the Dow Jones Sustainability Group Indexes and Innovest EcoValue 21™. Furthermore, numerous websites and investment firms list stocks and companies that have a dynamic ESH strategy record (Innovest, 2011; Sustainability-index.com, 2011). These indexes provide institutional and retail investors with a financial and social interpretation of the ESH practices and outcomes of a firm.

Methods

The primary objective of this research was to refine a more complete theory for assessing and formulating ESH strategy and to validate the DLRS. The proposition in this study was that the manner in which organizations assess and formulate strategy can impact ESH outcomes. Two research questions were empirically addressed:

RQ1: How efficacious is the theory in guiding the assessment and formulation of ESH strategy?

RQ2: What is the relationship between the relative levels of ESH risk within manufacturing sites studied compared to their developmental level of ESH strategy?

The unit of analysis was the manufacturing factory site. Pattern matching, cross-case comparison and explanation building were used for the analysis. The criteria for interpreting the findings in this study were to identify and address rival explanations. The results may be considered stronger if two or more cases support the same theory but do not appear to support an equally plausible rival theory (Yin, 2009).

Research Phases

In this study, the interview protocol was created on the basis of previously published research (Veltri & Maxwell, 2008). In addition, the interview protocol was reviewed by five experts in the ESH and business/operations management field for accuracy and clarity of the questions. The list of experts was determined by their status as academics with a record of funded and published research in the area of ESH and business/operations management for a minimum of 5 years at research-based universities in the U.S.

Suggestions and feedback received from these experts were reviewed by the two primary researchers and incorporated into an improved interview protocol. Case interviews were then conducted according to the interview protocol. Each case interview was digitally recorded, transcribed, coded and briefly analyzed after each interview. After all case interviews were completed for all cases, full analysis of each case was completed. Subsequently, cross-case comparisons were done between the cases. Records were requested on each case from EPA, OSHA, Department of Consumer and Business Services (DCBS), air quality and experience rating modification (ER Mod). These secondary data were then incorporated into the analysis to obtain an assessment of each facility's level of risk from ESH issues. Arranging the data into arrays, pattern matching and explanation building were then conducted.

DLSR Score	Risk Ranking	ESH Information Listed on Website	OSHA	EPA	Air Quality Orgs	DCBS	ER Mod	NGO or other agency reports of ease of working with and/or responsiveness to issue
1	**High**	None	4 or more violations	4 or more violations	4 or more violations	More than 150 days paid on average per claim	10% to 20% worse than the industry average	Reported to be difficult or unresponsive
2	**Substantial**	Brief mention of ESH activities	2 to 3 violations	2 to 3 violations	2 to 3 violations	100 to 149 days paid on average per claim	1% to 9% worse than the industry average	Reported some difficulty in working with
3	**Possible**	ESH mission statement and moderate amount of ESH activities	1 violation	1 violation	1 violation	50 to 99 days paid on average per claim	1% to 9% better than the industry average	Little difficulty in working with
4	**Slight**	ESH mission statement and large amount of webpage devoted to ESH activities	0 violations	0 violations	0 violations	1 to 49 days paid on average per claim	10% to 20% better than the industry average	Reported to be easy to work with and responsive

Table 1 Secondary Data Scoring Matrix

Sample Selection

In theory refinement research, it is suggested to use random sampling of the population of interest (Cook & Campbell, 1979). However, in case study research, the sample can be purposeful with some theoretical underpinnings (Eisenhardt, 1989; Miles & Huberman, 1994). The theoretical underpinning of this research was to provide ESH manufacturing managers with an empirically based decision-support guidance model for a) assessing their firm's developmental level of ESH strategy and b) formulating new and advanced levels of ESH strategy. Therefore, the selected sample was comprised of manufacturing companies of various sizes that had already participated in ESH research in the recent past of a similar nature.

Yin suggests using between two and six replications, depending on how complex the issue being studied is. Eisenhardt (1989) reports that the recommended number of cases varies, but "a number between 4 and 10 cases usually works well" (Eisenhardt, 1989). Fewer than four cases can be difficult to generate and refine theory with much complexity and is likely to be unconvincing, whereas more than 10 cases can become difficult to cope with the complexity and volume of the data. In this study, the selection of five cases fits into these recommendations. In addition, it was thought that the phenomenon would be found in a variety of manufacturing business structures in Oregon. This also assisted in comparing the five companies because they operate in the same regulatory environment and with the same oversight such as Oregon OSHA.

Ten companies were contacted, and five agreed to participate in this study. Of the 10 companies, when an actual person was reached, consent was provided in five instances. Five of the companies contacted never responded to telephone or e-mail contact. All five companies that participated in the study had some type of ESH strategy and technical practices embedded in their company operations. The sample was constructed to include companies of different sizes and industries within manufacturing, ranging from food to wood products.

Interview Protocol

A semistructured interview protocol was used at all organizations and provided the flexibility to focus on what was unique and similar at each of the companies (Eisenhardt, 1989). Interviews lasted from 60 to 90 minutes and included a facility tour. After each site visit, the digital interview files were transcribed, and field notes were edited and checked for accuracy. The transcribed notes were then given to a second researcher to check for any inaccuracies or issues of clarity. In addition, the interviewer also took notes to record impressions, context and any other relevant information. Any new or interesting areas that arose from the data were added to the protocol for subsequent cases (Eisenhardt, 1989; Yin, 2009).

Data Collection

Research design was based on the recommendations of experts in case study research (Eisenhardt, 1989; Handfield & Melnyk, 1998; Miles & Huberman, 1994; Yin, 2009). The three principles of data collection in case study methodology were used in this study (Yin, 2009). Multiple sources of evidence were gathered to create converging lines of inquiry or triangulation. Internal data about ESH strategy, structure, financing and outcomes were gathered from plant-level interviews with operations managers, human resources representatives and ESH specialists, from plant observation and from secondary data sources (EPA, OSHA, DCBS and local NGOs). These secondary sources also serve as a form of triangulation to compare the statements of the internal stakeholders (Yin, 2009). A case study database was created, which consisted of the data and interpretations of the data, and a chain of evidence was also maintained.

Moreover, the secondary data provided the risk assessment for each case. Table 1 shows how the secondary data were scored. For example, four or more violations each from EPA, OSHA and the local air quality organization yielded a score of 1 and a risk rating of High, whereas a company with zero violations from those same agencies yielded a score of 4 and a risk rating of Slight. These risk assessments were then paired with the DLRS scores (e.g., Reactive/Substantial Risk) to create a depiction of each case as shown in Figures 4 through 8.

Facility tours were part of the data collection effort. Internal consistency was ensured by taking plant tours. This provided contextual information and in-depth understanding of the plant processes and helped with triangulation (Wu & Choi, 2005). Moreover, line-level employees, engineers and operation supervisors, maintenance staff and other functional entities were routinely interviewed on a more informal basis while touring a facility. Although these data were not digitally recorded, it was included in the notes on each case facility and sometimes was quite relevant in reinforcing other data. This also served as another form of triangulation—gathering other pieces of data to shore up or disprove data collected in more formal, recorded interviews (Yin, 2009). Finally, data were also gathered from publicly available sources when available. Websites, published articles and reports from NGOs and regulators all formed part of the secondary data collected for each organization.

Another part of triangulation that mitigates biases and enhances reliability and validity involves combining observations from multiple researchers, data from multiple sources and/or different types of data (Eisenhardt, 1989; Jick, 1979; Yin, 2009). In addition, background information was also requested for all sites where interviews took place (e.g., organizational charts, mission statements, public reports). Gathering information from multiple respondents and sources, as well as the site visits, allowed researchers to mitigate many potential sources of bias. For example, interviewing several employees at each facility provided different perspectives on the same incidents or policies at the company. Triangulation allows for any inconsistencies to be followed up on and for greater confidence in the data that appear to be consistent.

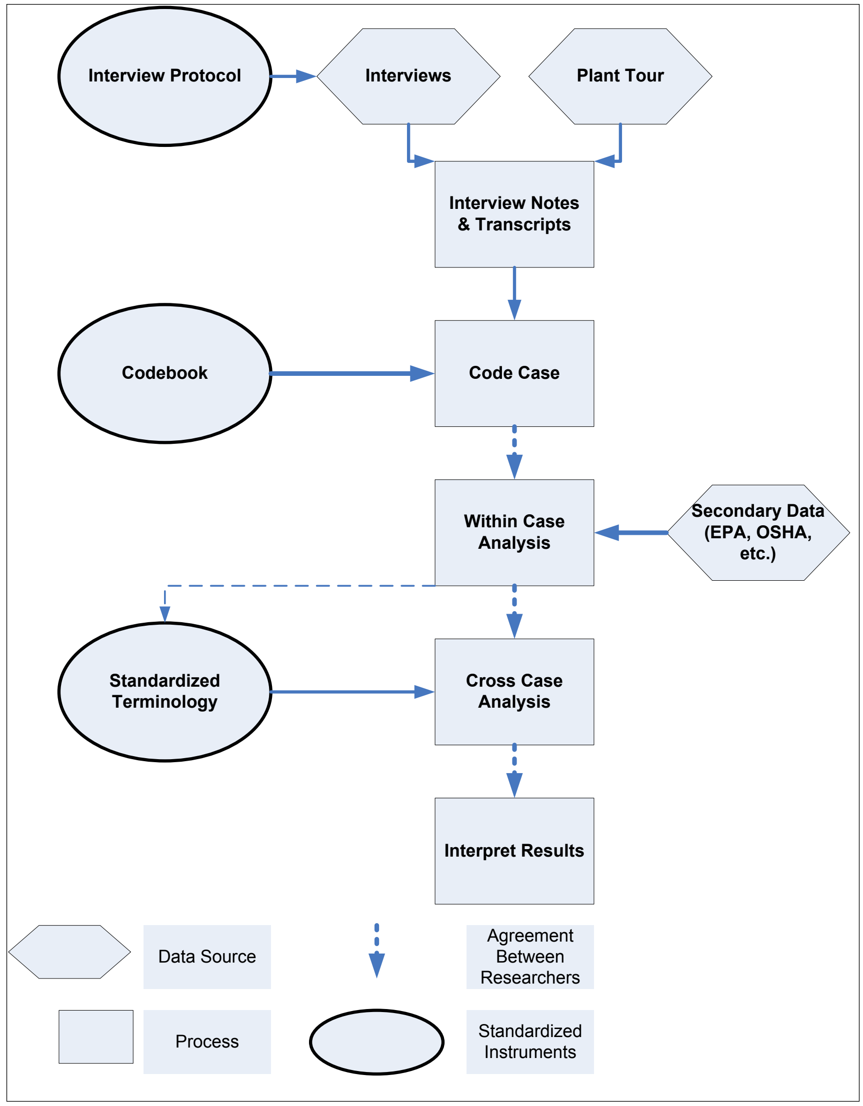


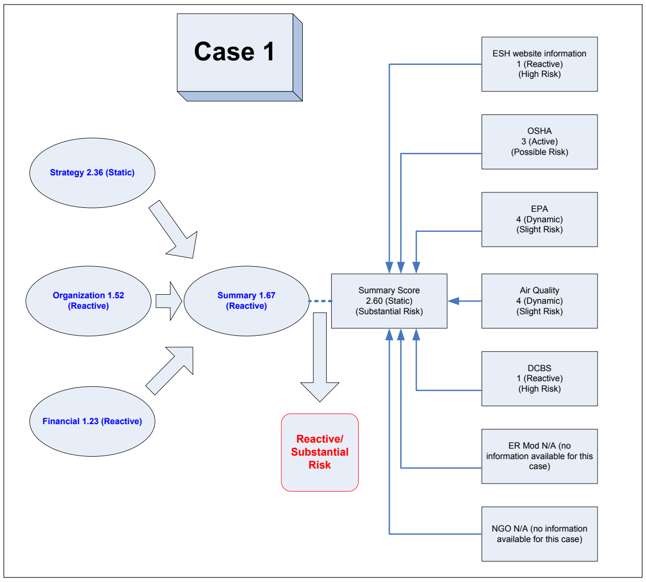
Figure 3 Coding & Analysis Process

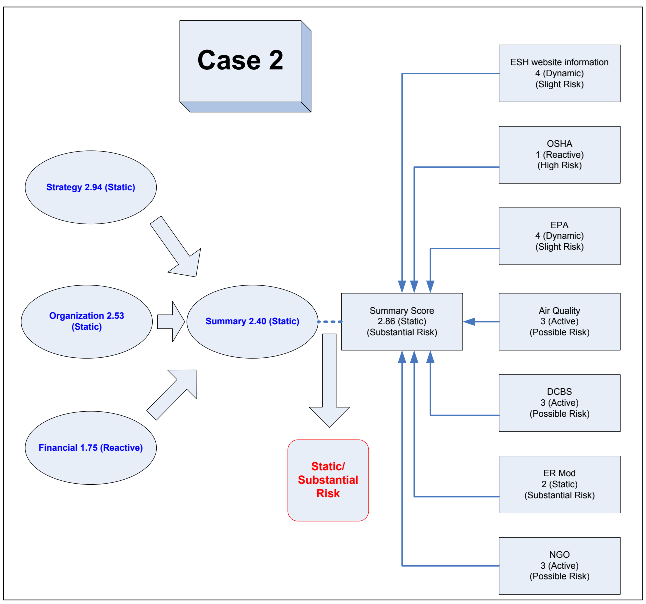
Coding

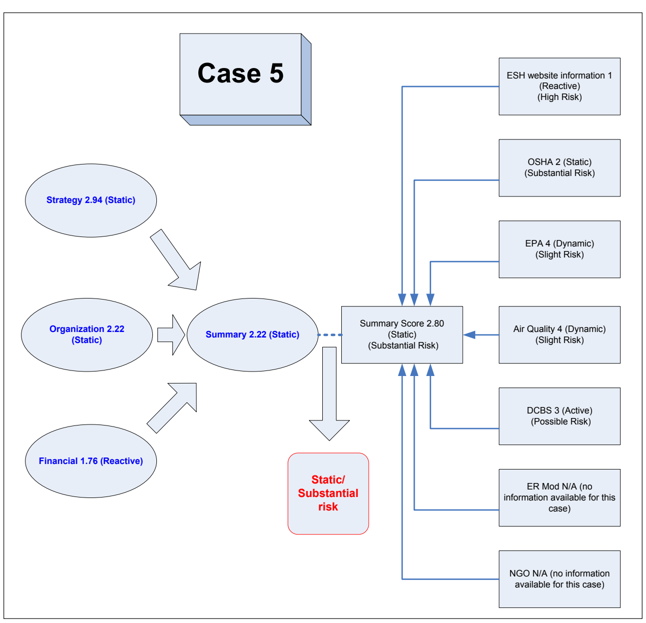
Coding was based on the transcripts, interviewer notes and secondary data (Figure 3). Coding included the construction of a code book. The code book defined terminology and constructs in a consistent way, including the coding scheme based on the framework of the DLRS. When inconsistencies existed between the data sources, respondents were contacted for clarification. This was done via telephone and e-mail.

After transcription, the data were coded into the categories and scored. Another researcher assisted with coding issues, and inconsistencies were discussed and agreed upon. This process increases the validity of the coding process. Two primary components of data analysis were within and cross-case analysis. Within case analysis helped examine the elements of the ESH management strategy. The cross-case analysis served as a form of replication where the constructs of interest were compared between cases to determine patterns and explanations (Yin, 2009).

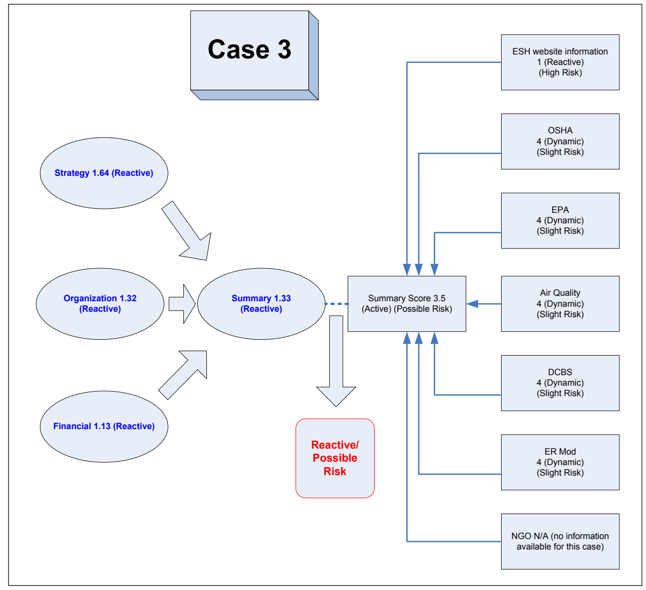
In case study research, issues of validity and reliability are addressed in several ways (Table 2). Construct validity was addressed during the data collection stage of this study. Multiple

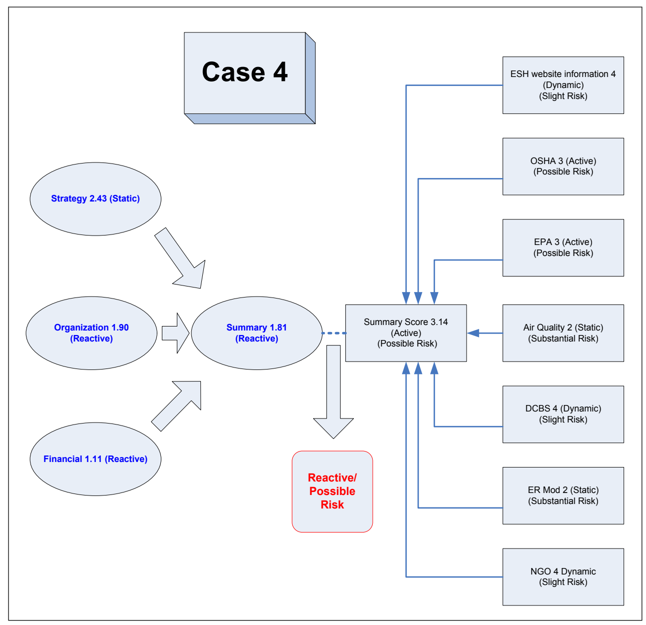






Cases 2 and 5 are shown together as they were assessed to have the same scores—Static/Substantial Risk.





Figures 4-8: Cases 1, 2, 5, 3 & 4 DLSR & Risk Profile

sources of evidence and a chain of evidence increased the construct validity of this study. Internal validity is an issue for case study research involving causality, which this study does not attempt to address.

Although case studies in general lack external validity, it can be addressed through replication (Eisenhardt, 1989; Yin, 2009). In the current study, each case was a replication of the others. A phenomenon found in all five cases may point the way for future research to address issues of causality, generalizability and predictability.

Although these five cases cannot be used to generalize to a larger population, they can be used to form the basis for future research and the types of manufacturing firms that might be selected to replicate these findings or to test the findings in different settings. Reliability was addressed in this study by using a case study protocol with a semistructured interview tool and the use of a case study database where the questions and subjects' responses were catalogued and coded.

Tests	Case Study Tactic	Phase of Research
Construct Validity Identify correct operational measures for the concepts being studied.	Use multiple sources of evidence √ Establish chain of evidence √	Data collection
Internal Validity Seek to establish a causal relationship, whereby certain conditions are believed to lead to other conditions, as distinguished from spurious relationships.	Do pattern matching √ Do explanation building √ Address rival explanations √	Data analysis
External Validity Define the domain to which a study's findings can be generalized.	Use replication logic in multiple-case studies √	Research design
Reliability Demonstrate that the operations of a study—such as the data collection procedures—can be repeated with the same results.	Use case study protocol √ Develop case study database √	Data collection

√: Tactic used in this study

Table 2 Case Study Validity & Reliability Methods Used

Results

The five cases all consisted of manufacturing plants. Table 3 provides profiles for the facilities. Table 4 provides a full description of secondary data gathered on each case. Table 5 provides a description of the secondary data scores for each case. Cases 1, 2 and 5 were assessed to have substantial risk, and Cases 3 and 4 were assessed to have possible risk. Within case analysis is a process of data reduction and data management (Miles & Huberman, 1994). For this research, there were six to ten pages of transcripts per organization, plus site visit notes and any publicly available information. The goal of the within case analysis was to structure, define, reduce and make sense of these varied pieces of information. The within case analysis had several main components. The first component was to understand how the ESH function was structured at each facility. The second component was to understand how people interviewed viewed their ESH management strategy. The third component was to look at each element of the DLSR system (strategy, organization and financial) and provide a score relating to the level (reactive, static, active or dynamic) (Table 6). The last component was to compare the score with secondary data that were gathered (Table 7).

The cross-case analysis was concerned with identifying patterns across the various organizations. It was facilitated by using a variety of tools to reduce the amount of data and to display the data in a meaningful fashion (Miles & Huberman 1994; Yin, 2009). Data reduction was primarily done through categorization and pattern matching. The end result of the within case analysis was the index scores of the DLRS for each case. Factors associated with each level were also analyzed. To facilitate the cross-case analysis, the cases were compared to one another and their levels of risk were assessed using the secondary data scores. The data were then arranged and rearranged in various configurations to search for patterns and explanations.

In the Strategy dimension of the DLSR (Table 6), the cases attained a variety of scores with Cases 2 and 5 attaining high Static scores. Cases 1 and 4 were in the mid-range Static dimension. Case 3 was the only one in the Reactive dimension (1.64). In the Organizational construct, two of the cases scored in the Static dimension (Case 2 and Case 5). Three cases had indexes in the Reactive dimension (Cases 1, 3, 4). In the Financial construct, all five cases scored an index of between 1.11 and 1.76. This means that essentially all cases were operating within the Reactive dimension of the DLSR in the financial element. Case 5 was close to the Static dimension, whereas Case 4 was near the bottom of the Reactive dimension.

Table 6 also shows the summary levels of each case compared to each other, solely based on the internal subject interviews. The summary levels were calculated by taking the total scores in all categories and dividing it by the number of answers provided. For example, Case 2 had a total score of 204 across all three categories with 85 answers given by subjects. Therefore, 204/85 yields 2.40 for a summary score and a level of Static. Cases 1, 3 and 4 obtained scores in the Reactive range across all elements. Case 3 was the lowest with a summary score of 1.33. Cases 2 and 5 had summary scores in the Static range.

Table 5 shows how each case actually scored in each secondary data category. Cases 1, 2 and 5 were assessed to have substantial risk and Cases 3 and 4 were assessed to have possible risk. Table 7 shows the difference in scores between DLSR and secondary data scores. Cases 2 and 5 remained in the same level. Case 1 had a difference of one level. Cases 3 and 4 had a difference of two levels.

Company	Company Profile	Products	On-site ESH	Union	Plant Tour	Triangulation Information Obtained
Company 1	Small company	Customized horse trailers	Yes	No	Yes	Yes
Company 2	Medium-sized	Particle board	Yes	No	Yes	Yes
Company 3	Small to midsized company	Firefighting tents and equipment	Yes	No	Yes	Yes
Company 4	Medium-sized company	Industrial and home use paints	Yes	No	Yes	Yes
Company 5	Large company	Refrigerated and frozen food products	Yes	No	Yes	Yes

Table 3 Company Profiles

Discussion

The DLRS provides an assessment of the level of strategy development compared to the facility's relative level of risk. This section provides an explication about the findings that have emerged based on the DLRS. Figure 4 shows that Case 1 was evaluated to have a summary score of 1.67. This means that the facility was operating in a Reactive fashion in regard to ESH issues. In the Strategy element, several factors corresponded with the Reactive level, such as minimum compliance with government regulations and minimal awareness of ESH issues. In the Organizational element, factors were identified, such as responding to ESH issues as they came up and isolation from other departments. In the Financial element, factors emerged, such as financing ESH issues as they arose and budgeting for ESH less than others in a comparable industry. For example, one interview respondent said, "We pay for things as they come up. So far it has worked for us." In addition, when asked about their overall ESH strategy, several respondents gave a one-word answer of, "Comply." However, the research literature has shown that emphasis on regulatory compliance may provide many businesses with a false sense of security (Pagell, et al., 2011; Rosenman, et al., 2006). Compliance does not ensure that all ESH issues have been adequately controlled.

Cases 2 and 5 were assessed to have summary scores at the Static level (2) using the DLSR (Figures 5 and 6). Using secondary data, Cases 2 and 5 were assessed to have Substantial Risk. Having both scores at the same level (2) potentially means that their ESH management strategy may have been prepared to meet the level of risk they could experience. At

	Number of Employees	ESH Information on Business Website	OSHA Reports	ER Mod	Environmental Reports	NGO reports of ease of working with; prompt action to address ESH issues
Case 1	15	No	1 other than serious violation	Reported less than 1.0	No air quality permits No EPA records located	No information reported, either positive or negative.
Case 2	78	Yes	3 citations issued; 4 serious violations; 2 other than serious violations	1.07 7% worse than the industry average	Issued one Notice of Noncompliance (NON No. 3002) for operating MEC-1 rotary dryer such that dryer inlet temperature exceeded a 24-hour average operating temperature.	Reported to be responsive and easy to work with to resolve issues.
Case 3	85	No	The facility has not had an inspection in several years, but the last one was completely clean and no citations were given.	0.83 17% better than the industry average	No air quality permits No EPA records located	No information reported, either positive or negative.
Case 4	94	Yes	The facility had an OSHA inspection within the last year and $500 in fines was given for nonserious offenses.	1.04 4% worse than the industry average	Three Notices of Noncompliance have been issued since 1995.	Reported to be responsive and easy to work with to resolve issues.
Case 5	250+	No	3 citations issued; 2 serious violations; 1 other than serious violation	Refused to release	Leaking Underground Storage Tank: 1998 Report of a leaking diesel tank 2000 cleanup complete; only soil contamination No air quality permits	Reported to be responsive and easy to work with to resolve issues.

Table 4 Summary Data of All Cases

	ESH Information Listed on Website	OSHA	EPA	Air Quality Orgs	DCBS	ER Mod	NGO or other agency reports of ease of working with and/or responsiveness to issue	
Cases								**Summary Score/Risk Ranking**
1	1	3	4	4	1	NA	NA	2.60 *Substantial risk*
2	4	1	4	3	3	2	3	2.86 *Substantial risk*
3	1	4	4	4	4	4	NA	3.50 *Possible risk*
4	4	3	3	2	4	2	4	3.14 *Possible risk*
5	1	2	4	4	3	NA	NA	2.80 *Substantial risk*

(Top): Table 5 Secondary Data Scores for Cases. (Middle): Table 6 Summary Scores. (Bottom): Table 7 DLSR Scores Compared to Secondary Data Scores

	Case 1	Case 2	Case 3	Case 4	Case 5
Strategy Score	2.36 (S)	2.94 (S)	1.64 (R)	2.43 (S)	2.94 (S)
Organization Score	1.52 (R)	2.53 (S)	1.32 (R)	1.90 (R)	2.22 (S)
Financial Score	1.23 (R)	1.75 (R)	1.13 (R)	1.11 (R)	1.76 (R)
Summary Score	1.67 (R)	2.40 (S)	1.33 (R)	1.81 (R)	2.22 (S)

Score was divided by the number of answers given to obtain the index score.
R = Reactive (1)
S = Static (2)
A = Active (3)
D = Dynamic (4)

	Case 1	Case 2	Case 3	Case 4	Case 5
DLSR Score	1.67 (R)	2.40 (S)	1.33 (R)	1.81 (R)	2.22 (S)
Secondary Data Score	2.60 (S)	2.86 (S)	3.50 (A)	3.14 (A)	2.80 (S)
Difference in Score	0.93	0.46	2.17	1.33	0.58

R = Reactive (1)
S = Static (2)
A = Active (3)
D = Dynamic (4)

the Static level, the Strategy element showed that respondents tended to view ESH as a cost that needed to be paid but did not add any financial benefit to the business. One respondent stated, “Anticipate and prevent as much as possible. Pay for what happens when we need to.”

Respondents at this level also thought there were times when production took precedence over ESH issues. One respondent stated, “You cannot shut down the line every time you see something.” The Organizational element revealed that some thought was given to exceeding compliance and that the ESH function had some authority to make interventions and changes. At this level, there was usually some type of company-wide ESH plan or protocol in place. Some factories had a plan provided to them by their insurer to promote worker safety and prevent environmental issues. One company had a contract that workers signed called the Caring Worker contract where there was agreement to intervene with fellow workers if unsafe behavior was observed and to nondefensively react if the worker was talked to about his/her unsafe behaviors. One worker described the following:

“I think the best thing is we can tell each other, and not only that we are expected to tell someone if something does not look right. No anger, no hurt feelings, just hey, the job needs to be done right so no one gets hurt and we all go home at the end of the day. That is the most important part.”

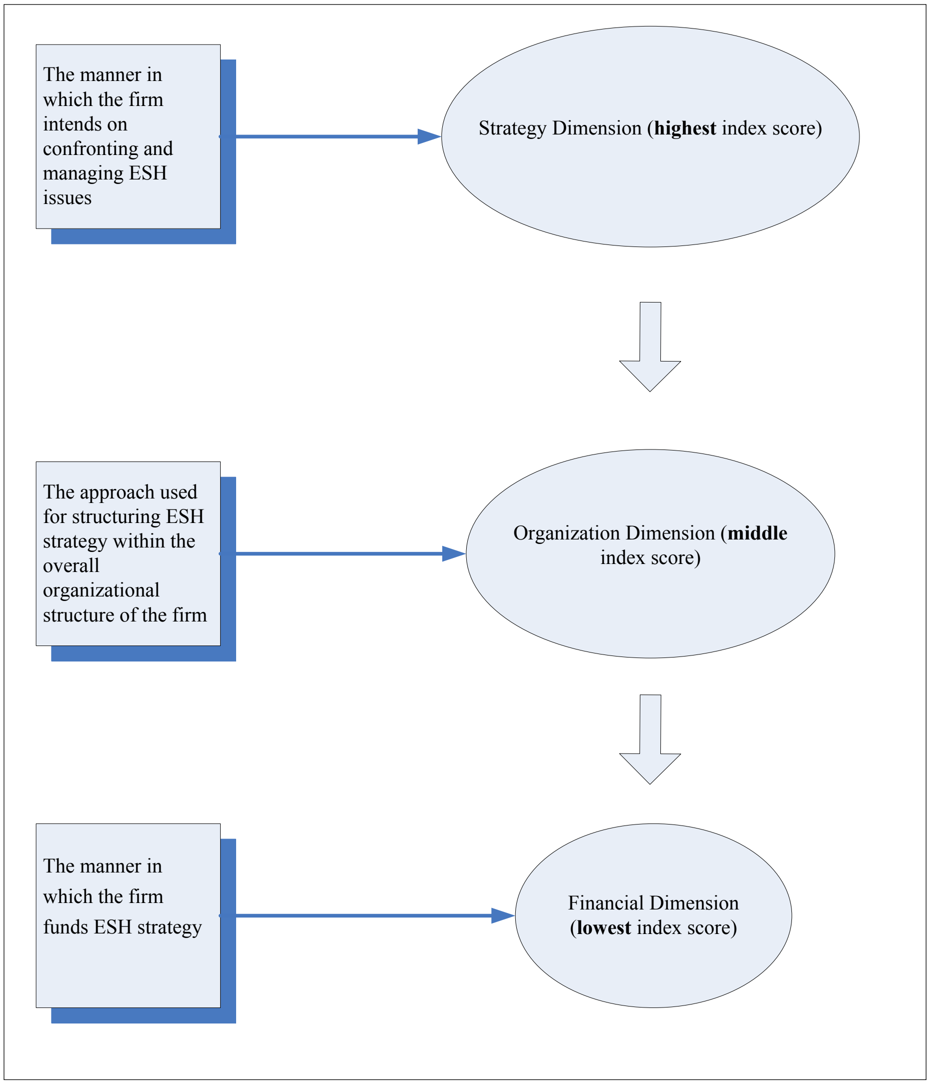


Figure 9 Pattern Matching Model of DLSR Results

The Financial element showed there was some ESH budgeting, but it was underfunded. Some efforts were made to enhance ESH efficiency and effectiveness. At this level, some respondents stated that ESH might somehow contribute to the company's competitiveness but with little detail about how this might happen. An ESH professional stated the following:

"We do not have our own budget, and I like it that way. If we had a budget, we would need to stay under it or be in trouble for going over. This way, we get what we need, and no one pays attention to what it costs."

This statement is a poignant example of one of the old, but still present, pathways in the ESH profession: make do and hope for the best.

Cases 3 and 4 were assessed to have summary scores at the Reactive level (Figures 7 and 8). They both also were assessed to have Possible Risk, scoring in the 3 range. These manufacturing facilities may be unprepared to address their level of existing risk. Although the level of risk is not as dangerous as it could be, their reactive stance could be problematic for many ESH issues that could arise.

Figure 9 shows pattern matching as one of the methods used to interpret the results. Every case received a smaller index score on its financial construct; a slightly larger score on its organization construct; and the largest score on its strategy construct, showing a distinct pattern across all cases. This may be due to the fact that most organizations put the greatest effort, resources and thought into their ESH management strategy, slightly less into how their ESH function fits into the organization and the least into how their ESH functions are financed.

An example of this is Case 2 where the manufacturing facility management expended much time, effort and resources into enacting an ESH program called the RADAR system, which they obtained from their insurance company. RADAR stood for "Recognize the risk, Assess the situation, Develop a safety work plan, Act safely and Report it." The RADAR system reminded workers each time they performed a job to check whether the job was safe and whether anything had changed since the last time they performed the job. The program included documentation where employees and supervisors needed to check off each RADAR step and to sign and date that the entire process was completed. Having this program still yielded Case 2 a high Static score on the Strategy dimension. This facility also had two on-site ESH professionals and some evidence of approaching ESH issues as a team with other departments. Factors such as these provided them a mid-2 score in the Organization Dimension.

However, when the Financial Dimension was reviewed, they scored in the Reactive level with their basic philosophy being "pay as things come up." A similar pattern was noted across all cases. These results are not unexpected as there has been a long history in the ESH field of inadequate financing of the ESH function and its related activities (Hunt & Auster, 1990; Linhard, 2005).

Consideration of rival explanations is one analysis method used in case study research as a way to increase reliability. In this study, there are several rival explanations for all cases having summary scores from the DLRS in the Reactive and Static range and having a distinct pattern in the elements (highest score in Strategy, lower in Organization, lowest in Financial). One explanation could be that some unknown difference exists between these five cases that agreed to participate in this study and companies that did not participate. One piece of evidence, which disproves this rival explanation, is that these five cases covered a broad range of manufacturing types, such as food, paint, particle board, tents and horse trailers. Also, no similarity exists between them regarding number of employees or how their ESH functions were configured. One recommendation from case study theorists is to use purposeful sampling and to choose cases that can be expected to possess the phenomenon of interest or ones that may not. The cases in this study depict several different types of manufacturing settings, and the results were still consistent. This lends support to the evidence that the DLRS model accurately describes many types of manufacturing.

How well ESH functions are managed is commonly evaluated using regulatory agency records, NGO attention, the facility's ER Mod rating and days paid per claim when workers experience injuries. These are the same records used in this study to profile a facility's risk (along with several others). For example, when asked how well a facility manages its ESH function, it is common to hear a response that refers to a recent OSHA inspection or lack of regulatory fines from the local air quality organization or EPA. Regarding what type of ESH issues the facility faced, one respondent in this study stated, "I would say we do not have any. I just tell my workers to use their common sense and that will help them avoid most problems, and so far it has. We have a good record, and we do not compromise safety to get our products out the door."

This case (Case 3) scored Reactively in all three dimensions of the DLSR with an overall score of 1.33, while its risk score was Possible (3). If the managers and owners only looked at the individual parts of their risk scores (OSHA, EPA, ER Mod, etc.), they might believe they were sufficiently prepared to manage their risk. Yet, there is a two-level difference between how they were prepared to manage their risk and their actual risk as profiled in this study. Assessing both scores and comparing them may provide a more complete and accurate picture of how the facility was prepared to control possible risks.

This study viewed the ESH function from the perspective of ESH professionals and from non-ESH professionals such as managers, owners and executives. Previous EHS research has focused on a single stakeholder, usually the worker. In turn, regulators have also tended to focus on workers and worker practices to create regulations. This is understandable since workers experience much of the impact of poorly managed ESH issues that can result in injury and even death. However, what is missing is that it is not the workers who make decisions about where and how effort is expended on ESH issues. It is the managers, executives and owners who make these far-reaching decisions. Omitting their perspective has created a gap in the ESH research. In this study, a multistakeholder approach was used to try to fill this gap.

Conversely, operational research tends to focus on the management perspective, which omits the worker perspective. It may be that manufacturing facilities could improve how they manage their EHS and operational functions by combining them into a joint system of management. This has the potential to improve both safety and operational performance simultaneously. The literature supports the idea that reduced ESH efforts can result in reduced operational and ESH outcomes and that increased ESH efforts can result in improved ESH and operational outcomes. In other words, a safer work environment may also be a more productive one. Moreover, some manufacturing managers and owners recognize this as well with one respondent stating, "Well, it goes hand in hand, just the same as if you are running a safe and clean environment, you will build more. To be around, you have to make money too. If you are running a safe environment with focused workers, whether it is on the product or on safety, it will translate into more production."

Joint management systems could streamline how the ESH and operation functions work cooperatively.

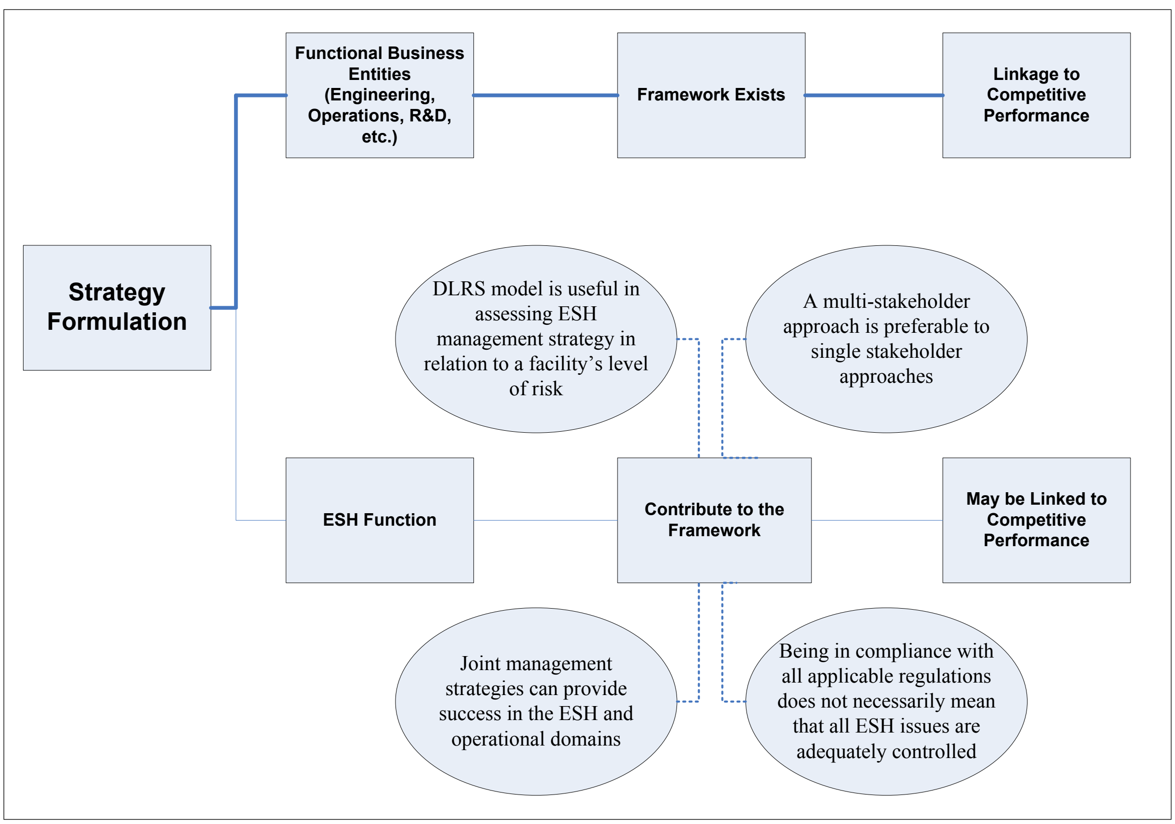


Figure 10 Possible Links Between EHS Management Strategy & Competitive Performance

Conclusion

Evidence exists to support that the refined theory and the DLRS provide an efficacious decision-support guidance model for a) assessing their firm's level of ESH strategy development, b) formulating new and advanced levels of ESH strategy and c) revealing the relationship between the relative levels of ESH risk compared to the developmental level of ESH strategy.

Existing ESH studies in manufacturing have tended to offer ESH management strategy theory in an untested fashion with little field work involved. Furthermore, extant EHS research in manufacturing has usually been conducted from a single stakeholder point of view with little attention paid to other stakeholders, such as operational managers or owners. Moreover, much of operational research has been conducted on operational management issues with the omission of the ESH perspective. This study has gone beyond the existing research in both fields by conducting field research and using a multistakeholder approach (Figure 10).

It was found that using the DLRS to compare a manufacturing facility's DLRS score with the facility's level of risk was useful in evaluating how well the facility was equipped to control and manage ESH issues. Informing all levels of management at manufacturing facilities, including ESH and operational management, that their level of ESH management strategy is an entire level below their level of risk has potential implications for the facility's overall operational performance. Being unaware of how ill-equipped or how well-equipped a manufacturing facility is to confront and manage risk is potentially catastrophic for everyone involved, including individual workers, the environment and the business's ability to remain viable.

The analysis also suggests that incorporating the DLRS into a management strategy could positively impact business and ESH strategies. The model provides separate scores of strategy, organization and financing as well as the summary score. Another important part of the refined theory and system is that it allows managers to evaluate their level of ESH management strategy, compare it to their level of risk and at the same time plan how to increase their construct level. Therefore, if managers wanted to determine how they could move their ESH management strategy toward a higher level, they could easily determine if there was one area where improvements would help improve their score. More importantly they could then improve their ability to sufficiently meet their level of risk. This research also suggests that manufacturing facilities could improve how they manage their EHS and operational functions by combining them into a joint system of management.

This research suggests that manufacturing facilities that are in compliance with all applicable government regulations may not have adequately controlled ESH risk. It has long been thought that minimal compliance with regulations should be enough to keep workers safe and to protect the environment. Comparison of the DLRS scores and the facilities' levels of risk show that this may not be the case. Risk evaluation in this study was based on common ways that risk is evaluated by manufacturing firms and ESH professionals, such as EPA fines, OSHA infractions, ER Mod scores, etc. It was found that the risk assessment did not match the facilities' level of ESH management strategy. No facility scored higher than a 2 (Static), indicating that some facilities may be able to meet their level of risk, but there is room for improvement. Moreover, there may also be room for excellence. This research asks if being adequate in EHS management strategy is enough when the consequences of poorly managed ESH functions can be so disastrous.

The DLRS essentially provides a snapshot of a moment in the facility's life. Strategies can change based on changes in the management team, the market, the facility's overall business model, etc. If a facility was adequately meeting its level of risk when it was assessed, this does not mean the facility is adequately doing so today. Therefore, it might be advisable for managers and owners to consider making attempts to move their facilities to a higher level of ESH management strategy so that they have more safeguards in place if circumstances change unexpectedly. Moreover, knowing that their level of risk is sufficiently met can also create room for innovation, which can then contribute to the competitiveness of the business.

One study limitation was that it was not possible to use multiple researchers in conducting the interviews and site tours. Yin (2009) recommends the use of multiple researchers to control for the biases of one individual researcher. It is recommended that future studies using case study methodology utilize multiple researchers whenever possible. It is also limiting to rely on respondent reports, which can include bias. Respondents can have faulty memories of events, which can introduce bias into their reports. They can also answer in a socially desirable way. In this study, it was known before going into the field that it was likely respondents might represent their ESH activities in a more favorable light. This was one reason multiple respondents were interviewed at each facility and that secondary data were gathered. These approaches assist in triangulating the evidence and mitigate some of the bias that is inherent in interviews.

This research resulted in several recommendations. Further study of the DLRS is recommended. The use of case study research methodology has extended and broadened this stream of research. However, future consideration should be given to using focus groups to refine the model into a usable format which could then be studied further in manufacturing settings. It would be potentially useful to create a hardcopy document that could be used in manufacturing facilities and digital formats to be used in office settings. It is also recommended to use a multistakeholder approach in future ESH and operational research, as it provides a more complete picture of both fields and their management strategies. Research into whether joint management systems can create improved ESH and operational outcomes is recommended as well. Lastly, it is recommended that future research be conducted on whether ESH regulations enhance the competitive advantage of manufacturing facilities and whether an ESH management strategy that relies solely on compliance adequately controls ESH issues.

References

Adam, E.E. & Swamidass, P.M. (1989). Assessing operations management from a strategic perspective. *Journal of Management, 15*(2), 181-203.

Adler, P.S., McDonald, W.D. & MacDonald, F. (1992). Strategic management of technical functions. *Sloan Management Review, 33*(2), 19-37.

Andrews, R., Boyne, G.A., Law, J. & R.M. Walker. (2009). Centralization, organizational strategy and public service performance. *Journal of Public Administration Research and Theory, 19*(1), 57-80.

Asche, F. & Aven, T. (2004). On the economic value of safety. *Risk Decision and Policy, 9*(3), 253-267.

ASSE. (2002). Whitepaper addressing the return on investment for

SH&E management programs. Retrieved from http://www.asse.org/practicespecialties/bosc/bosc_article_6.php

Barney, J.B. (1986). Types of competition and the theory of strategy: Toward an integrative framework. *The Academy of Management Review, 11*(4), 791-800.

Brown, K.A. (1996). Workplace safety: A call for research. *Journal of Operations Management, 14,* 157-171.

Bureau of Labor Statistics. (2009). Injuries, illnesses and fatalities. Retrieved from http://www.bls.gov/iif

Business & Legal Reports. (2006). The ROI of EHS: Practical strategies to demonstrate the business value of environmental, health and safety functions. Retrieved from http://catalog.blr.com/downloads/17103360.pdf

Carter, J. & Veltri, A. (1999). New approaches to determining the value of risk. Society of Risk Analysis and Economic Impact conference proceedings.

Cohen, K.J. & Cyert, R.M. (1973). Strategy: Formulation, implementation and monitoring. *The Journal of Business, 46*(3), 349-367.

Cook, T.D. & Campbell, D.T. (1979). *Quasi-experimentation: Design and analysis for field settings.* Boston, MA: Houghton Mifflin.

Corbett, C. & Klassen, R. (2006). Extending horizons: Environmental excellence as key to improving operations. *Manufacturing & Service Operations Management, 8*(1), 5-22.

Das, et al. (2008). Toward a theory of the linkages between safety and quality. *Journal of Operations Management, 26,* 521-535.

Dentchev, N.A. (2004). Corporate social performance as a business strategy. *Journal of Business Ethics, 55*(4), 395-410.

Eisenhardt, K.M. (1989). Building theories from case study research. *Academy of Management Review, 14*(4), 532-550.

Epstein, M. & Roy, M. (1997, Nov.-Dec.). Environmental management to improve corporate profitability. *Journal of Cost Management,* 26-34.

European Agency for Safety and Health at Work. (2004). Quality of the working environment and productivity. Retrieved from http://www.asse.org/practicespecialties/international/docs/dinte_environmentproductivity.pdf

Feldman, S.J. & Soyka, P.A. (1997). Does improving a firm's environmental management system and environmental performance result in a higher stock price? *Journal of Investing, 6*(4), 87-98.

Flynn, B.B. & Saladin, B. (2001). Further evidence on the validity of theoretical models underlying the Baldridge criteria. *Journal of Operations Management, 19*(6), 617-652.

Ford, M.T. & Tetrick, L.E. (2008). Safety motivation and human resource management in North America. *The International Journal of Human Resource Management, 19*(8), 1472-1485.

Handfield, R.S., & Melnyk, S.A. (1998). The scientific theory-building process: A primer using the case of TQM. *Journal of Operations Management, 16,* 321-39.

Hart, S.L. (1995). A natural resource-based view of the firm. *Academy of Management Review, 20*(4), 986-1014.

Henriques, I. & Sadorsky, P. (1999). The relationship between environmental commitment and managerial perceptions of stakeholder importance. *Academy of Management Journal, 42*(1), 87-99.

Hoffman, A.J. (2008). Strategy originates within the organization. In M.V. Russo (ed.), *Environmental Management.* Los Angeles, CA: Sage.

Hunt, C.B. & Auster, E.R. (1990). Proactive environmental management: Avoiding the toxic trap. *Sloan Management Review, 31*(2), 7-18.

Hunt, S.D. (1999). The strategic imperative and sustainable competitive advantage: Public policy implications of resource-advantage theory. *Journal of the Academy of Marketing Science, 27*(2), 144-159.

Innovest EcoValue 21™. (2011). Retrieved from http://www.csrwire.com/pdf/Research_Rating_Methodology.pdf

InvestorIdeas.com. (2008). Our global environment stocks, green stocks and Cleantech stocks directory at EnvironmentStocks.com. Retrieved from http://www.environmentstocks.com/Enviro_Stocks/Stock_List.asp

Jensen, R.C. (2007, Jan.). Risk reduction strategies. *Professional Safety,* 24-30.

Jick, T.D. (1979). Mixing qualitative and quantitative methods: Triangulation in action. *Administrative Science Quarterly, 24*(4), 602-611.

Kiernan, M.J. (1993). The new strategic architecture: Learning to compete in the 21st century. *Academy of Management Executive, 7*(1), 7-21.

Klassen, R.D. & Whybark, C.D. (1999). The impact of environmental technologies on manufacturing performance. *Academy of Management Journal, 42*(6), 599-615.

Kleindorfer, P.R., Singhal, K. & Wassenhove, L.N. (2005). Sustainable operations management. *Production and Operations Management, 14*(4), 482-492.

Levy, B.S., Wegman, D.H., Baron, S.L. & Sokas, R.K. (2006). *Occupational and environmental health: Recognizing and preventing disease and injury.* Philadelphia, PA: Lippincott Williams & Wilkins.

Linhard, J.B. (2005). Understanding the return on health, safety and environmental investments. *Journal of Safety Research, 36,* 257-260.

López-Gamero, M.D., Molina-Azorín, J.F. & E. Claver-Cortés. (2010). The potential of environmental regulation to change managerial perception, environmental management, competitiveness and financial performance. *Journal of Cleaner Production, 18*(10), 963-974.

McKone, K.E., Schroeder, R.G. & Cua, K.O. (2001). The impact of total productive maintenance practices on manufacturing performance. *Journal of Operations Management, 19*(1), 39-58.

Menon, A. & Menon, A. (1997). Enviropreneurial marketing strategy: The emergence of corporate environmentalism as market strategy. *Journal of Marketing, 61*(1), 51-67.

Miles, M.B. & Huberman, M.A. (1994). *Qualitative data analysis: An expanded sourcebook.* Thousand Oaks, CA: Sage.

Nath, P., Nachiappan, S. & R. Ramanathan. (2010). The impact of marketing capability, operations capability and diversification strategy on performance: A resource-based view. *Industrial Marketing Management, 39*(2), 317-329.

Nemetz, P.L. & Fry, L.W. (1988). Flexible manufacturing organizations: Implications for strategy formulation and organization design. *Academy of Management Review, 13*(4), 627-638.

Newman, W.R. & Hanna, M.D. (1996). An empirical exploration of the relationship between manufacturing strategy and environmental management: Two complementary models. *International Journal of Operations & Production Management, 16*(4), 69-87.

NIOSH. (2011). Engineering controls. Retrieved from http://www.cdc.gov/niosh/topics/engcontrols

Oregon OSHA. (2011). 2011 Oregon occupational injury and illness survey summary. Retrieved from http://actprod.cbs.state.or.us/iportal/report_catalog.html

Pagell, M. & Gobeli, D. (2011). How plant managers' experience and attitude toward sustainability relate to operational performance. *Production and Operations Management, 18*(3), 278-299.

Platts, K.W. (1994). Characteristics of methodologies for manufacturing strategy formulation. *Computer Integrated Manufacturing Systems, 7*(2), 93-99.

Porter, M.E. (1985). *On competition.* Boston, MA: Harvard Business Press.

Porter, M.E. (1998). *On competition.* Boston, MA: Harvard Business Review Books.

Porter, M.E. & van der Linde, C. (1995). Green and competitive: Ending the stalemate. *Harvard Business Review, 73*(5), 120-134.

Reinhardt, F.L. (1998). Environmental product differentiation: Implications for corporate strategy. *California Management Review, 40*(4), 43-73.

Reinhardt, F.L. (1999). Bringing the environment down to earth. *Harvard Business Review, 77*(4), 149-157.

Robson, L.S., Clarke, J.A., Cullen, K., et al. (2007). The effectiveness of occupational health and safety management system interventions: A systematic review. *Safety Science, 45*(3), 329-353.

Roome, N. (1992). Developing environmental management strategies. *Business Strategy and the Environment, 1*(1), 11-24.

Rosenman, K., Kalush, A., Reilly, M., Gardiner, J., Reeves, M. & Luo, Z. (2006). How much work-related injury and illness is missed by the current national surveillance system? *Journal of Occupational and Environmental Medicine, 48*(4), 357-365.

Shah, R. & Ward, P.T. (2003). Lean manufacturing: Context, practices bundles and performance. *Journal of Operations Management, 21*(2),129-149.

Sharma, S. (2000). Managerial interpretations and organizational context as predictors of corporate choice of environmental strategy. *Academy of Management Journal, 43*(4), 681-697.

Simpson, D. & Samson, D. (2010). Environmental strategy and low waste operations: Exploring complementarities. *Business Strategy and the Environment, 19,* 104-118.

Singh, J. (2000, Spring). Making business sense of environmental compliance. *Sloan Management Review,* 91-100.

SustainableBusiness.com. (2008). Sustainable stocks. Retrieved from http://www.sustainablebusiness.com/index.cfm/go/progressiveinvestor.stocks/?CFID=2494906&CFTOKEN=48566379

Sustainability Index. (2011). Retrieved from http://www.sustainability-index.com

Sveiby, K. (2001). A knowledge-based theory of the firm to guide in strategy formulation. *Journal of Intellectual Capital, 2*(4), 344-358.

Swink, M. & Way, M.H. (1995). Manufacturing strategy: Propositions, current research, renewed directions. *International Journal of Operations & Production Management, 15*(7), 4-26.

Tilley, F. (1999). The gap between the environmental attitudes and the environmental behavior of small firms. *Business Strategy and the Environment, 8*(4), 238-248.

Tompa, E., Dolinsch, R., de Oliveira, C. & Irvin, E. (2009). A systematic review of occupational safety interventions with economic analysis. *Journal of Occupational and Environmental Medicine, 29*(1), 5-24.

Veltri, A. & Maxwell, E. (2008). SH&E strategies available to firms and being used by firms: A conceptual framework for formulating strategy. *Journal of SH&E Research, 5*(3), 1-27.

Voss, C.A. (1995). Alternative paradigms for manufacturing strategy. *International Journal of Operations & Production Management, 15*(4), 1211-1222.

Walls, J., Phan, P. & Berrone, P. (2011). Measuring environmental strategy: Construct development, reliability and validity. *Business and Society, 50*(1), 71-115.

Ward, P., Duray, R., Leong, G. & Sum, C. (1995). Business environmental, operations strategy and performance: An empirical study of Singapore manufacturers. *Journal of Operations Management, 13,* 99-115.

World Resources Institute. (2011). Sustainability, leadership and education. Retrieved from http://www.wri.org/project/bell

Wu, Z. & Choi, T.Y. (2005). Supplier-supplier relationships in the buyer-supplier triad: Building theories from eight case studies. *Journal of Operations Management, 24,* 27-52.

Yin, R.K. (2009). *Case study research design and methods* (4th ed). Los Angeles, CA: Sage.

Acknowledgment of Reviewers

The *Journal of Safety Health and Environmental Research* gratefully acknowledges the following individuals for their time and efforts as manuscript reviewers during the period between Sept. 1, 2012, and Aug. 31, 2013. Their assistance in raising the standard of the papers published is immense and greatly appreciated. Although the members of the Editorial Board (names are italicized) generally reviewed more manuscripts than others (and provided much additional support), the vast majority of reviews were handled by ad hoc reviewers, chosen for their unique expertise on the topics under consideration.

Chandran Achutan, University of Nebraska Medical Center, Omaha, NE, USA

Magdy Akladios, University of Houston-Clear Lake, Houston, TX, USA

Alex Albert, University of Colorado, Boulder, CO, USA

Earl Blair, Indiana University, Bloomington, IN, USA

David Borys, University of Ballarat, Ballarat, Victoria, Australia

John Culvenor, University of Ballarat, Ballarat, Victoria, Australia

Jerry Davis, Auburn University, Auburn, AL, USA

Angela DiDomenico, ARCCA, Incorporated, Penns Park, PA, USA

Hamid Fonooni, East Carolina University, Greenville, NC, USA

John Gambatese, Oregon State University, Corvallis, OR, USA

Yang Miang Goh, National University of Singapore, Singapore

William Groves, The Pennsylvania State University, State College, PA, USA

Joel M. Haight, University of Pittsburgh, Pittsburgh, PA, USA

Jon Ivar Håvold, Aalesund University College, Aalesund, Norway

Matt Hallowell, University of Colorado, Boulder, CO, USA

Chris Janicak, Indiana University of Pennsylvania, Indiana, PA, USA

Todd William Loushine, University of Wisconsin-Whitewater, Whitewater, WI, USA

Ciaran McAleenan, University of Ulster, Jordanstown, Northern Ireland, UK

Michael O'Toole, Embry-Riddle Aeronautical University, Daytona Beach, FL, USA

Sathy Rajendran, Central Washington University, Ellensburg, WA, USA

Steve Rowlinson, The University of Hong Kong, Hong Kong

Fred Sherratt, University of Bolton, Bolton, U.K.

Richard Sesek, Auburn University, Auburn, AL, USA

Paul Specht, Millersville University, Millersville, PA, USA

Nicholas Tymvios, University of North Carolina-Charlotte, Charlotte, NC, USA

Anthony Veltri, Oregon State University, Corvallis, OR, USA

Sam Wamuziri, Glyndwr University, Wales, U.K.

Qingsheng Wang, Oklahoma State University, Stillwater, OK, USA

Jan Wachter, Indiana University of Pennsylvania, Indiana, PA, USA

Rodolfo Valdes-Vasquez, Colorado State University, Fort Collins, CO, USA x