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Emerging Strategies for Construction Safety & Health Hazard Recognition

Alex Albert, Matthew R. Hallowell and Brian M. Kleiner

Abstract

Work-related construction safety incidents continue to be a critical societal problem. Despite continued efforts, the industry has not seen any significant reduction in recordable injury rates in the last decade. An essential component in construction safety management is the identification of potential hazards to establish proactive physical or procedural controls that reduce safety risk exposure. Unfortunately, studies indicate that a large portion of hazards are not adequately identified or assessed, thus compromising worker safety.

To address this issue, promising site-based construction hazard identification strategies were identified in a wide body of literature and potentially breakthrough strategies were developed by an expert panel of construction safety professionals in brainstorming sessions. The strategies were then prioritized based on their potential and applicability to construction using the nominal group technique, facilitated by a group-decision support system. Consensus analysis was conducted to verify consistency within the expert panel. A prejob safety-meeting-quality measurement tool to provide active feedback regarding hazard identification capability and communication emerged as being the most relevant strategy. This was followed by a computer-based augmented virtuality training environment. The results of this study can be used by construction practitioners to strategically identify potential hazard recognition programs to complement existing methods. Future studies will focus on validating findings through field-based empirical tests on active construction projects.

Keywords
construction safety, hazard recognition, hazard identification, hazard recognition, safety risk

Introduction

The construction industry continues to account for a disproportionate number of occupational fatal and nonfatal injuries. (Findley, Smith, Kress, et al., 2004; Ho, Ahmed, Kwan, et al., 2000;). In the last decade, despite continual safety efforts, the construction sector has decelerated in terms of improvement in injury rates. According to the Bureau of Labor statistics (2012), the U.S. construction sector has been responsible for more than 1,000 fatal injuries every year between 1995 and 2008. In 2011, construction workers accounted for a fatality rate of 9.1 per 100,000 full-time equivalent (FTE) workers, as opposed to the all-worker fatality rate of 3.5 per 100,000 FTE workers (BLS, 2011). Similarly, nonfatal injuries rates were 3.9 per 100 full-time workers for construction, whereas the all industry nonfatal injury rates were 3.8 per 100 full-time workers (BLS, 2011). These injury statistics clearly show that construction workers are more likely to be killed or injured than workers in most other industries.

Traditionally, the construction industry has taken a reactive approach to safety. Accordingly, problems associated with an organization's safety program are only apparent when there is an increase in the number of injuries. With increased financial implications associated with occupational injuries and the emerging pursuit of zero incident projects, construction professionals are exploring the implementation of innovative safety strategies (Baud, 2012; Blake, 2012; Navon & Kolton, 2007) that can be introduced early in the project development process (Goetsch, 1996; Holt, 2001).

The fundamental goal of an effective safety program is to eliminate or reduce safety risk before work begins. To achieve this goal, it is important to identify as many hazards as possible prior to commencing work. Unrecognized hazards may have the potential to lead to unanticipated catastrophic accidents. Unfortunately, according to CDC (2012) and Carter and Smith (2006), a large proportion of construction hazards are not recognized because of the dynamic nature of the industry and task unpredictability (Bobick, 2004). In their assessment of method statements of three projects, Carter and Smith (2006) determined that the percentage of hazards recognized ranged between 66.5% and 89.9%. This often leads to the implementation of safety programs that are inadequate to manage actual safety risk. Workers who are not able to perceive safety hazards will be unable to respond or behave safely because they are unaware of the consequences that may result from their actions (Laurence, 2005; Sneddon, Mearns & Flin, 2004).

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In this study innovative and promising site-based hazard recognition program elements were identified through literature review and brainstorming sessions with an expert panel of construction safety professionals, and these elements were prioritized using the nominal group technique (NGT). Consensus analysis was performed to verify consistency and agreement within the expert panel. The results can be used by practitioners to strategically identify potential hazard recognition strategies that complement existing methods. It is suggested that future research focuses on further investigating the most promising strategies by testing them with active crews, measuring their effectiveness and determining the most cost-effective methods that could potentially become industry standard.

Literature Review

Hazard Identification & Evaluation

Occupational safety has gained considerable attention following the OSH Act of 1970, which shifted substantial safety responsibility to employers. According to the regulations, employers are to provide workers with a workplace free from any recognized hazards (29 USC 654 § 5). In addition, management is to provide workers with adequate training to recognize hazards in the workplace, thus allowing them to behave safely and make safety-conscious decisions (Spellman, 1998). Thus, hazard identification has become a critical element of an effective safety program.

According to National Safety Council (NSC; as cited in Mitropoulos, Abdelhamid & Howell, 2005, p. 817), a hazard is "an unsafe condition or activity that, if left uncontrolled, can contribute to an accident." To prevent injuries, hazard recognition methods are introduced to identify workplace hazards and mitigate risk associated with these hazards through the use of procedural or physical controls. Hazards that are not identified during the evaluation process may not have adequate controls in place; this may pose severe threat to both safety of workers and the environment. Thus, it is critical to execute an organized effort to identify and evaluate processes and activities for potential hazards. Such informal and formal methods provide valuable information to improve safety and manage operational risks.

Potential hazards are identified based on the knowledge of operations and past experience with similar work tasks. This usually involves brainstorming-type sessions among team members having familiarity with operational activities (Campbell, 2008). Several formal analytical hazard identification and evaluation tools are being used in the manufacturing and chemical industries. For example, a hazard and operability (HAZOP) analysis systematically uses key guidewords to identify hazards that may result from deviations from planned operations (Mushtaq & Chung, 2000). Additionally, fault tree analysis is a graphical array of logic gates that illustrate the series of faults that lead to an undesirable event (Brooke & Paige, 2003), and failure mode and effects analysis (FMEA) helps managers identify hazards related to potential failure modes (Stamatis, 2003). Although such formalized hazard recognition methods are commonly employed in other industries (Abdelgawad & Faye, 2012), they are generally unsuitable for construction because of the lack of standardization of tasks and the inherent dynamic nature of construction projects.

In the construction industry, a rigorous hazard management process usually involves the review of project scope documents, schedules and other relevant documentation to define construction tasks. Then, potential hazards related to the individual tasks and associated behaviors are identified and a risk assessment is conducted (MacCollum, 2006). Based on the results of the analysis, risk controls in the form of procedural or physical controls are implemented to eliminate or minimize risk. Similar methods have been used by researchers for hazard evaluation and management. For example, Albert and Hallowell (2013) evaluated hazards associated with the construction of powerlines and proposed a risk-based contingent liability model to identify prospective injury prevention methods; Mitropoulos and Guilama (2010) identified high-risk tasks in residential framing and provided safety measures to reduce task demands.

Unfortunately, the risk assessment process is completely dependent on the hazards that are included in the evaluation process (Mitropoulos & Namboodri, 2011), and the industry has consistently failed to identify and control hazards prior to construction. In fact, in a study conducted by Carter and Smith (2006), a large proportion of hazards were not identified. In that study of method statements of relatively standard work tasks such as concrete work, steel work, earth work and brickwork, only 66.5% to 89.9% of hazards were identified. Unidentified hazards will lead to an underestimation of risk associated with the project. As a result, control measures to prevent exposure to specific hazards necessary to prevent injuries may not be in place. Furthermore, workers may perceive a false level of security, when in reality there is an absence of adequate controls to prevent injuries (Fleming, 2008). Thus, a general understanding of accident causation coupled with the ability to identify hazards, and safe behavior are important for construction safety.

Accident Causation & Risk Perception

Poor construction safety performance has prompted many researchers to model accident causation specifically for the construction industry to identify proactive hazard management measures. These models descriptively decode hazardous attributes of construction environments and associate them with incidents. Early accident causation models focused primarily on modeling behavior and personal characteristics of workers as the primary causes of injuries. For example, accident proneness theories suggest that certain individuals are more likely to be involved in accidents as a result of "their innate propensity for accidents" (Shaw & Sichel, 1971, p. 14). Kerr (1950, 1957) corroborates this theory by claiming that accidents are caused by workers who are unable to adjust to dynamic work environments. A related accident causation model, the domino theory, (Heinrich, 1950; Manuele, 2003) suggests that occupational injuries are caused when unsafe conditions are combined with unsafe actions that originate from the faults of individuals.

Fortunately, accident causation models evolved as the understanding of the complexity of injuries causation improved. For example, Reason's multi-causality approach (1990) delineated the accident development process beginning with latent failures at the managerial levels to local trigger events at the workplace. To explain the complex nature of a worker's interaction with the work environment, Hinze (1996) developed the distraction theory, which suggests that productivity demands and difficulty reduce a worker's focus on hazards, increasing the probability of accidents.

According to Abdelhamid and Everett (2000), occupational accidents occur due to one or more of the following causes: 1) failing to identify an unsafe condition that existed before an activity was started or that developed after an activity was started; 2) deciding to proceed with a work activity after the worker identifies an existing unsafe condition; or 3) deciding to act unsafe regardless of initial conditions of the work environment. The constraint-response model proposed by Suraji, Duff & Peckitt (2001) suggests that environmental constraints and management actions may result in inappropriate conditions or work operations at the site which increases accident risk. According to the "systems model of construction accident causation" (Mitropoulos, 2005), task characteristics and unpredictability create hazardous situations in the workplace, and the exposure to these hazards creates the potential for accidents. Accidents occur under exposure when hazards are released as a result of errors or loss of control in the workplace. Haslam, Hide, Gibb, et al. (2005), in explaining the hierarchy of causal influences, illustrate that accidents occur as a result of the poor interaction between workers or work-team (e.g., worker behavior), workplace (e.g., poor housekeeping) and materials/equipment (PPE) that originate due to deficits in the construction design and process, project management, risk management, client and economic influences, or safety education and training.

These accident causation models were developed to explain contributory factors that lead to accidents with the ultimate goal of implementing timely and prudent prevention strategies. In a study examining contributory factors associated with 100 construction accidents (Haslam, Hide, Gibb, et al., 2005), 70% of accidents were estimated to have involved failure associated with human error (e.g., behavior and capability). These failures included workers' disregard for safety over other project priorities; inadequate hazard awareness and appraisal; and workers' propensity toward least efforts to accomplish defined project goals. The study attributed other accidents to workplace constraints, conditions and local hazards (49%); use of improper equipment (56%); and incidents involving the use of unsuitable materials (27%). Thus, a critical element to improve site safety performance is to have a competent workforce that can recognize hazard causal factors in the work environment along with a good understanding of the relationship between job-tasks, tools and workplace conditions.

According to Wilson (1989), workers are usually exposed to risk either because of their lack o knowledge about workplace hazards due to limited experience and knowledge or failure to behave safely, which may be associated with the workers' attitude toward safety (Abdelhamid & Everett, 2000) or the underestimation of perceived risk (Bailey, 1997; Choudhry & Fang, 2008). Also, inexperienced workers who are unable to recognize hazardous conditions will be unable to behave safely because of the lack in ability to recognize situations with injury-causing potential. On the other hand, experienced workers who perform similar tasks repeatedly may be conditioned to work in an unsafe manner due to their reliance on prior success (Denning, 2006). Thus, the construction industry needs to take active steps to enhance worker skills for hazard recognition.

Point of Departure

In response to recent research indicating the inadequacy of hazard recognition in construction projects, the current study identifies a few transformative hazard recognition program elements to improve safety performance. Specifically, the study 1) identifies current and effective hazard recognition program elements implemented in diverse industries such as construction mining, manufacturing, aviation chemical and the military; 2) identifies additional innovative program elements based on input and brainstorming sessions from an expert panel of associates representing Construction Industry Institute (CII) member organizations; 3) prioritizes the identified strategies based on established criteria that is required for the successful implementation in a construction setting; and 4) isolates few transformative strategies that will be developed and refined by the expert team in later phases of the study. The results of the study provide construction practitioners with useful information to strategically identify potential hazard recognition program elements to complement existing methods.

Research Methods

The research process consisted of two distinct phases designed to achieve several related objectives. In the first phase, the objective was to identify high potential hazard recognition programs based on literature and data provided by construction organizations in the U.S. that have achieved exceptional safety performance. In the second phase, the objective was to identify and refine the three strategies that experts believe have the greatest potential to improve hazard recognition and, consequently, safety performance.

To achieve these objectives an expert panel of 14 construction safety experts was formed. These experts were CII members who volunteered to participate based on requests made by the funding agency. Each panelist had more than 10 years' safety management experience. In total, panel members had accumulated more than 352 years' practical experience in the field of construction safety. In addition to their professional experience, seven experts were certified safety professionals (CSPs) and five were certified hazardous materials managers (CHMM). The panel also included one or more members who had obtained the following designations: professional engineer (P.E.), occupational health and safety technologist (OSHT), compliance safety and health officer (CSHO) and certified industrial hygienist (CIH). Several members were active in various safety and health groups such as ASSE, National Safety Council, Accident Prevention Association and local safety councils. Five panel members held a master's degree and six had bachelor's degrees in safety-related fields of study.

Phase 1: Exploratory Research Studies to Identify Hazard Recognition Program Elements

The research process began with an extensive literature search in an effort to identify hazard recognition program elements used in industries such as construction, mining, manufacturing, aviation, chemicals and the military. Following this literature review, the expert panel and the research team held a 1-day face-to-face meeting that began with a brief orientation to the research study and a description of the literature review results.

Hazard Recognition Program Elements	Description
Prejob safety meeting quality measurement tool	Tool that evaluates the crew's hazard identification capability and communication to create hazard awareness.
Senior leadership engagement in JSA process	A quantitative measure of the management's involvement in the JSA process through resource allocation and commitment.
Augmented and interactive virtuality training environment	Computer-based simulation tool that trains workers to identify hazards using a representative virtual environment.
Safety situational-awareness training	A worker centric program in which various potential hazards are detailed to the work crew prior to initiating work.
JSA post-kick-off audit	Evaluation of JSAs after task completion to obtain feedback on unidentified hazards.
Hazard identification board	A waterproof board displayed at the work site to communicate potential hazards as work progresses.
Precursory visual cues	Using visual aids such as tapes, signals, signs and LEDs to communicate hazards to the workforce proactively.
Physical area hazard simulation	An active exercise by the crew that simulates work to be done as a way of identifying associated hazards.
Foreman one-on-one w/employee	A one-on-one walk through the work facility, where an experienced foreman points to hazards in the environment.
Video/Photo monitoring and feedback	A continuous feedback process received through the review of previous work captured as videos or photographs.
Job safety/hazard analysis	A formal technique that focuses on specific work tasks as a way of identifying hazards before work is initiated.
Task demand assessment	An evaluative method in which task difficulty is assessed and better and efficient work practices are proposed.
What-if analyses	Use of a systematic, but loosely structured form of brainstorming sessions guided by what-if questions.
Action plan critique	A feedback mechanism involving the critiquing of established plans to improve implementation work plan.
Recordkeeping and accident analyses	Creation of a database that records lessons learned from past injuries and experiences to avoid recurrence of accidents.
Safety checklists	Survey of work area or construction process to ensure conformance to certain established criterion.
Method statement review/Work permitting	Audit of a written work plan elaborating on work tasks and conditions before a written permit to work is issued.
Walk-through safety and health audit	A observational method to identify active hazardous conditions, unsafe behavior through walk-through sessions.
Worker-to-worker observation program	A peer-to-peer safety observation program to provide feedback on worker performance with respect to safety.
Proactive safety alert systems	Incorporation of detection technologies into equipment that sound an alarm, or is disabled when a hazard is detected.
Preuse analysis and planning	A formal study conducted prior to any process modification, or the use of new equipment or chemicals in the job site.

Table 1 Emerging hazard recognition programs with application to construction

S No.	Criterion	Description
1	Active	The strategy needs to be participant centric and encourage the work force to be involved actively in hazard detection. The strategy must focus on using the workers senses and use techniques such as visual or audio cues.
2	Testable	The strategy needs to be practically testable within both the virtual and real environment.
3	Minimize disruptions	The strategy must be easily integrated with existing work practices, must be user friendly and must require only reasonable recourses for implementation.
4	Measurable	The degree of implementation or the quality of the system implementation needs to clearly be measurable.
5	Feasibility	The technique that will be implemented will need to be easily implemented with the current level of technology available to the construction industry.
6	Knowledge acquisition	The strategy must allow the easy dissipation of knowledge to the workforce and must focus on the long term improvement and retention of the knowledge by the workforce.
7	Scalable and adaptable	The strategy must easily be adaptable to different work conditions, crafts and locations. The technique must also be easily applied to a large group of workers.
8	Scenario building	The strategy must have the potential to help workers in scenario building and must increase the current level of hazard recognition.
9	Worker Participation	The strategy must be worker-centric and must focus on getting workers actively involved in the aim of improving hazard recognition to improve safety performance.
10	Potential	Safety professionals must see promise in the strategy in enhancing hazard recognition levels.

Table 2 Decision criterion for down-selection process

Following this introduction, the experts were encouraged to share additional hazard recognition strategies, apart from those identified in literature, that were being implemented in their respective organizations. They were also encouraged to brainstorm additional methods that may be theoretically promising. To enhance efficiency, a round-robin technique was used where each member voiced his/her experience and opinion. After the first round of idea sharing, a second opportunity was provided to share ideas that may have generated while listening to the first round.

The meeting facilitator recorded all ideas on a whiteboard. Following the round-robin discussion the experts provided electronic and printed forms of the strategies implemented in their organizations such as job hazard analyses, safety audit sheets and leading indicators of safety performance. In total, more than 50 hazard recognition strategies were identified from literature and data provided by the expert panel.

Among the identified strategies, several were dismissed (e.g., event tree analysis, HAZOP analysis, FMEA) based the panel's evaluation of each strategy's suitability for site-based implementation in the construction industry. Some reasons provided by the panel to justify dismissal of certain strategies included: unsuitability for application in inherently dynamic environments, inappropriate for nonstandardized tasks, and inaptness for site-based application (e.g., relevant only to design phase). The output of this phase resulted in 21 hazard recognition program elements; Table 1 presents a summary and a succinct description of each.

Phase 2: Short Listing of Potential Hazard Recognition Program Elements

The goal of phase two was to evaluate the 21 strategies and identify two to three with the greatest potential for transformative improvement in construction hazard recognition that the expert team would refine in later phases. To achieve this objective, a 2-day face-to-face meeting was held. During this meeting, the expert panel was divided into three subcommittees, each with at least four members. Each subcommittee was given 3 hours to brainstorm and choose three or four of the 21 strategies that its members believed had the most potential. Then, the subcommittees presented their strategies to the entire panel.

During that session, participants were given an opportunity to ask questions regarding the presented strategy in order to help them comprehend its potential. Once each subcommittee reported to the entire panel, all participants were asked to anonymously rate each presented strategy based on pre-established decision criteria (Table 2, p. 156). During this process, the experts assumed that the strategies are implemented as intended and to their complete potential. The decision criteria were catalogued through brainstorming sessions during which the experts were asked to identify all attributes necessary for successful field implementation. The criteria were catalogued until theoretical saturation was achieved (i.e., no additional criteria were identified). A Likert scale was used to rate the strategies based on the criteria in Table 2 (1 = strongly disagree; 3 = neutral; 5 = strongly agree).

This rating process was conducted efficiently using the NGT, which was facilitated by Grouputer, a group decision support software system donated by an expert panel member's organization. The NGT, unlike the Delphi procedure, is a highly structured and rapid decision-making method used while obtaining input from multiple group members (Fitzgerald & Findlay, 2011; Forsyth, 2009). This was important since the short-listing process required the input from time-conscious working safety professionals who constituted the expert panel (Carney & Worth, 1996). The voting process was led by two professional meeting facilitators who were not a part of the research team (Dennis & Wixom, 2002).

	Active	Testable	Minimize disruptions	Measurable
Prejob safety meeting quality measurement tool	6.50	6.93	7.46	8.11
Augmented and interactive virtuality training environment	5.54	7.32	5.39	7.07
Senior leadership engagement in JSA process	6.82	4.32	4.32	6.00
Physical area hazard simulation	7.50	5.61	1.75	5.89
Safety situational-awareness training	4.14	7.36	7.50	5.57
Hazard identification board	7.71	4.14	7.21	3.61
Foreman one-on-one w/employee	5.18	3.79	5.39	4.04
Precursory visual cues	4.43	4.39	6.29	4.04
JSA post-kick-off audit	2.75	6.00	6.14	6.39
Video/Photo monitoring and feedback	4.43	5.14	3.54	4.29
Mean rank sum	55.00	55.00	55.00	55.00
Kendall's coefficient of concordance (W)	0.407	0.263	0.443	0.334
Actual calculated chi-square value	51.30	33.13	55.78	42.15
Critical value of chi-square value	16.92	16.92	16.92	16.92
Degree of freedom	9	9	9	9
Asymptotic level of significance	0.00	0.00	0.00	0.00

H_o = respondents' ratings are unrelated (independent) to each other within each group
Reject H_o if the actual chi-square value is larger than the critical value of the chi-square

Table 3 Results of rating process

The NGT allowed the researchers to obtain first-hand information during the face-to-face session from industry experts and encouraged participation from all group members (Heuer & Pherson, 2010). Grouputer allowed each expert to independently and anonymously rate the strategies (Boddy, 2012; Elliott & Shewchuk, 2002; Rains, 2007) in a personal window on his/her own computer. The use of such technology for group collaboration studies has indicated several benefits such as increased participant satisfaction and a greater equality in participation (Lewis, Bajwa, Pervan, et al., 2007). This method allowed a simultaneous and parallel rating system (Lesley, 2010; Nunamaker, Dennis, Valacich, et al., 1991), which effectively reduced dominance bias and the collective unconscious or bandwagon effect (Kennedy & Clinton, 2009).

Results & Discussions

The research process resulted in 100 high-quality ratings from each expert participant, yielding a total of 1,400 ratings. To compare each strategy objectively, mean ranks were computed for each criterion. That is, if a given strategy (e.g., hazard identification board) received the highest rating based on a given criterion (e.g., active) by most experts within the panel, the strategy was assigned the highest ranking for that specific criterion. The use of mean ranks, rather than average scores, provides a basis for making comparisons between several attributes and can be used to make inferences regarding the reliability or agreement between the various ratings (Reid & Smith, 2007). The results of the analysis for the 10 short-listed strategies are provided in Table 3 and are sorted by the relative effective score. Because each strategy was ranked between 1 and 10 and there were several ties, the mean rank sum for each criterion adds up to 55. According to the results, the two top strategies were: 1) prejob safety meeting quality measurement tool and 2) an augmented and interactive virtuality training environment. Although the two strategies will be designed, refined and tested in a future study, following is a brief discussion of the two strategies.

Prejob Safety Meeting Quality Measurement Tool

The prejob safety meeting quality measurement tool accumulates best practices that are essential for successful hazard recognition and communication. After complete development, the tool will allow crews to assess the quality of their meeting by benchmarking their performance against industry best practices. Industry best practices will be accumulated in subsequent phases of the study, under different stages--namely plan, do, assess and adjust (Figure 1). As indicated in Figure 1, the plan phase will provide guidelines on identifying the job, decom-

Feasibility	Knowledge acquisition	Scalable and Adaptable	Scenario building	Worker Participation	Potential	Relative effectiveness score
6.93	8.04	8.14	7.89	6.89	7.82	74.71
4.29	5.43	5.00	5.50	6.00	6.75	58.29
6.82	5.21	7.29	2.86	5.11	7.14	55.89
3.64	6.07	2.04	8.14	7.96	6.89	55.49
6.14	4.75	5.82	4.39	4.79	4.79	55.25
6.39	5.43	6.68	4.57	4.75	4.43	54.92
5.29	6.50	5.18	5.82	7.07	4.50	52.76
6.07	5.43	4.18	5.25	5.04	4.36	49.48
6.14	3.25	5.43	5.96	2.89	3.86	48.81
3.29	4.89	5.25	4.61	4.50	4.46	44.40
55.00	55.00	55.00	55.00	55.00	55.00	
0.304	0.495	0.396	0.352	0.352	0.306	
38.35	62.42	49.94	44.36	44.36	38.52	
16.92	16.92	16.92	16.92	16.92	16.92	
9	9	9	9	9	9	
0.00	0.00	0.00	0.00	0.00	0.00	

posing it into manageable tasks, and recognizing associated hazards and mitigation methods. The do stage will provide guidelines on the location where the meeting is to be held, the roles of the supervisor and crewmembers, and the associated documentation. Finally, the assess and adjust phase will provide procedures to be followed when job changes occur and an opportunity to evaluate meeting quality and areas where subsequent improvement is necessary. The evaluation process will promote self-assessment where crews, based on their performance, can rate their maturity level in hazard recognition (Figure 2, p. 159). The goal of this tool is to help workers attain the mature level through iterative implementation and benchmarking. This process will provide workers with feedback (Renn & Fedor 2001), promote self-regulation (Latham 2007) and goal setting (Locke, Shaw, Saari, et al., 1981), which are essential components in any continuous improvement process.

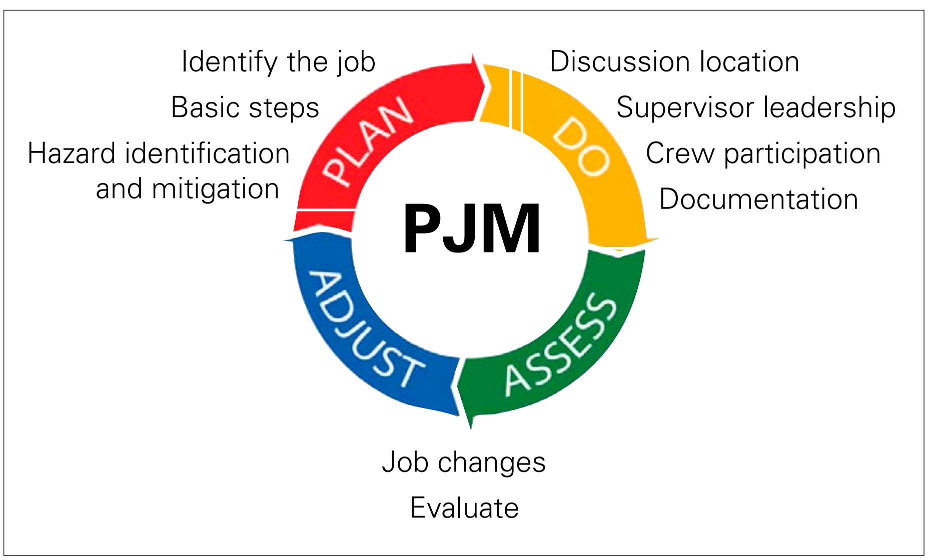


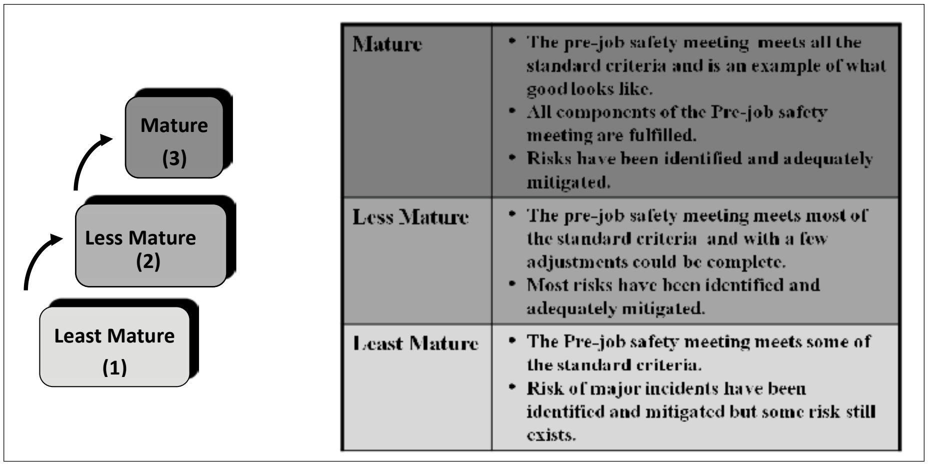
Figure 1 Stages of the prejob safety meeting

Augmented & Interactive Virtuality Training Environment

The augmented and interactive virtuality training environment will provide workers with a risk-free, high-fidelity environment that replicates actual project conditions as a platform to improve hazard recognition skills. The 3D environment will be created by the integration of a building information modeling (BIM) model and a database of photographs representing project conditions using a reliable game engine (e.g., Unreal Development Kit, Unity3D). Figure 3 (p. 159) presents a preliminary rendering of the environment.

In the virtual environment, workers will be tasked with identifying hazards in various realistic work-scenarios. The tool will then provide immediate feedback on the hazards that were successfully identified and those that were not recognized. It is expected that the repeated feedback process (Renn & Fedor, 2001) in diverse work scenarios along with the concept of serious games (Zyda 2005) for training purposes will improve situational awareness (Endsley, Bolte & Jones, 2011) and workers' ability to recognize hazards in dynamic environments.

An assumption made in the analysis is that there was concordance or agreement between the judges in the rating process. Kendall's coefficient was used to measure the agreement between the expert panel's ratings (Howell, 2012; Siegel & Castellan, 1988). This statistic tests whether there is consistency in ratings among the experts. If the coefficient of concordance is statistically significant at a predefined significance level (e.g., 0.05), then the null hypotheses that the experts ratings are not in agreement can be rejected and the alternate hypothesis may be accepted (Kendall & Babington-Smith, 1939; Sheskin, 2003). Kendall's coefficient



Mature	• The pre-job safety meeting meets all the standard criteria and is an example of what good looks like. • All components of the Pre-job safety meeting are fulfilled. • Risks have been identified and adequately mitigated.
Less Mature	• The pre-job safety meeting meets most of the standard criteria and with a few adjustments could be complete. • Most risks have been identified and adequately mitigated.
Least Mature	• The Pre-job safety meeting meets some of the standard criteria. • Risk of major incidents have been identified and mitigated but some risk still exists.

Figure 2 Continuous improvement maturity levels

of concordance for each criterion is shown in Table 3. All were significant to $\alpha = 0.05$. The degree of agreement is also comparable with other research studies focusing on consensus ordering (Chan, Chan, Lam, et al., 2010; Xia, Chan & Yeung, 2011; Xu, Chan & Yeung, 2010). Since the number of criteria rated is greater than seven, the chi-square value was computed as suggested by Siegel and Castellan (1998) and Chan, et al. (2010). Based on the chi-square distribution with nine degrees of freedom and a significance level of 0.05, the critical value was 16.92. The chi-square value for each criterion measure is shown in Table 3. Because all were larger than the critical value one can conclude that there is concordance among the expert ratings.

Conclusion

A critical component in safety risk management is to adequately identify hazards and mitigate its associated risk using safety program elements. Unfortunately, recent research has shown that the construction industry has performed poorly in this aspect. Although studies have revealed the inadequacy in hazard recognition within the industry (Carter & Smith, 2006), there has been minimal research in identifying efficient ways to make improvements. In most projects, due to limited availability of resources and time constraints (Vaziri, Carr & Nozick, 2007), contractors are forced to select a subset of hazard recognition program elements for effective field implementation. However, little is known regarding the relative influence of available methods. As a result, contractors often choose safety and hazard recognition program elements based on their subjective intuition with little regard to relative effectiveness (Hallowell & Gambatese, 2009).

In response to this gap in knowledge, this study identified and catalogued 21 potential site-based hazard recognition program elements from literature and an expert panel of safety professionals. Further, the most promising strategies were prioritized using ratings provided by the expert panel. Consensus analysis performed on the ratings obtained indicated the presence of reasonable agreement between the experts and that inferences could be made based on the mean ranks computed. Based on the analysis the prejob safety meeting quality measurement tool emerged as being the most effective strategy to improve hazard recognition. Other studies have also emphasized the importance of quality safety meetings for improved hazard communication and awareness (Hallowell & Gambatese, 2009). This was followed by the augmented and interactive virtuality training environment. Such environments have been particularly shown to be beneficial for electrical safety training (Zhao, Lucas & Thabet, 2009) and other educational purposes (Boud, Haniff, Baber, et al., 1999; Hughes, Stapleton, Hughes, et al., 2005). The results of the study can be used by construction safety practitioners and construction managers to strategically identify potential hazard recognition programs to complement already existing methods.

Figure 3 Rendering of the preliminary augmented and interactive virtuality training environment

A primary limitation of the study is that the expert panel represented only professionals representing CII member organizations. As a result, findings may not be generalizable or valid for general industry due to constraints in resources, differences in management operations, safety culture, type of projects undertaken and similar factors. This is especially true given that the individual strategies were ranked based on the attributes identified by the panel members. However, several expert members have had broad experience on numerous projects all over the world for small, medium and large companies, and have undertaken safety roles on diverse projects in their past.

To validate and verify generalizability of research findings, future empirical field-research studies will be undertaken in diverse projects to test the effects of the most promising strategies on hazard recognition. The research question will aim to test the proposed null hypothesis that the strategy does not improve the proportion of hazards identified and controlled before the start of construction. Also, questions regarding the cost of implementation and effectiveness of these strategies that could potentially become industry standard methods will be determined. ✪

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Safety & Health Certificate Programs: Practical Application Beyond Training

Mitchel Rosen, Koshy Koshy and Mehul A. Patel

Abstract

Well-trained workers are required for building and maintaining workforce capacity. Part of the training is accomplished through certificate programs, in which students complete a series of courses that encompass a body of knowledge. Previous studies have validated the effectiveness of certificate programs for construction, emergency preparedness, healthcare and transportation management. This study outlined the benefits and challenges graduates (n = 95) of an occupational safety and health certificate program encountered while implementing changes at their worksite and attempted to make career enhancements after completing a program offered through an OSHA Training Institute Education Center. A 36-question online survey was completed by certificate program graduates who finished the program from 2007 to 2012 (6 months to 5 years, post-completion). As a result of completing the program, 93.5% reported that they were better prepared to improve safety and health at their worksite and 81.6% implemented changes. Challenges they encountered included the cost of completing the program, management buy-in for implementing change and limited staff resources.

Keywords
certificate programs, workforce development, safety and health training programs

Introduction

Certificate programs provide opportunities for learners to develop their personal and professional goals. Participants are awarded the certificate after completing a predetermined number of classes that encompass a body of knowledge. They enhance occupational skills increasing their value in the job market. Learning methodologies employed by certificate programs include classroom learning, online courses and hands-on training.

Certificate programs are seen as an underutilized feature as they often serve as a stepping stone to further one's education (Carnevale, Rose, Short, et al., 2011). Many certificate programs are conducted by 2-year and 4-year colleges and universities as well as by for-profit organizations. These programs can be a path to a better paying job or additional education. There is some evidence that certificate programs have higher rates of completion than degree programs and they are more affordable than a 2-year associate degree program (Bosworth, 2011).

National studies have shown that those individuals who have one more year of education beyond high school earn 5% to 10% more than individuals who do not (Bosworth, 2011). Bureau of Labor Statistics suggests that positions that require only a certificate will grow at a faster rate than occupations that require a bachelor's or graduate degree (Bosworth, 2011). The length of time that it takes a learner to complete a certificate program is shorter than a traditional degree program, which can accelerate the individual's earning potential without investing the additional time and money into a college or university academic program (Carnevale, et al., 2011).

Literature Review

The McKinsey Global Institute estimates that the U.S. could be short 1.5 million college graduates and 1.6 million technical-or vocational-level trained workers by 2020. Certificate programs are essential for meeting this gap in workforce capacity. Sectors with the largest gaps for technically trained workers are healthcare and manufacturing. Nationally replicable training programs are seen as the most effective way to meet this demand in the shortest possible time [President's Council on Jobs and Competitiveness (Jobs Council), 2011].

Professional development through certificate programs offers an affordable mechanism to increase knowledge and skills that enhance staff quality, satisfaction and may lead to retention of employees (Baker, Johnson, Turski, et al., 2012). Certificate programs are helpful for developing workforce capacity in niche areas such as construction, healthcare, transportation and veterinary medicine.

There are many examples of successful certificate programs from different industries. For an example, American Society for Healthcare Engineering's (ASHE's) Health Care Contruc-

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tion Certificate Program is designed to provide builders with insights on the unique challenges to managing construction at a healthcare facility. Contractors and subcontractors who have completed the program have reported that they were better equipped to manage construction at healthcare facilities as a result of completing the program (Davis, 2003).

Certificate programs are effective for training professionals on new practices and rejuvenating their knowledge. A study of a veterinary continuing medical education program found that it was effective for enhancing the flow of applied research-based knowledge from educators and researchers to dairy veterinary practitioners, thereby increasing the participants' knowledge of the latest information in their field (Schuenemann, Bas, Workman, et al., 2011).

Studies have shown that certificate programs are useful for reaching hard-to-serve populations such as minorities, low-income adults and young adults who may not have performed well in school (Carnevale, et al., 2011). One study was conducted of 45 participants who completed the Maternal and Child Health Certificate Program (MCH). The program is designed to recruit students who are interested in making larger contributions to the healthcare field by drawing on their past experience and building on their leadership skills. Of the 20 to 24 students recruited per semester, one-third are from racial and/or ethnic minority groups. Students reported a boost in their self-confidence as a result of completing the program and were able to form learning communities to advise each other. Fifty percent of the participants changed their jobs or expanded their current responsibilities and 32% enrolled in master's level programs in public health or other MCH programs, upon completing the program (Bernstein, Paine, Smith, et al., 2001).

Training is most effective when it is related to specific occupations and learners have the opportunity to apply what they learned through hands-on practice in their work. The long-term benefit of connecting theory and practice is that it allows students to apply the information they learned to advance their work and careers. A study of workers who completed an aftercare certificate program found that the participants often referred to the training materials to handle situations at work; they also used it to train fellow workers who were not able to attend the training. Successfully implementing the program included effectively communicating challenges to management and sharing their experiences with their fellow certificate recipients (Baker, et al., 2012).

An interdisciplinary certificate program is offered by Texas A&M Department of Landscape and Architecture and Urban Planning, College of Architecture; Texas Transportation Institute; Zachary Department of Civil Engineering; and Bush School of Government and Public Service. This program aims to give the students an understanding of the interdisciplinary nature of transportation in contemporary society. The courses focused on disaster preparedness planning, finance, performance management and public health issues related transportation (Ndubisi & Dumbaugh, 2010). Program graduates transitioned more easily from school to workforce and had more career options as a result of completing this program (UTCM), 2008.

Certificate programs have proven to be an effective method for schools of public health to reach their audience for continuing education. Since 2001, the demand for certificate programs has seen significant growth in public health preparedness and disaster management and has become a recruiting strategy for schools to bring public health and other professionals into academic programs without requiring them to commit to full-time enrollment (Horney, 2009).

The objective of this article was to assess safety and health certificate program graduates on how they implement changes at their worksite, as well as understanding how the certificate program impacts career changes.

Methods

Safety & Health Certificate Program

The Office of Public Health Practice (OPHP) at Rutgers School of Public Health [formerly known as the University of Medicine and Dentistry of New Jersey (UMDNJ), which merged with Rutgers University on July 1, 2013], developed two safety and health specialist certificates programs in 2006, one in construction safety and the other in general industry. These programs were designed to provide safety and health knowledge to individuals who may not have formal education (an associates, bachelor's or graduate degree) in safety. The certificate is awarded by the Region II Atlantic OSHA Training Center (AOTC). Established in September 2002, AOTC is an authorized OSHA Training Institute Education Center (OTIEC), managed through the OPHP (OSHA, 2013a, 2013b).

The survey intended to identify how participants were better prepared to improve safety and health at their work site after completing the certificate program. An intended outcome of the survey was to identify how training was able to change behaviors of individuals at their workplace, therefore increasing the safety and health of workers and workplaces. This research utilized the Kirkpatrick (1998) levels of learning evaluation, specifically focusing on Level 3, which is behavior and is defined as the extent to which change in behavior has occurred due to a training program.

Program Curricula

Table 1 lists the courses offered in the general industry and construction certificate programs. Each program has five required courses. The required courses for the general industry certificate are designed to develop skills in general industry standards; industrial hygiene; respiratory protection; injury and illness prevention programs (I2P2) and machine safeguarding. The electives for general industry include accident investigation; combustible dust hazards; electrical safety; ergonomics; permit-required confined spaces; and recordkeeping. The required courses for the construction certificate program include accident investigation; construction standards; excavation, trenching, and soil mechanics; fall protection; and I2P2. The electives include disaster site worker preparedness; permit-required confined spaces; and asbestos, lead and mold inspection.

The construction standards (OSHA 510) and general industry standards (OSHA 511) courses provide an overview of the construction and general industry OSHA standards. The other courses enhance subject-matter knowledge and reinforce safe work practice principles in their respective areas. The subject-matter courses (other than OSHA 510 and 511) were selected for the certificate program based on the frequency of these hazards causing fatalities, injuries and violations at work sites (OSHA, 2013c). The learning objectives for the OSHA numbered courses were developed by OSHA's Directorate of Training and Education (DTE) and the OPHP developed the curriculum. OPHP developed the learning objectives and curricula for the asbestos, lead and mold inspection courses.

General Industry Certificate Program

Required Courses

- OSHA 511: Occupational Safety and Health Standards for General Industry
- OSHA 521: OSHA Guide to Industrial Hygiene
- OSHA 2225: Respiratory Protection
- OSHA 7100: Machine Guarding
- OSHA 7500: Introduction to Safety and Health Management

Electives: Two of Three

- OSHA 2250: Principles of Ergonomics Applied to Work-Related Musculoskeletal and Nerve Disorders
- OSHA 2264: Permit-Required Confined Spaces
- OSHA 3095: Electrical

Electives: Two of Three

- OSHA 7125: Combustible Dust Hazards
- OSHA 7505: Accident Investigation
- OSHA 7845: Recordkeeping

Construction Certificate Program

Required Courses

- OSHA 510: Occupational Safety and Health for Construction
- OSHA 3010: Excavation, Trenching and Soil Mechanics
- OSHA 3110: Fall Arrest Systems
- OSHA 7500: Introduction to Safety and Health Management
- OSHA 7505: Accident Investigation

Electives: Choose Three

- OSHA 2264: Permit-Required Confined Spaces
- OSHA 7600: Disaster Site Workers
- Asbestos Inspector
- Lead Inspector/Risk Assessor
- Mold Inspection and Testing in the Indoor Environment

Table 1 Required and elective courses offered in the certificate programs

Study Design

An online survey administered to all participants of the certificate programs was conducted to identify the value and how the certificate programs have changed work practices. The survey was developed by researchers at Rutgers University and was granted approval by the Institutional Review Board (IRB). The survey contains 36 questions, and includes skip-logic for questions that do not apply to a previous response.

The survey was implemented using Zoomerang.com, an online survey instrument. Conducting the survey through an online system has several advantages. Zoomerang allows surveys to be sent to large numbers of individuals, with features that include the ability to e-mail participants who have not completed the survey. This feature allowed for follow-up announcements to be sent only to those who had not completed the survey. Skip logic enables the survey to be dynamic in the sense that only relevant questions are asked, based on the previous response. If a question response is "no," then a follow-up question related to a "yes" answer is skipped.

Data were collected through the online survey. Data analysis yielded descriptive statistics about the study participants, including their gender, age, educational level and number of years' experience in occupational safety and health. Many questions included a yes or no response, and others included a five-point Likert scale, ranging from strongly agree to strongly disagree. Likert scale data are ordinal data. These responses were analyzed using modes and a distribution of the responses. The level of agreement to the statements provided an understanding of how the certificate program affected the behaviors of workers at their workplacea. Open-ended survey questions were analyzed for content and themes that helped inform how the training impacted workplace practice.

A total of 95 people have completed the certificate programs at the Rutgers School of Public Health. This survey was distributed electronically via e-mail to all 95 graduates. The OPHP program manager sent an e-mail to program graduates indicating that they would receive a survey through Zoomerang.com. One day later, the survey was launched. A follow-up e-mail was sent 1 week later through Zoomerang.com to those who had not completed the survey. Two additional follow-up emails were sent to those who did not complete the survey. One week after the third follow-up email was sent, the survey was closed.

Results

Demographics

Table 2 (p. 165) contains the demographics of survey respondents. These include gender, age, educational level, years' experience in occupational safety and employment location. The highest level education attained is equally distributed across

A) Gender of certificate program graduates (n = 60)

Male	83.3%
Female	16.7%

B) Age of certificate program graduates (n = 60)

18-30	0.0%
31-40	10.0%
41-50	40.0%
51-60	41.7%
61 and Older	8.4%

C) Educational level of certificate program graduates (n = 61)

High School	26.2%
Associates	21.3%
Bachelor's	24.6%
Master's	24.6%
Doctoral	3.3%

D) Years' experience in occupational safety and health of certificate program graduates (n = 61)

Less than 5 years	18.0%
5-10 years	36.1%
11-15 years	11.5%
16-20 years	13.1%
21-25 years	14.8%
26-30 years	1.6%
More than 30 years	4.9%

Table 2 Participant demographics

high school graduate, associate degree, bachelor's degree and master's degree. Only 5.3% of respondents held a degree in safety and four of them had a construction health and safety technician (CHST) certification. None had CIH, CSP, ASP or OHST certifications. Others had specialized certifications including certified occupational hearing conservationists (two), paramedic/EMT (two), certified utility safety administrator (two) and professional engineer (one). When surveyed about their future educational goals, 60.9% reported that they planned to pursue other certifications and 46.2% of those who wanted to pursue certifications were interested in the CSP designation.

Survey Results

Surveys were distributed to all 95 certificate program participants who graduated between March 20, 2007, and June 7, 2012. Of those, eight were not deliverable because the e-mail address on file was not valid, one opted out of the survey, and two did not complete the survey leaving a total of 84 as the valid number of participants. A total of 61 individuals completed the survey for a response rate of 72.6%. Of these respondents, 25 reported that safety was a part of their overall job responsibilities and 36 reported that safety was their full-time position. Forty-three respondents completed the construction certificate and 28 completed the general industry certificate. Ten participants completed both programs, and are included in the total reported for each program.

Motivation for Completing a Certificate Program

The majority of the respondents reported that they completed the certificate program to increase their knowledge base (81.7%) or skills (66.7%); other responses included career advancement and preparation for a certification exam. Table 3 presents student motivations for completing the program.

The certificate programs are designed to meet the training needs of the workforce. This study showed that this objective was met, as 91.7% of the participants reported that they strongly agreed or agreed that the courses within the certificate programs are appropriate for the work they conduct. When asked about deleting any courses from the curriculum, 94.9% of the respondents replied "no"; additionally, 36.7% wanted to add courses to the respective construction or general industry certificate program.

Of the 19 suggestions for additional courses, 11 wanted more construction-focused courses in scaffolding, heavy machinery, flagging, rigging and fall protection. Suggestions for new courses to the general industry certificate program included training on the global harmonization system (GHS), biosafety, walking and working surfaces, and forklift safety. Other suggestions included incident command and maritime safety. Only three respondents suggested that courses be deleted from the program. Of these, one suggested that the 3-day fall protection course was too long, another did not see the significance of mold training being part of a construction certificate program, and another expressed concerns about the disaster site worker course being cancelled several times by OPHP and suggested that it was an impediment for students completing the program.

Goals of the certificate programs are to increase participants' knowledge and skills and to promote changes at their workplaces that will help create a safer work environment. Almost 79% of the participants indicated they intended to make changes to company work practices based on the knowledge and/or

Response option	Percentage
I wanted to increase my knowledge base	81.7
I wanted to increase my skills	66.7
My supervisor recommended I complete the program	15.0
I wanted to increase the potential to advance my career	63.3
I want to prepare for a certification (e.g., CSP, CIH)	35.0
I wanted/needed to learn about specific issue(s) in my workplace	33.3
Other	10.0

Table 3 Motivations to complete a certificate program (n = 61)

skills learned in the certificate program, and they provided 45 examples of intended changes. These included 14 graduates who expected to provide new training programs (administrative controls) including ladder safety, incident investigation and other safe-work practices training (unspecified). Other proposed work site improvements included changes to the safety culture, implementing process improvements and a general increase in awareness and knowledge of safety issues (administrative controls). When asked if they implemented changes, 81.6% indicated they had made changes. These changes were summarized as changes to PPE policies (36.2%), changes to administrative controls (51.7%) and changes to engineering controls (44.8%). One participant reported that his site expected to obtain the OSHA Voluntary Protection Programs (VPP) Star designation as a result of applying the training.

Graduates faced several barriers when they attempted to implement changes at their work sites and 27 of them provided examples. Several were related to the safety culture at their workplace. The reluctance to change was described by one participant as the worker's attitude of "I've been doing it this way for years." Educating upper management and workers was seen as critical to overcoming this impediment. Other hindrances included the costs associated with maintaining a safety program and language barriers within the workforce.

The certificate programs are designed to provide participants with strategies for executing safety programs at their job sites. Participants provided 38 examples of what they learned through the training that helped them with implementing safety programs. Of these examples, 14 were related to becoming familiar with OSHA standards and the importance of communicating potential violations to management as well as front-line workers, to implement safe work practices and avoid potential violations that could lead to penalties. Several participants also reported the importance of involving others in the process, including having safety teams to help with inspections, having an active safety committee and the importance of management support.

The survey investigated if completing the certificate program had an effect on the participants' job responsibilities or their employment situation. After completing the certificate program, 43.2% applied for a new position, 56.8% increased their responsibilities in their current position and 29.7% changed their job responsibilities. Responses indicated that the certificate program increased participant knowledge so they could perform their job with more confidence, enhanced their inspection abilities, and were able to advise managers with no safety experience. One participant commented, "The certificate program has provided me with the tools to help other work groups resolve safety- and OSHA-related issues. Although I have not achieved a higher level as of yet I am able to contribute to the overall safety of my workplace."

Peer Training

Safety training or personal development training is part of 75.4% of the survey respondents job function and 66.7% are OSHA outreach trainers (OSHA, 2013d). Participants facilitate toolbox training, construction and general industry outreach training, and targeted training in subject areas such as PPE, lockout/tagout, scaffolds and fall protection. Those who reported that they facilitated training used the case studies they obtained through the program (84.4%) and the overall knowledge of safety (95.6%) to enhance their training.

Facilitating Learning Beyond the Certificate Program

Participants were introduced to several web-based safety and health resources as part of the programs. A large majority (83.6%) reported that they were better able to find web-based safety and health resources as a result of completing the training. Some sites they have utilized after completing the program include OSHA (98.3%), other federal websites (50%), and state and local government sponsored sites (85%). Eight respondents listed other industry-supported organizations they utilized, including National Fire Protection Association, National Safety Council and Bureau of National Affairs.

The certificate programs provided an opportunity for graduates to serve as resources to each other. When asked if participants kept in contact with their fellow program graduates, 63.9% of the respondents said "yes" and 22 provided examples of areas in which they reached out to their classmates for assistance. Several were able to share networking opportunities for new positions. They also shared other resources including ideas for improving training, assisted each other in preparing for the CSP or ASP certification exams, served as a resource for OSHA standards and provided fresh perspective on matters.

Enhancing Management Skills

Several questions were related to personal enrichment that the respondents received as a result of completing the program. The vast majority of graduates strongly agreed or agreed that the program strengthened their ability to manage work site safety and health. Participants indicated that they were better prepared to discuss safety and health issues with their supervisor, improve safety and health issues on their job site, correct safety and health issues that may have caused injury and illnesses, and develop policies to improve workplace safety and health. Additionally, participants strongly agreed or agreed that the certificate programs increased their knowledge and skills, improved their job performance and increased or reinforced existing knowledge and skills (Table 4, p. 167).

Overall Impression of the Program

Participants were asked an open-ended question, "Please provide any comments about the certificate program," to solicit their overall impression of the program. A total of 19 participants responded, with 17 responses being testimonials to the overall satisfaction those graduates had with the program's administration and instruction, and the knowledge they received through the training. One participant stated that the program "rounded out" his/her knowledge and another stated that the program "opened up" new resources. The other two participants suggested that there should be some form of national recogni-

	SA	A	N	D	SD
I am better prepared to discuss safety and health issues with my supervisor	43	13	5	0	0
I am better prepared to improve safety and health issues at my work site	43	14	3	0	1
I am able to make better safety and health decisions	45	15	1	0	0
I am able to correct a safety or health issue that may have caused an injury or illness	37	19	3	0	1
I am able to change a workplace safety and health policy	32	18	9	0	1
Increased my knowledge regarding an occupational safety and health issue	45	15	1	0	0
Increased my skills regarding an occupational safety and health issue	43	16	1	0	0
Provided useful information that is applicable to my job	43	15	3	0	0
Helped me do my job better	41	16	4	0	0
Reinforced my knowledge and skills already in place	46	14	1	0	0

SA = Strongly Agree A = Agree N =Neutral D = Disagree SD = Strongly Disagree

Table 4 Personal enrichment due to completion of the certificate program

tion for the certificate programs and this would enhance their marketability.

Discussion

Certificate programs are an effective way to develop occupational safety and health capacity in the workforce. Courses enhance student knowledge base and help them develop strategies for implementing safety and health at their work sites. Students increased their familiarity with OSHA standards and case studies focused on work site incidents and injuries. This information is often conveyed through the training programs the graduates facilitated at their work sites. Such peer-to-peer training encouraged them to think about their company's safety culture and motivated them to strive for improvement. Effectively communicating information to management improves buy-in for support of safety programs.

Site Implementation

As a result of completing the certificate programs, graduates were better prepared to implement changes at their job sites. The knowledge they received in courses on confined spaces, fall protection, PPE and machine safety gave them the knowledge to make operational changes. Administrative controls they developed included protocols for focused inspections, offering additional safety training, establishing incident investigation protocols and implementing shift rotations.

Personal Enrichment

The majority of certificate program graduates completed the program in 12 to 24 months. In most cases, they completed the program with the same cohort of students (coincidence, not by design). Having the support of their classmates was instrumental for implementing safety at their work sites. They supported each other by providing feedback on job-specific issues involving job hazard analysis, developing safety and health plans, and sharing leads on career opportunities. Having cohorts from different sectors including utilities, and state and federal government was advantageous for them to gather a fresh perspective on how to handle safety issues.

Students were trained to use online federal, state, and local safety and health resources as part of the program. Participants were recommended to sign up for online communications such as OSHA's biweekly Quick Takes and the monthly OPHP e-news as a resource to keep up with changes in the industry. A total of 98.3% of the participants reported they referenced online resources they learned through the certificate programs to help them with job-related safety and health issues.

Impediments to Success

Major barriers to implementing safety programs were the costs associated with developing and maintaining an effective program and the workhours that needed to be dedicated for day-to-day management. The most effective strategy these graduates used for getting additional resources was to educate senior management about the costs related to incidents and injuries. The technical knowledge they received, especially on OSHA standards, helped them to make convincing arguments about the benefits of an effective safety and health management program. Also, explaining the possibility of having an OSHA inspection and the potential for penalties due to noncompliance was effective for gaining management buy-in.

Overall Benefits

As the job market continues to experience shortages of technically trained workers, certificate programs will continue to be in demand. These programs have demonstrated their ability to develop technical competencies in a relatively short period of time (Bosworth, 2011; Jobs Council, 2011). Study participants reported similar experiences to the graduates of an afterschool and MCH certificate program. The safety program and afterschool program graduates used their course materials to train fellow workers, they kept in contact with their classmates after the program and served as a resource to each other, and they emphasized the importance of having their management support to effectively administer the program (Baker, et al., 2011). Many MCH graduates continued their education by enrolling in graduate programs, similar to the safety program graduates, and they faced similar impediments to completing the program including lack of time to attend the courses and financial issues (Bernstein, et al, 2001).

Study Limitations

This type of study has several limitations in its design. The first limitation is that all the data are self-reported changes. Individuals may report changes that did not occur and increase the positive changes reported in the results. Many studies that assess Level 3 behavior changes include observation of workplace practices. This study did not include observation. However, studies have shown that self-reported behavior changes are valid and reliable (Curry & Purkis, 1986; Nelson, 1996). The second limitation is that online surveys can lead to uncertainty of what is meant by specific categories of responses. For example, individuals may interpret the categories of "strongly agree," "agree," etc., differently. A third limitation is that the research team did not have valid e-mail addresses for all certificate program graduates. A total of eight e-mail addresses were not valid.

Conclusion/Next Steps

All 95 students who completed these certificate programs over a 5-year period were invited to complete the survey; all of those who participated reported safety as their primary or secondary job responsibility. It is hard to glean from these data how the recent graduates (completing the program within 6 months to a year) fared compared to those who completed the program over a longer period in obtaining or enhancing their marketability.

This study shows that completing these certificate programs enhanced students' overall knowledge of safety, gave them the confidence to more effectively communicate safety needs to their coworkers, and encouraged them to continue their safety education by exploring online resources and completing certifications.

1) This study evaluated the overall benefits of a safety and health certificate program. It would be beneficial to evaluate how the individual subject-matter courses helped the students in implementing safety related to those hazards at their work sites.

2) The cost of completing the program was cited as a barrier by several students. OPHP will seek support of corporate or foundation sponsors to help potential program candidates defray some costs associated with the program.

3) As social networking through Facebook and LinkedIn become more popular, it would be beneficial to establish a group for program alumni to share their collective experiences.

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Investigating Accident Investigation Characteristics & Organizational Safety Performance

Jan Wachter and Patrick Yorio

Abstract

Accident investigation processes can differ substantially in the way they are developed and implemented. Little empirical evidence exists that explores the characteristics of the accident investigation process in terms of its influence on or association with occupational injuries and illnesses experienced by organizations. In the current study, we show how variations in the length of time to initiate an investigation, the focus of an investigation and who actually conducts an investigation are associated with organizational safety performance. To do so, we surveyed more than 300 establishments regarding characteristics of their accident investigation programs and statistically explored their relationship with occupational injuries and illnesses.

Our findings indicate that the length of time to initiate an investigation may be less important than the content focus of the investigation and who is primarily responsible for conducting the investigation. We found that programs that included a focus on human error and used a team- or employee-based approach to conducting the investigations are most often associated with lower injury and illness rates. However, even though the accident investigation process characteristics are associated with safety performance as determined through our correlations and regressions, they do not significantly account for the variability found in accident rates among organizations, supporting the notion that accident causation is a complicated process impacted and controlled by many factors.

Keywords
accident investigations, injury rates, occupational injuries and illnesses, causal factors

Introduction

Accident investigations are considered a key component to an organization's safety management system. Two safety management system consensus standards, OHSAS 18001 (British Standards Institute, 2007) and ANSI/ASSE Z-10 (2012), both include accident investigation as a key element of "checking and correcting." Further, numerous OSHA and MSHA standards include legislative text related to an accident investigation requirement.

The purpose of accident investigation is to systematically investigate the reasons why an individual was injured during the course of employment, to determine the causes of an accident, and to develop means to prevent similar future accidents (adapted from Oakley, 2003). Corrective and preventive actions are key components to accident investigation programs (Brauer, 2006). Grounded in the findings of an investigation, these actions are implemented to correct those human and physical elements that were not planned for or controlled properly. When accident investigations are designed and implemented effectively they can provide a window to reality by providing a means of discovering what is really going on (RoSPA, 2012), discovering latent organizational weaknesses and active human error, and improving performance by implementing preventive and corrective actions.

Given the important role that accident investigations have in managing risk and improving safety performance (Manuele, 2007; Phimister, Oktem, Kleindorfer, et al., 2003), little has been written and researched regarding how investigations should actually be carried out. Rarely has exploratory research been conducted into who within an organization should actually conduct the investigations and what characteristics of investigations make a difference in an effective versus an ineffective accident investigation program.

Perhaps because of this lack of guidance, organizational accident investigation programs can vary in the length of time it takes to initiate the investigation, the person(s) who is primarily responsible for conducting the investigation and the focus of the investigation. For example, organizations may internally require that an investigation start within 24 hours or less from the time of the safety incident, while other organizations may not emphasize such a time line. Also, many investigation programs are designed such that the responsible supervisor is assigned the sole responsibility of conducting the investigation, while others design their program in such a way that the safety representative assumes full responsibility for conducting the investigation. Further, characteristics can vary among organizations based on the focus of the investigation. For example, some organizations may focus on physical hazards that contributed to the incident, while others may include a focus on human error factors.

The purpose of this study is to determine if and how the noted characteristics of accident investigation programs are associated with or are predictive of safety performance in organizations. This interest was borne out of results from a larger survey study conducted by the authors that looked at the effect

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of 10 distinct and interactive safety management practice constructs (including accident investigation) on employee perceptions and accident rates.

Because the safety management practices that impact accident rates are numerous and their interactions are complicated (with accident investigation practices being only one piece of a complex puzzle), this study is not meant to be a cause-and-effect investigatory analysis. Instead, this study attempts to theoretically and pragmatically report the rather interesting differences in association between the management practice of accident investigation and safety performance depending on certain characteristics of the accident investigation program.

Theoretical Background

The ultimate goal of any organizational safety management system is to reduce risk by preventing occupational injuries, occupational illnesses and property loss (ANSI/ASSE, 2012). Good investigations can provide unique opportunities to learn from safety incidents that have occurred. Investigations can also be a powerful educational experience for those directly involved by improving understanding of safety and health management principles, controlling hazards present in the workplace, and embedding the resulting lessons in the organizational memory (RoSPA, 2012).

As noted, the characteristics of accident investigation programs can differ substantially. Through a qualitative process of interviewing experts in the safety profession (i.e., 10 leaders in the safety and health profession were interviewed, representing industry, academia and consultation groups) three general ways in which accident investigation program designs can differ were identified: 1) the length of time to initiate the investigation; 2) the focus of the investigation; and 3) the design in terms of who is routinely involved in conducting the accident investigation. Each of these is briefly discussed in the following sections.

Length of Time to Initiate an Investigation

Accident investigations can vary in the length of time between the time the incident occurred and the time the investigation was initiated. Logically, there can be a resulting difference in investigation quality between investigations that are initiated immediately following an incident and those that are initiated days following the incident.

A major reason to investigate quickly is to accurately record all the factors that contributed to the incident. These factors could be transient (e.g., evaporating solvent, leaking valve, concentrations of airborne hazards) and/or prone to adulteration over time (e.g., footprints, dust patterns), so collecting and recording information as soon as possible may be important. In addition, if hazards, unsafe conditions and unsafe acts are identified as quickly as possible, then indirect and root causes that led to the incident or nearly caused a loss may be more promptly identified and dealt with, leading to a lower state of risk. Based on this logic, as the length of time to initiate the investigation decreases, the overall number of incidents an organization experiences may also decease.

Existing consensus standard provide little guidance that instructs investigations to be initiated within a specified period of time. The prominent existing management system consensus standards (e.g., OHSAS 18001, ANSI/ASSE Z10) do not discuss the length of time to initiate investigations as a component to the check and correct element beyond mentioning that "incident investigations should begin as soon as practical" (ANSI/ASSE, 2012). Further, within the regulatory framework of OSHA and MSHA, only the process safety standard (29 CFR 1910.119) requires that employers investigate incidents within a specified period of time [29 CFR 1910.119(m)(2) requires that "an incident investigation shall be initiated as promptly as possible, but not later than 48 hours following the incident"].

However, the authors were unable to find any empirical research conducted to support the basis of this regulatory requirement and any hypothetical reduction in subsequent incidents based on the time to initiate. We, therefore, attempted to study this research question by asking establishments about the length of time they take to initiate an accident investigation and subsequently explored how differences in this characteristic vary with objective safety performance statistics.

Accident Investigation Focus

Accident investigation programs can differ in the actual content that is focused on during the investigation. As a primary element to any investigation, the exact casual factors that led to the safety incident must be determined in order to effectively make changes that mitigate future risk (Oakley, 2003). However, the leading consensus standards and OSHA and MSHA regulations lack guidance about which specific system factors to focus on during the investigation.

The leading consensus and regulatory standards do not go beyond emphasizing the need to identify all casual factors that led to an incident. For example, MSHA requires in 30 CFR 50.11(b)(5) that "an explanation of the accident or injury, including a description of any equipment involved and relevant events before and after the occurrence, and any explanation of the cause of any injury, the cause of any accident or cause of any other event which caused an injury" must be included in the investigation report. OSHA's process safety standard contains a similar requirement. For a discussion on the different focuses that accident investigation may have, the reader is directed to the work of Oakley (2003).

It is relatively easy for investigation programs to focus primarily on making changes to or correcting the physical environment, equipment, tools and machinery that may have contributed to the safety incident. These physical factors are typically easy to visually identify, understand and correct. These unsafe conditions are usually present until corrected. They are unlike unsafe acts that require "catching" workers committing unsafe acts, which could be sporadic over time and place. Once these unsafe acts are discovered, then investigations are needed to understand why these behaviors occurred that led to human performance errors that often involve psychology and employee perception factors (Yorio & Wachter, 2013). Since more than 80% of accidents are still attributed to unsafe acts (Seo, 2005), it is critical that accident investigations effectively explore the reasons a worker's behavior or performance led to an incident in an effort to correct those management system deficiencies. Some of these reasons could be lack of knowledge, lack of motivation or job distractions that caused unsafe behaviors and human error to occur (Yorio & Wachter, 2013). Thus, the need to include a human error focus in incident investigations may be of critical importance to a robust accident investigation program.

Who Conducts the Investigations

Accident investigations can also differ based on who actually conducts the them. Little guidance is provided by the leading consensus standards and safety standards on this issue. In the process safety standard, OSHA comes the closest to addressing the issue: "An incident investigation team shall be established and consist of at least one person knowledgeable in the process involved, including contract employee if the incident involved work of the contractor, and other persons with appropriate knowledge and experience to thoroughly investigate and analyze the incident" [29 CFR 1910.119 (m)(3)]. An OSHA letter of interpretation (2006-07/12/2006-PSM compliance for ammonia refrigeration systems) discusses this standard and articulates its intended meaning and minimum compliance requirements. The letter of interpretation suggests that, at minimum, the investigation must be conducted by one person who is knowledgeable in the process involved and this person can be a knowledgeable employee, a process engineer or an operational supervisor. Although this standard minimally requires that only one knowledgeable person conduct the investigation, the language alludes to the premise that more knowledgeable persons may be more effective.

The leading safety management system consensus standards do not explicitly discuss the make-up of the investigation team. They do, however, indirectly allude to the premise that the make-up must be carefully considered. For example, OHSAS 18001 suggests that the process of investigating incidents should provide the collective with overlapping knowledge sets on what defines an incident for the organization and the types of corrective actions that are applicable. It further suggests that the process must be impartial and objective.

The reality, though, is that most workplaces have a single person, typically the supervisor (OSHA, 2012), foreman or safety manager, conduct most accident investigations (Short, 2012). This may be due in part to the lack of concrete guidance on who should investigate accidents within an establishment. Furthermore, the researchers were unable to find any empirical support that explores the premise that who investigates accidents actually "matters" in terms of the organization's objective safety performance.

Organizations can choose from a variety of people to investigate safety incidents. Possible choices for such a responsibility include the following (BLR, 2011; Oakley, 2003): safety committee members and employee representatives trained in accident investigation; a knowledgeable supervisor and/or site manager; or a safety representative. The following section discusses the value of having certain types of people responsible for the accident investigation (adapted from BLR, 2011, except where noted). The list was generated by the authors and experts (BLR, 2011; Oakley, 2003) based on their experience with accident investigation programs.

Employees and/or safety committee members. The authors believe that accident investigations represent a good way to involve employees in safety and health. Equally important is the fact that workers are the experts when it comes to the work they do. Most workers can tell another person about the most hazardous components of their job without much cognitive effort (Martinez, 2010). Martinez (2010) reports seeing many instances in the workplace where workers knew exactly why an accident happened and had the perfect solution to prevent its recurrence. OSHA publications allude to the premise that employee involvement in accident investigations will not only give the organization additional expertise and insight (that managers may not have), but in the eyes of the workers, could lend credibility to the results.

For example, OSHA suggests that employees from outside the accident area may know the right questions to ask and those in the accident area may be witnesses or may answer questions about normal area operations. The agency also suggests that employee involvement benefits the involved employees by educating them on potential hazards, and the experience usually makes them believers in the importance of safety, thereby strengthening the safety culture of the organization (OSHA, 2012). In support of employee involvement in accident investigation practices, Royal Society for the Prevention of Accidents (RoSPA, 2012) argues that one major pitfall in accident investigation is a lack of workforce involvement. RoSPA also contends that trade union safety representatives have a legal right to participate in accident investigations.

Safety committee members make good investigation team members because they may have a broader view of the safety issues as well as a potentially broader skill set. In addition, they typically represent a wide range of departments and can bring expertise and support in implementing preventive and corrective actions, especially if their specific departments are affected.

Knowledgeable supervisors and site manager. The usual investigator for accidents is the supervisor in charge of the involved area and/or activity. Supervisors provide insight into normal operating procedures, employee training and other issues. They are familiar with both the production processes involved and the people, and may know how best to approach workers in order to get the most amount of accurate information. Supervisors may have to carry out corrective actions and are probably in the best position to prevent a recurrence. Excluding them from the investigation process may severely weaken the implementation of corrective actions. However, their reputation is on the line and the quality of their supervision may have contributed to the accident. They may be too close to the situation not to have bias (Short, 2012). When the site manager is involved in accident investigations, workers understand that safety is taken seriously by upper management.

Safety manager/safety representatives. The safety representative is typically an important member of an accident investigation team because s/he probably has a keen sense of safety issues and an awareness of safety performance trends in the workplace. Safety managers are often assigned to writing the final investigation report. Since most safety managers are an organization's technical experts on hazard identification, evaluation and control, as well as regulatory compliance, they are a logical choice for being on accident investigation teams.

Each of these individuals may be required to investigate safety incidents alone or in combination with each other. When the investigation is conducted by multiple representatives from each of these categories, an accident investigation team is considered. The following section examines the potential advantages and disadvantages of a team-based accident investigation approach.

Accident investigation teams. Teams are used by organizations to facilitate the achievement of collective goals through teamwork. Teamwork enables the achievement of goals beyond the capabilities of individuals working alone (Marks, Mathieu & Zaccaro, 2001). Some theory has been generated to support the premise that team-based approaches to accident investigation, as compared to single investigators (e.g., supervisors), can be beneficial. Teams counteract the prime concern of using sole investigators, which is the questionable objectivity that sole investigators may have if they are required to conduct investigations in their own areas of responsibility (Short, 2012). A team-based approach may bring more balance and perspective to the investigation and will likely produce a better quality outcome than a single individual. The bottom line is that in most situations two (or more) heads may be better than one (Short, 2012). Also, expanding the team to include both management and worker representatives may achieve greater buy-in from their respective peer groups.

General benefits of a team-based investigation approach include providing access to local, expert knowledge, particularly about operational issues; supporting the building of trust and the development of just, open and fair cultures; developing participants' understanding of risk management in practice; promoting learning about how to investigate in general; creating a workforce of occupational safety and health champions, particularly in supporting implementation and closure of corrective and preventive actions; and providing a check of safety management standards (acting as a complement to formal audit of management systems) (RoSPA, 2012). Research by RoSPA (2012) has shown that a team approach to learning from accidents that involves employees can be extremely powerful, particularly if it is led by senior managers and supported by safety professionals acting as facilitators.

But teams are not without disadvantages. Because teams are necessarily composed of multiple members, they tend to be slower at getting into action and may take more time to work through potential disagreements when compared to sole investigators. A team approach requires that more people be trained in accident investigation techniques and this necessitates personnel hours diverted from primary job duties. Also, some witnesses may be reluctant to cooperate with and/or talk to certain members of the investigation team. Furthermore, some safety and health theorists argue that despite everyone's good intentions and good faith efforts to objectively investigate the safety incident, personal biases of the individual team members may still impact findings (Short, 2012).

In addition to the strictly characterized team- or individual-based approaches to accident investigations, many organizations use both individual and team approaches for conducting investigations in order to maximize the efficiency of the investigation practice. For instance, individuals could conduct the less serious or more routine investigations, and when a significant incident occurs, a team is formed (Short, 2012).

If an organization wants to minimize the amount of investigation resources being used and address investigator bias concerns, or to allow a fresh set of eyes to look at a problem, one option is to allow individuals to conduct solo investigations, but not in the department they work in or supervise. Regardless of who or how many people conduct the investigations, all investigators should be trained in investigation methods and selected based on their expertise and experience (Short, 2012).

As noted, the authors found no empirical research evidence needed to justify an explicitly developed hypothesis regarding the effect of who actually conducts investigations on measures of safety performance. To that end, the authors sought to explore the impact of this choice on occupational injuries and illnesses experienced by the establishment.

Pragmatic Focus of This Study

This study was exploratory in nature to determine if any associations exist between some specific characteristics of the accident investigation process and safety performance. This investigation was part of a much larger study that looked at 10 safety management practice areas (including an accident investigation construct) on safety performance. However, the research described in this article has been the only one of our studies to date that has analyzed the individual characteristics of a safety management system practice with safety performance statistics. The reason for this is largely due to the interesting associations that were discerned initially in the larger study among the individual statements/questions under the accident investigation construct with safety performance statistics. This study largely attempts to explain these associations.

Thus, the individual statements/questions used to characterize a "rolled up" safety management system practice (accident investigation) in the larger study were transformed into individual hypotheses to investigate for interpreting the correlations and other statistical results that were obtained. Based on the results of these correlations and statistical analyses, certain characteristics of accident investigation programs may be more associated with reduced accident rates. This could lead organizations to emphasize these characteristics more when designing and implementing accident investigation programs.

Methods

In 2011 and 2012, data were collected using a safety manager survey designed to assess and link existing safety management system practices with safety performance outcomes. The survey was designed to assess the relative impact of 10 individual safety management system practices on objective safety performance statistics (i.e., TRC and DART rates). The survey was designed to be completed by individuals responsible for safety at each establishment (e.g., safety managers, safety representatives).

A total of 69 items was included within a survey designed to measure, among other things, the presence and characteristics of safety and health management system practices used in organizations and the TRC and DART rates for each organization. Each safety manager was asked to evaluate the degree to which each item within each practice reflected the safety management practice for the organization. Almost all items on the survey were measured using a 7-point scale from strongly disagree (1) to strongly agree (7) or never (1) to always (7). Additional questions asked the respondent to select a number or range of numbers (i.e., TRC and DART rates).

Through ASSE, the survey was distributed to ~2,400 of its members (mainly in the U.S.) and 330 completed the entire survey (participation rate of 14%). The mean number of employees per establishment was 632. Multiple industrial sectors were represented in the sample, including agriculture (n = 4), construction (n = 53), transportation and distribution (n = 20), education (n = 5), government (n = 18), healthcare (n = 9), light manufacturing (n = 84), heavy manufacturing (n = 92), mining (n = 23), research and development (n = 7) and service (n = 15).

The complete safety manager survey measured 10 safety management system practices: pre- and post-task safety reviews, safe work procedures, hiring practices for safety, cooperation facilitation, employee involvement in implementing specific safety-related processes, safety training, communication and information sharing, accident investigation, detection and monitoring, and safe task assignment. These practices represent objective and observable functions that can be proactively developed, implemented and administered by organizational managers.

These practices can be individually considered, but they seldom exist individually within an organization. They are most often administered as a system in some combination with each other. Further, consistent with the broader human resource management practice literature, these safety management practices can be researched individually or as a system. The only management system practice discussed in this article is the accident investigation system practice and the characteristics of this construct as defined by its individual component questions/statements. [For a discussion of the effects of these 10 practices (and the composite of these 10 practices) on safety performance statistics and the interactive effects among these practices, please see Wachter (2012)].

Six of the questions included in the survey were related to the accident investigation practice used within the organization. Safety managers were asked to evaluate the degree to which each characteristic was reflective of the process used to investigate safety incidents in their respective organizations. Except for the characteristic that measured the time to initiate the investigation, each characteristic was measured using a 7-point scale from never (1) to always (7). These questions were:

•When an incident does occur, typically how soon is it investigated? (Length of Time) (Measured through a 3-point scale: < 24 hr, 24 to 48 hr, > 48 hr)

•How often do incident investigations seek to uncover potential reasons why human error might have occurred? (Human Error Focus)

•How often are incident investigations conducted by a team, consisting of some combination of a safety representative, the injured employee's immediate supervisor and employee representatives? (Team)

•How often are employees involved in conducting accident investigations? (Employee Involvement)

•How often are incident investigations conducted by the injured employee's supervisor alone? (Supervisor)

•How often are incident investigations conducted by the safety manager or safety representative alone? (Safety Representative)

The intent of asking these questions was to determine if the following accident investigation process characteristics were associated with objective safety outcomes, such as TRC and DART rates:

•individual(s) routinely involved in conducting accident investigations;

•time it takes to initiate accident investigations;

•focus on human error during accident investigations.

To answer these research questions, a correlation and regression approach was utilized. Pearson correlations were calculated and the significance of these correlations was determined using a two-tailed test. (Both Pearson and polychoric correlations were executed for all pairs of variables. Because the results between both analytical approaches were consistently reported, only the results from the Pearson correlation analysis are reported.) Regression analysis was used to predict both TRC and DART rates based on who was primarily responsible for accident investigations in each establishment measured. It should be noted that these rates are impacted by many factors, including the 10 management system practices that the larger survey investigated. The authors' intent is not to show causality among independent and dependent variables in this mini-study, but rather to show and explain associations of accident investigation characteristics with measures of safety performance.

Results

The mean establishment TRC and DART rates for the 330 respondents were 2.74 and 1.48, respectively. Independent sample *t* tests were performed on the TRC and DART rates between manufacturing versus non-manufacturing organizations. No significant differences were found between these two sampling groups. This suggests that the distribution of the TRC and DART rates are somewhat uniform across industrial sectors. We also tested the distribution of the safety performance outcomes (i.e., TRC and DART rates) using a formal Shapiro-Wilk test. In statistics, the Shapiro-Wilk test tests the null hypothesis that a sample $x1, ..., xn$ came from a normally distributed population. Using this test, the authors found that the distribution did not deviate from the normal distribution.

The correlation results are shown in Table 1. The correlations among the questions/statements designed to measure the characteristic reflecting who is responsible for investigating the safety incident with TRC and DART rates are interesting. There is a significant ($p \leq .01$) negative correlation with TRC and DART rates across the accident investigation characteristic that measures whether a team approach to conducting accident investigation is routinely utilized (i.e., those consisting of some combination of a safety representative, the injured employee's immediate supervisor and employee representatives). This finding is consistent with the item that measured whether employees were routinely involved in conducting accident investigations. These correlation coefficients suggest that a routinely used team-based approach to accident investigation is associated with the lower safety incident rates, and, further, that routine involvement of employees in the process is associated with the lower incident rates. Conversely, and somewhat surprising, when supervisors alone conduct accident investigations, there is a positive correlation ($p \leq .05$) with TRC and DART rates (e.g., the more that safety supervisors investigate accidents alone, the higher the incident rates). No significant correlation was found with incident rates when safety representatives alone conduct accident investigations.

As for the time it takes to initiate accident investigations, there is no significant correlation (Pearson or polychoric) with TRC and DART rates. However, there is a significant, negative correlation ($p \leq 0.05$) as to the degree that incident investigations seek to uncover potential reasons that human error might have occurred with TRC and DART rates (e.g., accident investigations that routinely seek the reasons why human error occurred and how it may have contributed to the incident are associated with lower incident rates).

Some intriguing correlations were found among the question responses themselves. Incident investigations that routinely focus on the reasons behind human error are significantly and positively correlated with team- and employee-based accident investigation approaches (at $p \leq .01$), but significantly and negatively associated with supervisor-based accident investigation approaches (also at $p \leq .01$). There is no significant correlation with the safety representative accident investigation approach.

One explanation of these results is that team- and employee-based accident investigations are more effective at root-cause analysis and determining the true underlying reasons as to why human error has occurred, while supervisor-based investigation approaches may be deficient. Another related explanation could be that more biases are introduced in the supervisor-alone accident investigation approach (leading to less accurate accident investigations) when compared to other approaches. This notion is supported by Manuele (2007) who suggests that supervisors may not be the most objective in performing accident investigations due to the fact that management system deficiencies found could be a reflection of their own deficiencies as supervisors (e.g., supervisors conducting accident investigations could be pointing their fingers at themselves).

When a team-based approach is used, it is positively and significantly correlated ($p < .01$) with an employee participation approach, but negatively and significantly correlated ($p < .01$) with both supervisor and safety representative participation alone approaches. This suggests that when respondents view a team approach to accident investigations, their perceptions are that it includes workers. Also, a team-approach versus an individual alone approach (supervisor or safety manager) may be somewhat mutually exclusive in the minds of safety managers responding to this set of characterization statements (either-or proposition), so the negative correlation of these question responses (team vs. individual approaches) would be expected.

Many of the identified correlations between accident investigation characteristics and safety performance statistics are significant from a *p*-value perspective. The significant *p*-values observed could be a result of the large sample size used in this study (n > 300). However, the magnitude of the correlations between accident investigation characteristics and safety performance statistics is low, which supports the notion that accident causation is a complicated process affected by many factors and safety management system practices.

Regressions were executed in order to more fully explore the potential differences in the association between organizational accident investigation programs characterized by who routinely investigates accidents with TRC and DART rates. The regression results are consistent with the correlation results. Table 2 (p. 175) reports the results in which the response from the items measuring who routinely investigates safety incidents is used to

Variable	Mean	SD	1)	2)	3)	4)	5)	6)	7)
1) Length of Time	1.49	.69							
2) Human Error	5.21	1.49	-.26**						
3) Team	5.08	1.75	-.12*	.46**					
4) Employee Involvement	4.81	1.71	-.07	.36**	.62**				
5) Supervisor	3.13	1.70	-.02	-.19**	-.34**	-.25**			
6) Safety Representative	3.70	1.97	.05	-.03	-.33**	-.24**	.29**		
7) TRC Rate	2.70	.82	-.02	-.13*	-.25**	-.20**	.10*	.08	
8) DART Rate	1.43	.48	-.04	-.14*	-.23**	-.20**	.15**	.03	.76**

Note: * p < .05, ** p < .01.

Table 1 Descriptive statistics and correlations

	Predictors	B	Beta	t	p	R^2
1	Size	.01	.00	.07	.95	.01
	Safety Representative	.12	.10	1.68	.10	
2	Size	-.04	-.03	-.48	.63	.01
	Supervisor	.18	.12	2.01	.04	
3	Size	.03	.02	.33	.74	.04
	Employee Involvement	-.32	-.22	-3.84	<.001	
4	Size	.03	.02	.41	.69	.06
	Team	-.36	-.25	-4.55	<.001	

Table 2 Regression results—TRC rate predicted by who is primarily responsible for accident investigation while controlling for establishment size

	Predictors	B	Beta	t	p	R^2
1	Size	.00	.00	.01	.99	.00
	Safety Representative	.02	.03	.66	.48	
2	Size	-.03	-.04	-.64	.52	.03
	Supervisor	.12	.16	3.01	<.001	
3	Size	.02	.02	.39	.69	.04
	Employee Involvement	-.19	-.22	-3.65	<.001	
4	Size	.02	.03	.45	.65	.05
	Team	-.22	-.24	-4.21	<.001	

Table 3 Regression results—DART rate predicted by who is primarily responsible for accident investigation while controlling for establishment size

predict TRC rates while controlling for organizational size. Table 3 reports the same types of regression coefficients using the DART rates as the outcome. Both tables report the regression coefficient (B), the standardized regression coefficient (Beta), the *t* value, the *p* value and the R^2 for each regression equation.

As one can see in the tables, a similar pattern is revealed on the effect of investigation responsible party and both TRC and DART rates. When the safety representative alone is responsible for accident investigations, there is no affect on either TRC or DART rates (revealed by the nonsignificant *p*-value for the regression coefficients). As employees are routinely involved in the process of accident investigation, there is a significant and negative prediction of both TRC and DART rates. Similarly, the team-based approach to accident investigations significantly and negatively predicts both measures of objective organizational safety performance. Most interesting, perhaps, is that organizational accident investigation programs that utilize the injured employees' immediate supervisor as the sole investigator actually have a positive and significant prediction of the TRC and DART rates. In other words, as supervisors alone investigate accidents, the TRC and DART rates are likely to increase. These findings are discussed more in the following section.

It is noted that although the correlations in these analyses are significant, the coefficients of determination (R^2) in these regression analyses are low, indicating that the variability occurring in accident investigation process characteristics data cannot explain adequately the variability in the safety performance data. This suggests that accident investigation characteristics may act as surrogate parameters for and/or track some other more important or more sensitive independent variable(s) that more directly impact(s) accident rates. This finding is consistent with the premise that accident causation is a complicated process impacted by many factors, with accident investigation process characteristics being only one variable.

Discussion & Conclusions

In this article, the authors explored how different characteristics of an accident investigation program may affect objective safety performance statistics. The study focused on three general characteristics: length of time to initiate investigation; the human error focus of the investigation; and who is the primary entity responsible for conducting the investigation.

Through the correlation results, some evidence was found that the length of time to investigate accidents may be less important than both the content focus and investigation team make-up. In addition, investigations that include the uncovering of the causes of human error are negatively associated with objective organizational safety performance. In other words, as organizations focus on why people did not behave properly and committed human error, they are perhaps more likely to experience lower levels of occupational injuries and illnesses. The single survey question associated with the content focus of accident investigations was high level and did not attempt to elucidate why workers are behaving improperly.

Perhaps the most significant finding is the result that the agent that an organization chooses to investigate accidents may make a difference in occupational injury and illness prevention. Through the correlations and regressions presented in this study, the authors do not argue cause-and-effect relationships; rather, these correlations and regressions merely point to associations among the variables. However, based on the correlations and regression results, it appears that team-based and employee-based investigation approaches may be associated with and can predict lower accident rates when compared to approaches where the supervisor or safety representative alone conducts the accident investigation. Most surprising is the finding that organizational accident investigation programs that rely solely on the supervisor to execute the process of investigation may actually experience higher occupational injury and illness rates.

We offer a few potential reasons for these findings. Perhaps team-based and employee-based accident investigation approaches actually generate higher quality accident investigation results, maybe due to a "two heads are better than one" perspective (for the team-based approach) or due to employees generally having work "expertise" and thus better abilities at diagnosing and controlling the cause of accidents when compared to supervisors or safety managers (for the employee-based approach). In other words, through the use of team-based approaches, a more thorough, truer picture of the events that led to the incident are actually revealed and more effective corrective and preventive actions result. Another possible explanation (and consistent with the objectives for "checking and correcting" in OHSAS 18001) is that the process of involving multiple people in the investigation facilitates overlapping knowledge sets among members of the collective. Involving multiple people in the investigation also simultaneously facilitates the process of communicating the findings of what led to the incident, the corrective actions being implemented, and ways to avoid future similar incidents to the multiple stakeholders involved in the organization's accident investigation program.

In addition, the results could be explained by the idea that accident investigation team composition could be an important surrogate parameter that reflects a healthier and more mature safety management system. Of all the myriad components of a safety management system, perhaps how an organization chooses to investigate its accidents is strongly associated with a well-run safety management system in general. Or these results could be indicative of something more specific. The characteristic of working in teams (e.g., team-based approach to accident investigation) and/or engaging employees in safety activities (e.g., employee-based approach to accident investigation) could be the actual predictors of safety performance, and accident investigations are one of many tools being used in organizations to achieve teamwork and employee engagement.

In engagement, an organization's workers execute their roles by driving personal energy into physical, cognitive and emotional labors and by so doing achieve active, full work performance. Engagement occurs when individuals are emotionally connected to others and cognitively vigilant (Harter, Schmidt & Hayes, 2002; Kahn, 10990). Connection and vigilance can be described as being psychologically present, attentive, integrated and focused in their role performance. Thus, the more engaged workers are in the safety function (e.g., being involved on accident investigation teams), the more likely they will perform in a safe manner due to this cognitive, emotional and physical vigilance.

According to Maslow's hierarchy of needs model and, related to this idea, the importance of worker engagement, one essential human need is to be innovative and solve problems. Advances in brain science have proven, through functional magnetic resonance imaging studies, the brain reward pathway is activated when people are recognized for their intellectual contributions (Martinez, 2010). As workers contribute their expertise to improve occupational safety more frequently (such as being involved in accident investigations), they will feel a sense of gratification. Many best-selling business books such as *Wikinomics, Crowdsourcing* and *Sway* illustrate how the benefit of harnessing the collective knowledge of employees is a key to company success (Martinez, 2010).

Having workers on accident investigation teams could be an important means to promote worker engagement in safety. Recent research (Wachter, 2012) has shown that safety management system practices and employee perception constructs improve objective safety performance by engaging workers (e.g., worker engagement acts as an important mediator between safety predictors and safety outcomes). Perhaps these findings can be specifically applied to accident investigations and interpreting the results obtained in this study: by involving workers in accident investigations, they are more engaged in safety and, ultimately, have higher levels of safety performance.

Without further research, it is difficult to precisely determine why team- and employee-based accident investigation approaches are associated with lower accident rates. Generating and deploying another survey (perhaps a more qualitative survey) composed of additional exploratory questions regarding characteristics of team- and employee-based accident investigation approaches could answer how these approaches operate.

It should be noted that in this study, the overall impact of accident investigation characteristics on safety performance statistics is relatively minor based on coefficients of determination calculated in the regression analyses. This is somewhat expected since accident causation is a complicated process impacted by many factors (Wachter, 2012). However, the correlations between some of the characteristics studied and safety performance statistics are significant based on the calculated p-values, even if the correlations themselves are somewhat low. This is also expected since individual characteristics were being explored in this study, rather than an accident investigation construct comprised of many characteristics.

Irrespective of these limitations and the risk of over-interpreting the statistical results, the study provides evidence to support the use of team- and employee-based approaches to conduct accident investigations in organizations. The theory presented within this article is now bolstered by the empirical evidence that suggests team- and employee-based accident investigation approaches are associated with lower accident rates. Given the dearth of information on this topic, these results represent important first steps in attempting to explain how accident team composition could impact directly the quality of accident investigation and more indirectly accident rates. ✪

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Weight Management Through Motivational Counseling in the Workplace

M. Allison Ford, Mary Amanda Haskins and Chip Wade

Abstract

The consequences of obesity are staggering when considering the total healthcare cost associated with the disease. The obesity epidemic is further compounded when considering the implications to workplace health promotion not only due to the healthcare cost but also the loss of employee productivity. Occupational health professionals have a daunting task in addressing obesity in today's workforce. We evaluated motivational counseling (MC) for weight management with 101 employees and to what extent adherence to the MC sessions impacts the magnitude of weight loss. The employees participated in weekly counseling sessions lasting 15 to 30 minutes focused on weight management. Our findings indicated significantly greater weight loss in staff-related employees and employees with greater adherence to the MC program. There were no differences across gender or race. These findings indicate that MC is an effective modality for addressing obesity-related preventive health disparities in today's workforce.

Keywords
motivational counseling, weight management, preventive health, workplace health, occupational health

Introduction

Since the early 1980s, the rate of obesity has grown from 15% to 35% in adults, resulting in significant economic and health consequences to society (NCHS, 2013). While it is estimated that two-thirds of adults are now either overweight or obese, by 2015, it is predicted that 40% of the U.S. adult population will be obese (Allison, Zannolli & Narayan, 1999; Must, Spadano, Coakley, et al. 1999). As for the financial consequences, it is suggested that obesity-associated healthcare costs are greater than those attributable to smoking, drinking and poverty (Schulte, Wagner, Ostry, et al., 2007). While there are a number of estimations based on a breadth of various data, conservative estimates indicate that annual U.S. obesity-related medical costs were about $86 billion, including $30.3 billion for full-time employed adults (Finkelstein, DiBonaventura, Burgess, et al., 2010; Finkelstein, Trogdon, Cohen, et al., 2009). Total healthcare costs are expected to continue to increase as more of the population becomes obese and has increased comorbidities related to obesity.

Worldwide, the direct health consequences of obesity are widely known. Obesity is a primary risk factor for cardiovascular and circulatory disease and mortality. Comorbidities of obesity increase the pervasiveness and severity of type II diabetes, elevated LDL cholesterol, reduced HDL cholesterol and hypertension (Whitlock, Lewington, Sherliker, et al., 2009). Additionally, obesity is a significant risk factor in noncardiovascular diseases such as liver cirrhosis, chronic renal failure, osteoarthritis and obstructive sleep disorders (Aspden, 2011; Ejerblad, Fored, Lindblad, et al., 2006). Given the increase in the rate of obesity and the fact that employed adults spend a quarter of their lives at work, the contribution of obesity to morbidity and mortality in working populations is epidemiologically, productively and economically significant.

Economically, obesity directly contributes to the rising cost of health insurance as well as workers' compensation expenses (Ostbye, Dement & Krause, 2007). Some have suggested that the increases in direct and indirect healthcare cost resulting from obesity contribute to the affordability of health and workers' compensation insurance expenses (Finkelstein, et al., 2010). The cost of obesity not only pertains to higher medical claims expenses, but also plays a significant role in the increase of short- and long-term disability expenses (Schulte, et al., 2007). Overall, it has been reported that obese individuals between age 18 and 65 have medical costs that are roughly 37% higher than normal weight individuals (Gabel, Whitmore, Pickreign, et al., 2009). Furthermore, obese employees file more compensation claims, have more costly claims and have more lost workdays than do non-obese employees.

From a workplace productivity standpoint, obesity is associated with increased rates of absenteeism and reduced productivity (Finkelstein, et al., 2009; Finkelstein, et al., 2010; Schulte et al., 2007). When compared to normal weight employees, obese employees have been shown to have decreased productivity, take more sick days and longer sick leaves (Finkelstein, et al.,

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2010; Thompson, Edelsberg, Kinsey, et al., 1998). Statistically, when compared to normal-weight employees, obese employees were found to be 1.7 times more likely to experience a high level of absenteeism and were 1.6 times more likely to report moderate absenteeism (Narbro, Jonsson, Larsson, et al., 1996). These statistics are particularly compelling when considering some estimations that suggest the costs to employers due to obesity-related reductions in productivity are greater than the direct costs of the medical care (Finkelstein, et al., 2010).

The burden of obesity and related disparities on workplace health professionals is evident. In today's workforce, the demands across industries vary, however some suggest job demands may impact physical activity routines, healthy behaviors and eating habits, all of which have been identified as corollaries to overweight and obesity (Yamada, Kameda, Noborisaka, et al., 2001; Yamada, Ishizaki & Tsuritani, 2002). When discussing workplace health promotion, research suggests that employees adhere better to a workplace health promotion when the program incorporates both workplace and personal risk factors, opposed to only personal risk factors (Sorensen, Barbeau, Stoddard, et al., 2005). Considering employed adults spend a quarter of their lives in a workplace, there is an opportunity through a workplace health program to provide counseling for employees' health behaviors and their associated risk for obesity (Yancey, McCarthy, Taylor, et al., 2004).

Motivational counseling (MC) is a practice focused on augmenting an individual's principle understanding of a specific counseling topic. MC has been applied to various types of behavior-change counseling, with a breadth of studies focusing on obesity-related behaviors (Wagner & Ingersoll, 2009). MC is an individual-focused approach to encouraging behavioral change through a support-focused, nonjudgmental design (Miller & Rollnick, 1991). Contrary to a typical counseling session, MC incorporates support focused self-directed sessions on a regular basis on a specific counseling topic. Whereas, traditional counseling models often rely on clinicians to provide untailored advice to their clients.

The primary elements of MC are the supporting, nonjudgmental process of encouraging "change talk." Change talk is the discussion of the individual's own reasons and arguments for behavioral changes. An additional element is encouragement in the decisiveness about behavioral change while simultaneously addressing discrepancies between the current behavior and personal goals and values.

Several studies support the efficacy of MC as a succinct counseling method to facilitate health behavioral changes across a number of health-related topic areas (Dunn, Deroo & Rivara, 2001). Specifically, MC has been indicated to promote improved long-term outcomes for several health outcomes with behavioral obesity treatment being the most established (Miller & Rollnick, 2002; Resnicow, DiIorio, Soet, et al., 2002). In looking at the efficacy of MC for weight management regardless of population, West, DiLillo, Bursac, et al. (2007) reported MC increased weight loss by improving attendance at group sessions, which enhanced the focused aspects of the program. Streit, Stevens, Stevens, et al. (1991) showed a significant relationship between self-monitoring and weight loss, suggesting that attendance at MC sessions may play a role in long-term weight loss.

When focused specifically on obesity and/or weight management counseling, MC has been shown to be effective in promoting changes in diet and physical activity (VanWormer & Boucher, 2004). Additionally, MC has resulted in greater short-term weight loss, significantly improved glycemic control and treatment adherence in overweight women (Smith, Heckemeyer, Kratt & Mason, 1997). While the key elements and efficacy of MC has been shown to be an effective modality for addressing health behavioral changes and weight loss in the general population, there is little work on MC as a workplace health promotion technique. There is a need for further work on strategies that merge traditional workplace health protection with workplace health promotion that relates to weight gain and obesity (Sorensen & Barbeau, 2006).

Given the epidemiology, productivity and economic significance of overweight and obesity today and the efficacy of MC as a counseling technique in addressing a range of health behavioral changes, this study focused on weight loss through MC in a population of 101 employees over a 5-year period. The purpose of the current study was to determine whether the level of adherence to MC sessions within a weight management program in a group of employees enhances long-term weight loss.

Methods

Employees

One hundred and one employed adults (41 males, 60 females) who visited a university employee health center for counseling from 2009-13 and were referred for weight management counseling were asked to enroll. Preliminary enroll-

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Male	Female	ΔMale-Female	White	Black	ΔWhite-Black	Staff	Adminstrative	ΔStaff-Administrative
Initial Weight (lbs)	259	195	64***	215	227	12	223	217	6
Exit Weight (lbs)	240	173	67***	229	234	5	198	199	1
Height (in)	74	71	3	77	71	6	73	75	2
HDL	58	64	6	60	66	7	60	63	3
LDL	113	130	16	124	133	9	127	133	6
Triglyceride	120	133	13	131	141	11	126	134	8
Blood Sugar	98	108	10	105	116	11	103	122	19**
Systolic	94	96	2	93	90	3	100	94	6
Diastolic	72	81	9	74	73	1	82	84	2
N	75	52	23	64	59	5	66	59	7

****,**,* indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.*

Table 1 Demographic characteristics and differences in means

ment criteria included a BMI of 27 or greater. Employees were required to complete a full lipid profile panel, blood pressure, blood glucose, cholesterol (LDL and HDL) and triglyceride test prior to the initiation of the MC sessions.

Table 1 shows employee descriptive statistics. Columns 1 and 2 report characteristics based on gender with differences shown in column 3; columns 4 and 5 show characteristics based on race with differences shown in column 6; and columns 7 and 8 show characteristics based on employment type with differences shown in column 9. There were significant differences in initial weight and ending weight between employment types, while characteristics across gender and race were insignificant.

MC Sessions

The employees met with an obesity-related health promotion practitioner for an initial MC session, lasting 20 to 30 minutes. Each employee continually attended a weekly individual meeting of approximately 15 to 20 minutes to follow up on each weekly health behavior change initiated by the employee. During these meetings, the employee had private time to ask questions and receive personal feedback on perceived barriers/obstacles. Specifically, the focus of the MC session was to encourage a discussion on behavioral change and commitment language, engaging in discussions of what motivated change, the uncertainty about changing eating and physical activity habits, and how behavioral changes might be consistent with the employee's values and goals. At the end of each session, the employee's weight was recorded and the next MC session was scheduled. It is important to note that the employees voluntarily attended the MC sessions indicating a preliminary level of self-motivation for participation.

Empirical Methodology

The researchers tested the impact of MC on weight loss controlling for gender, race and employment type. The team first conducted a univariate (*t*-test) comparison between gender, race and employment type on change in weight. A breadth of literature suggests MC encourages an increase in long-term health benefits across a myriad of health disparities (Wing, Koeske, Epstein, et al., 1987), race (Agur-Collins, Kumanyika & Adams-Campbell, 1997) and specifically obesity (Streit, et al., 1991). However, there is a paucity of findings discussing the attendance of MC sessions within a weight loss program. Next, the research team examined the impact that the level of attendance to the MC sessions had on weight loss, controlling for race, gender, employment type and other common physiological measures, using the following regression equations:

$$\Delta Weight_{intial\text{-}final} = \beta_0 + \beta_1 Height_{intial} + \beta_2 HDL_{intial} + \beta_3 LDL_{intial} + \beta_4 Triglyceride_{intial} + \beta_5 Blood\text{-}Sugar_{intial} + \beta_6 Systolic_{intial} + \beta_7 Diastolic_{intial} + \beta_8 Gender + \varepsilon_{i,t} \quad (3)$$

$$\Delta Weight_{intial\text{-}final} = \beta_0 + \beta_1 Height_{intial} + \beta_2 HDL_{intial} + \beta_3 LDL_{intial} + \beta_4 Triglyceride_{intial} + \beta_5 Blood\text{-}Sugar_{intial} + \beta_6 Systolic_{intial} + \beta_7 Diastolic_{intial} + \beta_8 Race + \varepsilon_{i,t} \quad (4)$$

$$\Delta Weight_{intial\text{-}final} = \beta_0 + \beta_1 Height_{intial} + \beta_2 HDL_{intial} + \beta_3 LDL_{intial} + \beta_4 Triglyceride_{intial} + \beta_5 Blood\text{-}Sugar_{intial} + \beta_6 Systolic_{intial} + \beta_7 Diastolic_{intial} + \beta_8 Employment + \varepsilon_{i,t} \quad (5)$$

$$\Delta Weight_{intial\text{-}final} = \beta_0 + \beta_1 Height_{intial} + \beta_2 HDL_{intial} + \beta_3 LDL_{intial} + \beta_4 Triglyceride_{intial} + \beta_5 Blood\text{-}Sugar_{intial} + \beta_6 Systolic_{intial} + \beta_7 Diastolic_{intial} + \beta_8 Attendance + \varepsilon_{i,t} \quad (6)$$

The dependent variable is the ΔWeight from the initial visit to the final visit. Recognizing the need to control for physiological differences in employees, the researchers included the employee's initial height (Heightinital), the initial high density lipoprotein (HDLinital), the initial low density lipoprotein (LDLinital), the initial triglyceride (Triglycerideinital), the initial blood sugar (Blood-Sugarinital) and the initial blood pressure measures (Systolicinital) and (Diastolicinital).

The indicator variables of interest were: 1) gender, which is an indicator variable equal to one for males, zero otherwise; 2) race which is an indicator variable equal to one for whites, zero otherwise; 3) employment which is an indicator variable equal to one for staff, zero otherwise; and 4) attendance which is the percentage of attendance to MC sessions. It should be noted within the study sample that employees where either male or female, white or black, and staff or administrative. Staff would be consistent with grounds, maintenance, janitorial and service related employment, whereas administrative would be faculty, secretarial and administrators.

The research team extended the regression analysis by examining the relation between gender, race and employment type, and the degree of attendance to the MC sessions as follows:

$$\Delta Weight_{intial\text{-}final} = \beta_0 + \beta_1 Height_{intial} + \beta_2 HDL_{intial} + \beta_3 LDL_{intial} + \beta_4 Triglyceride_{intial} + \beta_5 Blood\text{-}Sugar_{intial} + \beta_6 Systolic_{intial} + \beta_7 Diastolic_{intial} + \beta_8 Gender \times Attendance + \varepsilon_{i,t} \quad (7)$$

$$\Delta Weight_{intial\text{-}final} = \beta_0 + \beta_1 Height_{intial} + \beta_2 HDL_{intial} + \beta_3 LDL_{intial} + \beta_4 Triglyceride_{intial} + \beta_5 Blood\text{-}Sugar_{intial} + \beta_6 Systolic_{intial} + \beta_7 Diastolic_{intial} + \beta_8 Race \times Attendance + \varepsilon_{i,t} \quad (8)$$

$$\Delta Weight_{intial\text{-}final} = \beta_0 + \beta_1 Height_{intial} + \beta_2 HDL_{intial} + \beta_3 LDL_{intial} + \beta_4 Triglyceride_{intial} + \beta_5 Blood\text{-}Sugar_{intial} + \beta_6 Systolic_{intial} + \beta_7 Diastolic_{intial} + \beta_8 Employment \times Attendance + \varepsilon_{i,t} \quad (9)$$

Results

In Table 2 (p. 181), the researchers addressed the impact of MC on weight loss in race, gender and employment type specifically across attendance levels to the MC sessions. Stratifying adherence to the MC sessions by attendance to > 75% (Adhere 1), < 75% to > %50 (Adhere 2) and < 50% (Adhere 3), revealed significant differences between initial weight and exit weight across all variables of interest. Table 3 (p. 181) presents significant differences found across the attendance groups. While there were no significant differences in initial weight, significant differences were found in exit weight. Specifically, employees in the higher attendance groups realized greater weight loss.

Table 4 (p. 182) presents the regression findings. Similar to Tables 2 and 3, the researchers found no relationship between

	Adhere 1			Adhere 2			Adhere 3		
	Initial Weight (lbs)	Exit Weight (lbs)	Δ (lbs)	Initial Weight (lbs)	Exit Weight (lbs)	Δ (lbs)	Initial Weight (lbs)	Exit Weight (lbs)	Δ (lbs)
Male	260	252	8	257	249	8	259	241	18***
Female	189	184	5	184	176	8	191	178	13*
White	243	240	3	238	227	11*	241	229	12*
Black	249	241	8	244	238	6	247	229	18***
Staff	251	242	9	246	235	11*	247	228	19***
Administrtaive	249	240	9	243	235	8	246	231	15*

****,**,* indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.*

Table 2 Differences in means for gender, race and employment type by change in weight across adherence to MC sessions

gender and race to change in weight. Controlling for medical characteristics, a positive and significant relationship was found for employment type and adherence with change in weight. No interactions were noted between race and gender on adherence, however a significant positive interaction was found between employment type and adherence.

Discussion

Motivational counseling as a weight management health promotion initiative significantly enhanced weight loss in employees. More importantly, weight loss was significantly greater in employees who had greater adherence to the MC sessions over time. The current study provides practical information for workplace health professionals who are challenged with not only occupational exposures but in addressing the growing health disparities in today's workforce. Given the significant contribution of obesity to morbidity and mortality in working population, additional health promotion techniques are needed to address obesity in the workplace. The current study provides initial evidence that MC for weight management may be an effective modality in the workplace.

When discussing obesity and rising economic and societal cost, the association to cardiovascular health, heart attack, stroke, circulatory and respiratory system conditions are important in the discussion (Whitlock, et al., 2009). However, from an occupational standpoint, because overweight and obese people suffer from a higher incidence of chronic disease, including musculoskeletal disorders, recovery from injury or illness (occupational and nonoccupational) is often more difficult and more expensive than for normal-weight individuals (Finkelstein et al., 2010; Thompson, et al., 1998). These extended durations of temporary disability have a significant impact on the direct cost to an employer.

Workplace hazards contribute significantly to the overall population's morbidity, mortality, and financial and social costs, which are all principle reasons for governmental, private and public sector support of occupational health and safety. As such, with the increasing healthcare cost and workers' compensation expenses relating to modifiable health behaviors such as alcohol use, smoking and obesity, occupational health professionals are moving toward occupational health programs that not only address workplace hazards, but also support health lifestyle behaviors. The favorable impact of MC on weight loss has been reported in as few as two MC sessions with greater weight loss being proportional to the length of the program. Our results support the notion that adherence to a program impacts weight loss. Additionally, our findings suggest that MC for weight management may be an effective supplement to current workplace health programs.

	Adhere 1	Adhere 2	Adhere 3	Δ Adhere 1-Adhere 2	Δ Adhere 1-Adhere 3	Δ Adhere 2-Adhere 3
	Initial Weight (lbs)	Initial Weight (lbs)	Initial Weight (lbs)	Initial Weight (lbs)	Initial Weight (lbs)	Initial Weight (lbs)
Male	260	257	259	3	1	2
Female	189	184	191	5	2	7
White	243	238	241	5	2	3
Black	249	244	247	5	2	3
Staff	251	246	247	5	4	1
Admisntrative	249	243	246	6	3	3
	Adhere 1	Adhere 2	Adhere 3	Δ Adhere 1-Adhere 2	Δ Adhere 1-Adhere 3	Δ Adhere 2-Adhere 3
	Exit Weight (lbs)	Exit Weight (lbs)	Exit Weight (lbs)	Exit Weight (lbs)	Exit Weight (lbs)	Exit Weight (lbs)
Male	252	249	241	3	11*	8
Female	184	176	178	8	6	2
White	240	227	229	13**	11*	2
Black	241	238	229	3	12*	9
Staff	242	235	228	7	14***	7
Admisntrative	240	235	231	5	9	4

****,**,* indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.*

Table 3 Differences in means by difference in adherence to MC sessions

	Δ Weight						
	[1]	[2]	[3]	[4]	[5]	[6]	[7]
Height (in)$_{initial}$	0.201	0.184	0.134	0.168	0.214	0.187	0.158
	(0.116)	(0.201)	(0.143)	(0.101)	(0.149)	(0.131)	(0.138)
HDL$_{initial}$	1.118*	1.189*	1.164*	1.152*	1.216*	1.103*	1.157**
	(0.059)	(0.062)	(0.057)	(0.059)	(0.066)	(0.082)	(0.046)
LDL$_{initial}$	-0.624*	-0.532**	-0.614	-0.512**	-0.552	-0.617*	-0.412**
	(0.064)	(0.061)	(0.106)	(0.032)	(0.211)	(0.081)	(0.042)
Triglyceride$_{initial}$	1.211*	1.067**	1.058*	1.105**	1.116	1.213	1.098**
	(0.063)	(0.041)	(0.069)	(0.084)	(0.134)	(0.171)	(0.059)
Blood Sugar$_{initial}$	0.556	0.421	-0.336	0.487	0.424	-0.613	0.404
	(0.207)	(0.118)	(0.106)	(0.201)	(0.138)	(0.117)	(0.121)
Systolic$_{initial}$	0.303	0.213	0.216	-0.119	0.168	-0.231	0.163
	(0.106)	(0.107)	(0.203)	(0.101)	(0.117)	(0.143)	(0.108)
Diastolic$_{initial}$	0.217	0.263	0.303	0.187	0.203	0.187	-0.197
	(0.116)	(0.123)	(0.108)	(0.148)	(0.211)	(0.165)	(0.118)
Gender	-0.149				0.314		
	(0.119)				(0.157)		
Race		0.134				-0.203	
		(0.106)				(0.154)	
Employment Type			0.256**				0.222**
			(0.034)				(0.044)
Adherence				0.304***	0.249**	0.256**	0.311***
				(0.000)	(0.023)	(0.041)	(0.000)
Gender x Adherence					0.214		
					(0.123)		
Race x Adherence						0.232	
						(0.164)	
Employment Type x Adherance							0.234**
							(0.043)
Adj R2	0.216	0.204	0.284	0.301	0.249	0.303	0.267

***,**,* *indicate significance at the 0.01, 0.05, and 0.1 levels, respectively.*

Table 4 Regression analysis

Our findings indicate the actual percentage of attendance days relative to the whole program is a significant factor in change in weight. These findings are particularly interesting as prior work has shown that long-term adherence is an important factor while not directly testing attendance to the MC sessions. These findings have strong implications for the structure of MC sessions and the importance of regular attendance and adherence to the individual's behavioral changes.

While the study shows that MC significantly influences the magnitude of weight loss observed in employees who consistently participate in MC sessions compared to employees who participate at a lesser rate, regardless of gender and race, we did see a significant difference in weight loss between employment type. Specifically, we reported greater weight loss in staff employees versus administrative employees. We do not directly test any job characteristics, but anecdotally we interpret staff-related employment as having greater manual labor characteristics, while administrative employment would be characterized as office/sedentary type of work. As such, the potential exists that staff employees have greater physical activity throughout the day than do administrative employees.

One limitation of this study is that it focuses only on university staff and faculty/administrators. While the results can be generalized across employment, there are many factors that are specific to various occupations. While the researchers controlled for race, gender and physiological factors, there is uncertainty around these factors that would be specific to occupations outside a university setting. Future research would be warranted across a larger spectrum of occupations and employment types.

Conclusion

Literature consistently indicates that employees who are obese take more sick time and have more injuries and higher healthcare costs than their non-obese counterparts. This difference has been shown across countries and across types of companies. As employers are recognizing the importance of disease management and wellness programs (e.g., smoking cessation) for overall employee well-being and healthcare costs, they may also consider implementing programs to help employees achieve and maintain a healthy weight. The current study provides evidence that an employer-directed and supported MC program focused on weight management could have a positive and significant impact on the economic costs and productivity related to an obese working population. In summary, the current study provides compelling evidence that MC for weight management may be a practical and effective program in addressing obesity and related health disparities in the workplace. ✪

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