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A hierarchical factor analysis of a safety culture survey☆

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ABSTRACT

Introduction: Recent reviews of safety culture measures have revealed a host of potential factors that could make up a safety culture (Flin, Mearns, O'Connor, & Bryden, 2000; Guldenmund, 2000). However, there is still little consensus regarding what the core factors of safety culture are. The purpose of the current research was to determine the core factors, as well as the structure of those factors that make up a safety culture, and establish which factors add meaningful value by factor analyzing a widely used safety culture survey.
Method: A 92-item survey was constructed by subject matter experts and was administered to 25,574 workers across five multi-national organizations in five different industries. Exploratory and hierarchical confirmatory factor analyses were conducted revealing four second-order factors of a Safety Culture consisting of Management Concern, Personal Responsibility for Safety, Peer Support for Safety, and Safety Management Systems. Additionally, a total of 12 first-order factors were found: three on Management Concern, three on Personal Responsibility, two on Peer Support, and four on Safety Management Systems.
Results: The resulting safety culture model addresses gaps in the literature by indentifying the core constructs which make up a safety culture.
Impact on Industry: This clarification of the major factors emerging in the measurement of safety cultures should impact the industry through a more accurate description, measurement, and tracking of safety cultures to reduce loss due to injury.

1. Introduction

Organizations in the United States lose up to 170 billion dollars annually due to work-related injuries (as cited in Towers Watson, 2010). The National Safety Council's (NSC) most recent statistics show annual losses can be as high as 183 billion dollars (National Safety Council, 2010). The NSC additionally reported each worker must increase his or her productivity on average $1,250 to make up for a single injured worker. Conversely, Takala (2002) reported shareholder price was higher for organizations that have an effective safety and health management system.

Injuries and the associated costs decrease over time when an organization views safety as an investment rather than an expense (OSHA, 2003). A small near-term investment in safety can potentially prevent larger future costs in workers compensation, lost-time work, or substantial legal costs. Additionally, a company's public reputation could be damaged if the incident was significant and thus, the possibility to hurt a company in the marketplace (Myers, 2010). Behm, Veltri, and Kleinsorge (2004) argue that safety cultures, which include prevention and detection programs, can increase employee awareness and reduce costs associated with injuries.

There was a great deal of discourse around the concept of "safety culture," following a series of publicly scrutinized incidents. For example, the Upper Big Branch Mine in West Virginia had previously been cited for numerous safety violations (Maher, Powers, & Hughes, 2010). A methane buildup resulted in an explosion and mine collapse. In the following days, there was speculation surrounding the safety culture of workers, as well as those who held leadership positions at this mine. Even when supervisors assured employees working conditions were safe, the miners knew their safety equipment (e.g., the methane detectors and ventilation systems) did not consistently operate (Berkes & Langfitt, 2010). Miners observed engineers rewiring methane detector equipment under management supervision so employees could continue to work in these unsafe environments for the purpose of increasing productivity (Christopher, 2010). Yet, employees did not notify the federal and state mining inspectors and appeared to breach safety protocols themselves. If cultures such as the Upper Big Branch Mine are sustained for an extended period, disasters are almost inevitable (Agnew & Daniels, 2010). On the other hand, a positive safety culture can help prevent work-related injuries; including major disasters similar to what occurred at the Upper Big Branch Mine.

☆ The survey analyzed within this study was developed and revised by Safety Performance Solutions Inc. for the sole use of their clients.

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Geller and colleagues (Geller, 2005; Hickman & Geller, 2003; Ludwig & Geller, 2000) have empirically examined the concept of safety culture. According to Geller (2001a), a positive safety culture encompasses a purposeful relationship between management and employees to improve the safety of all workers. This means that an organization should have adequate safety procedures and proper equipment for their employees. Additionally, management should consistently communicate the importance of safety. Those who work safely should be rewarded and those who participate in unsafe practices should be penalized (Pidgeon, 1991).

External pressures may force an existing safety culture to adjust (e.g., tragedy, conforming to a new law). Sulzer-Azaroff, McCann, and Harris (2001) labeled this particular culture "reactive" because the organization adjusts their policies after an event has occurred. However, if employees are not motivated to act safely, most policies will not increase safe behaviors on a large scale (Geller, 2001a). Instead, Geller (1994) advocates that employee motivation for safety should come from participation in the safety program, not a bureaucratic process or regulatory policy. Geller (2001b) proposes a positive safety culture focuses on preventive measures. Sulzer-Azaroff et al. (2001) labeled this type of culture "proactive" because the organization places safety as a priority *before* a negative event occurs or a law is established.

2. Organizational culture and safety culture

Safety culture is just one of many within an overall organizational culture. A positive safety culture should be developed within the framework of an organizational culture to help ensure organizational consistency within safety culture programs (Clarke, 1998). Before continuing with a safety culture literature review, it is necessary to understand what organizational culture is in a broader context, and why researchers continue to focus on it.

Organizational culture comes from the external environment and the integration of an internal framework (Schein, 1990). There are varying definitions of organizational culture. Organizational culture encompasses the central beliefs, values and assumptions of the organization (Denison, 1996). Alternatively, a more frank definition of organizational culture is, "the way we do things around here." Schein's (1990) commonly held definition of culture is:

> [A] pattern of basic assumptions, invented, discovered, or developed by a given group, as it learns to cope with its problems of external adaptation and internal integration, that has worked well enough to be considered valid and, therefore is to be taught to new members as the correct way to perceive, think, and feel in relation to those problems (p. 111).

Safety culture, like organizational culture, does not have a universal definition. Lee and Harrison (2000) define safety culture as, the values, attitudes, beliefs, risk-perceptions and behaviors as they relate to employee safety. The Health and Safety Executive of the United Kingdom defined it as:

> The safety culture of an organisation is the product of individual and group values, attitudes, perceptions, competencies and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization's health and safety management… Organisations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety and by confidence in the efficacy of preventive measures (as cited in Gadd & Collins, 2002, p. 2).

Guldenmund proposes safety culture is "[the] aspects of the organizational culture which will impact on attitudes and behavior related to increasing or decreasing risk" (p. 251).

Most organizations have mission statements, which should be a reference for appropriate conduct for employees. Cultural assumptions and values are typically the basis of an organization's mission. Yet, this is not always the case. For example, the mission statement for Massey Energy Co., which owned and operated the Upper Big Branch Mine, is currently:

> Customers: To supply our customers with the highest quality coals at reasonable and competitive prices.Shareholders: To earn optimal rates of return on the capital used in our business.Employees: To provide for the best possible well-being of members.Communities: To be responsible citizens and responsive to the needs of our environment. (http://www.masseyenergyco.com).

Preliminary evidence from the investigation into the mine disaster suggests that these principles stated in the company's mission were not applied consistently at the Upper Big Branch Mine (Berkes & Langfitt, 2010; Christopher, 2010). Obviously, the organization's mission and values cannot create or change a culture alone. Interventions directed at the individual employee level is necessary (Redmon & Mason, 2001).

Kotter and Haskett (1992) suggest that stronger cultures that involve employees can affect the organization in three ways. When goals of management and employees are united, each understands the necessity of their work to the organization. Thus, strong communication between management and employees is vital. Secondly, the motivation and "engagement" (Bakker & Schaufeli, 2008) of employees can favorably impact business outcomes (Harter, Schmidt, & Hayes, 2002). Lastly, strong cultures enhance performance by supplying structure and control without the need of an overbearing establishment of rules and other formalities. All of these components can contribute to a positive safety culture as well.

Employee surveys are typically used to examine organizational culture. Jung et al. (2009) reviewed 70 instruments for measuring employee attitudes and perceptions across different dimensions of the culture. Twenty-six major dimensions (e.g. ethics, rewards, development, leadership, goals) were identified within those instruments.

3. Safety culture constructs

Reviews of safety culture surveys identified some common constructs (Flin et al., 2000; Guldenmund, 2000):

- Management Concern
- Personal Responsibility
- Peer Support for Safety
- Safety Management Systems

The following sections provide an overview of these core constructs as well as some potential sub-constructs leading up to a hierarchical factor analysis to discover which factors contribute unique variance to safety culture. Some constructs reviewed below have never been included in a published survey of safety culture, but have potential to offer meaningful value to safety culture measurement.

Management Concern for Safety. The most prevalent construct in every survey reviewed was the perception of management/supervisors' attitudes and behaviors around safety (Flin et al., 2000). Potential sub factors include management consideration of employee safety, care for employees, and enforcing safety policies and regulations within their respective business and industry. Additionally, Dollard and Bakker (2010) found evidence that positive safety culture values can permeate an organization if top management leads safety efforts by communicating and exhibiting the importance of safety. Branham (2010) suggests leadership (management and supervisors) should spend more time on the floor with employees, much like football coaches are on the field with their players.

Work pressure typically is seen as a sub-factor of Management Concern because management creates the operation and production schedules (Janssens, Brett, & Smith, 1995; Phillips, Cooper, Sutherland, & Makin, 1993). Management should encourage safe behavior along with their operational goals. The two should not be viewed as mutually exclusive. Otherwise, employees view production as a higher priority than safety and unsafe behavior may be reinforced and repeated. Survey questions regarding work pressure would ask if management sets unrealistic production goals without regarding safety, or if the current production goals set by a supervisor or management force employees to compromise safety.

In many safety culture surveys, it is not clear whether employees were reacting to senior executives or their direct supervisors when answering the questions about management (Flin et al., 2000). To clarify this ambiguity, safety culture surveys should distinguish between the individual's supervisor and senior management.

Personal Responsibility for Safety. Harvey et al. (2002) defined personal responsibility as the "perceived responsibility for involvement in safety issues" (p. 23) whereby workers are accountable for their own safety and management is accountable for reducing their workers' risky behavior, as is part of their job description. Harvey et al. found that workers tend to feel less responsibility than managers/supervisors. Perhaps because of this, Guldenmund's (2000) review gave little attention to the construct. However, personal responsibility does appear in surveys by Cox and Cox (1991) and Coyle, Sleeman, and Adams (1995). Survey questions around personal responsibility for safety would ask employees if employees get blamed by management without investigation, if they report minor injuries and incidents regularly, and if they engage in risky behavior. Risky behavior has been measured through surveys of one's perception of personal risk (Brown & Holmes, 1986), attitudes toward levels of risk taking (Diaz & Cabrera, 1997; Janssens et al., 1995; Zohar, 1980) and self-reports (Alexander, Cox, & Cheyne, 1995; Lee, 1998; Mearns, Flin, Fleming, & Gordon, 1997; Phillips et al., 1993).

Peer Support for Safety. Outside of measures of management caring, a "caring" factor among peers was not found within any survey reviewed by Flin et al. (2000) or Guldenmund (2000). However, co-workers are constantly around each other while completing job tasks (some of which may be dangerous and hazardous). Therefore, a construct of employee caring seems to be an important safety culture construct related to moment-to-moment safety behaviors.

Nevertheless, there is a robust model of employee-focused caring in the safety literature. For over two decades, Geller (1991, 1994, 2001a, 2001b) has been advocating an Actively Caring factor as an essential part of safety culture. Geller (1991) originally coined the term, "Actively Caring," as "employees acting to optimize the safety of other employees" (p. 607). Geller (2001b) suggests Actively Caring occurs when employees go out of their way to alert a co-worker who is exhibiting at-risk behavior or congratulating an employee for performing their task safely. He described Actively Caring as positive behaviors that lead to a safer working environment that are reinforced through positive consequences (e.g., a caring social interaction) that occur after a particular action (Skinner, 1981). Workers who give feedback are also reinforced for "optimiz[ing] the safety of other employees" (Geller, 1991, p. 607). Actively Caring is further discussed in Roberts and Geller (1995) and Geller (1991, 1994, 2001a, 2001b). In the context of safety culture measurement, Actively Caring may be referenced as Peer Support for Safety. Survey questions around Peer Support for Safety ask employees if they should caution each other about hazardous work, do caution each other, and respectfully acknowledge each other when they witness a particularly safe behavior.

Safety Management Systems (SMS). Safety systems involve tactics that managers use to manage safety (Flin et al., 2000). These methods include actions such as designating safety officials (Phillips et al., 1993; Zohar, 1980), creating safety committees (Ostrom, Wilhelmsen, & Kaplan, 1993; Zohar, 1980), enacting policies (Diaz & Cabrera, 1997), or developing prevention strategies (Diaz & Cabrera). Hahn and Murphy (2008) also argued that perceived worker involvement in safety programs and safety feedback should be included in definitions of safety systems.

Despite the prevalence of the construct in the literature, safety systems were not consistently defined in the previous reviews (Flin et al., 2000; Guldenmund, 2000). Nor were the components measured reliably in past surveys (Fernández-Muñiz, Montes-Peón, & Vázquez-Ordás, 2007; Hale, 2003; Hale, Heming, Carthey, & Kirwan, 1997). Thus, a more refined concept of Safety Management Systems (SMS) offers a consistent definition and assessment (Fernández-Muñiz et al., 2007; Hale, 2003). While Flin et al. (2000) went as far to say SMS may not be necessary when assessing safety culture, others have demonstrated SMS scales can improve the measurement of an overall safety culture if the SMS is well-organized and defined (Bottani, Monica, & Vignali, 2009; Cooper & Phillips, 2004).

Fernández-Muñiz et al. (2007) has significantly expanded the construct in recent years, suggesting an effective SMS should contain six important subfactors: safety policy, incentives for employee participation, training, communication, planning, and control. Fernández-Muñiz et al. included a separate factor of employee involvement. However, their study still did not include all potential subfactors of an SMS within a safety culture. Thus, additional research, reviewed below, suggests the following could be regarded as sub-factors in a SMS:

- Safety Policy, Procedures, and Rules
- Training
- Communication
- Incident Reporting and Analysis
- Safety Audits and Inspections
- Rewards and Recognition
- Employee Engagement
- Safety Meetings/Committees
- Suggestions/Concerns
- Discipline

Safety policy, procedures and rules. Guldenmund (2000) found procedures/rules to be a prominent subfactor in studies reviewed (Lee, 1998; Mearns et al., 1997; Ostrom et al., 1993). This subfactor is defined by employee perceptions of the frequency which they comply or violate rules and procedures. Although Flin et al. (2000) suggested this construct is related to risk taking because risk involves breaking rules and not following safety policy, the majority of studies suggested categorizing it under SMS (Fernández-Muñiz et al., 2007; Hale, 2003).

Training. Training is defined as a program that includes all necessary safety information, adequate practice, and consistency. In a more recent meta-analysis, Christian, Bradley, Wallace, and Burke (2009) found that selecting and training safe workers can increase dispositional factors related to safety culture (e.g. safety knowledge, safety motivation). This, in turn, can aid in decreasing the number of accidents and injuries within the workforce. Safety specific training also demonstrates the company places a priority on safe work practices (Christian et al., 2009).

Communication. Hale, Guldenmund, van Loenhout, and Oh (2010) emphasize that components of the SMS need to be consistently communicated and applied from top management and safety professionals. Top-down communication is necessary to show mid-management and frontline workers that a proper safety initiative is vital for organizational success (Dollard & Bakker, 2010). Examples of communication include regular communication of safety goals from management to employees and certainty that incident reports are regularly reviewed and shared with employees.

Incident reporting and analysis. Nielsen, Carstensen, and Rasmussen (2006) suggest reporting minor injuries and near-misses are associated with decreases in injury rates. Nielsen et al. (2006) advocate that employees should not only report minor or near incidents, but they should also have an opportunity to offer suggestions for future preventive measures. Incident reporting and analysis may also be related to both management concern and employee involvement, however, most suggest it is primarily a SMS factor (Nielsen et al., 2006).

Safety audits and inspections. Kunreuther, McNulty, and Kang (2002) emphasize the importance of proper inspections and audits in a safety management plan. This element of an SMS can be particularly costly, so Kunreuther et al. suggest using a third party to coordinate inspections, instead of hiring or using current employees who may have biases. Branham (2010) calls audits "forced compliance," but audits and inspections also consist of offering regular safety feedback from inspections and prioritizing hazards according to potential for injury.

Rewards and recognition. Rewards and recognition are important for safety management systems if they adequately reinforce safe behavior while punishing at-risk behavior (Hsu, Lee, Wu, & Takano, 2008; Pidgeon, 1991) through a fair incentive and feedback system. A fair system also entails not rewarding employees who excel toward production goals while failing to work in accordance with safe procedures (Hsu et al., 2008). Examples of rewards and recognition include performance reviews and safety celebrations. However, the recognition of safety milestones is only productive if it does not inhibit incident reporting. Geller (2000) suggests celebrating milestones such as a specific number of incident reports or safety audits.

Employee engagement. It is empowering for employees to be involved in their work processes and associated safety processes (Hsu et al., 2008). Branham (2010) suggests a workforce is engaged when individuals promote safe behaviors and actively reduce workplace hazards. Dollard and Bakker (2010) suggest employee engagement in safety can lead to positive organizational outcomes such as fewer work-related injuries if employees have adequate resources. Interestingly, overall safety culture is more correlated with worker engagement than worker compliance with rules and procedures (Christian et al., 2009). As such, Podgórski (2006) suggests, good SMSs have a mechanism for employee engagement. Survey questions around engagement ask employees if they correct safety hazards without being told, even if it temporarily prohibits production.

Safety meetings/committees. Hale et al. (2010) stress the importance of having a vehicle whereby workers and management can discuss and solve safety issues. Christian et al. (2009) suggest one way safety information can be communicated formally is through meetings. This can be achieved through open employee participation or through representatives voted on by employees (Podgórski, 2006). Washington State requires all large organizations to construct safety committees under certain conditions and suggests smaller operations conduct regular safety meetings (Washington State Department of Labor and Industries, 2009). Within these regulations safety meetings/committees were required to be held monthly and a manager representative must be present. Examples of topics discussed in these meetings included: reviewing safety/health inspection reports to correct safety hazards, evaluate accident investigations conducted to determine if the causes of the safety hazard was identified and corrected, and evaluate workplace accident and illness prevention program and discuss suggestions for improvement. These guidelines around safety meetings are constructive for the successful implementation of a positive safety culture (Podgórski, 2006) and should be assessed in safety culture assessments.

Suggestions/concerns. Tharaldsen, Mearns, and Knudsen (2010) suggest a system for employees to recommend improvements in safety procedures to managers (bottom-up communication). However, suggestions need to be taken seriously, or else employees could view the process as a joke (McAdam, 2011). Thus, this subfactor also involves supervisors acting swiftly and appropriately in response to the suggestion. Some organizations that have saved money due to employee suggestions offer a monetary award to the employee who made the recommendation (McAdam, 2011).

Discipline. Disciplinary actions should be consistent, fair, and appropriate when at-risk behaviors are found whether an injury occurs or not. Branham (2010) suggests it is best to avoid discipline when an alternate learning opportunity is available, because discipline never immediately follows the at-risk behavior. Further, he suggests discipline should be used constructively to encourage workers, not merely to discourage particular behaviors. Survey question examples may include asking if employees are disciplined when they should be and if discipline for violations is fair and consistent.

4. Safety culture survey and factors

Safety culture, like organizational culture, is measured by surveying employee attitudes and perceptions of the organization, its management, and their own actions regarding safety. There have been numerous attempts at developing safety culture surveys. Guldenmund (2000, pp. 230-234) and Flin et al. (2000, pp. 181-184) have each presented extensive tables that review existing surveys and the aforementioned constructs. Flin et al. focus on common constructs of safety culture surveys while Guldenmund primarily reviews the many theories and models of safety cultures. Each provides detailed information about the surveys (e.g. number of questions, factors measured). However, it is difficult to find a single survey that exhibits any predictive quality in actual safety performance or statistics. Nevertheless, until a full meta-analysis is conducted, what accurately predicts a good safety culture is not easily discerned (Flin et al., 2000).

The safety culture factor analysis in this study aims to clarify core factors that should be included in safety culture measurements. The individual factors included in the factor analysis were chosen because they appeared in a majority of safety culture surveys as reviewed by Flin et al. (2000) or Guldenmund (2000). The most common factor in any review involved management concern, so this was included in the current research as Management Concern for Safety. However, gaps seemed to be prevalent in previous safety culture survey literature. A Personal Responsibility factor did not appear much in the literature. However, employees should be responsible for safety and level of risk within their organization (Harvey et al., 2002). The concept of Actively Caring (Geller, 2001a) has not received any attention in existing surveys so it was included in the present study as Peer Support for Safety. Finally, SMS has not been included in a safety culture survey as extensively as the above review suggests it should. This study suggested several constructs that could be added as sub-factors of a Safety Management System.

Thus, "Safety Culture" was indicated in the previous review of the literature by four related but distinct factors: Management Concern, Peer Support for Safety, Personal Responsibility, and Safety Management Systems with a number of sub-factors. Safety Culture was considered a higher-order latent variable that shaped these factors. Moreover, sub-factors that were likely to be highly correlated with safety culture are investigated, consistent with Edwards and Bagozzi's (2000) suggestions. Based on the literature review, Fig. 1 presents potential major factors and subfactors which may be included in a survey measuring safety culture.

The factor structure was considered as a reflective construct with effects indicators flowing from the construct to the individual factors (see Fig. 1) rather than a formative construct. Simply stated, the safety culture causes the items of the survey to reflect the changes in the overall construct. This is the typical structure when considering the development of a survey.

This study further investigated the safety culture construct through both an exploratory and hierarchical confirmatory factor analysis. An exploratory factor analysis was conducted to determine which questions contribute meaningful value to the model. A hierarchical confirmatory factor analysis was conducted to validate the results of the exploratory analysis and to determine the hierarchical structure proposed by the current model. There were two hypotheses. We expected the proposed core factors, as well as the structure of those factors above, to represent

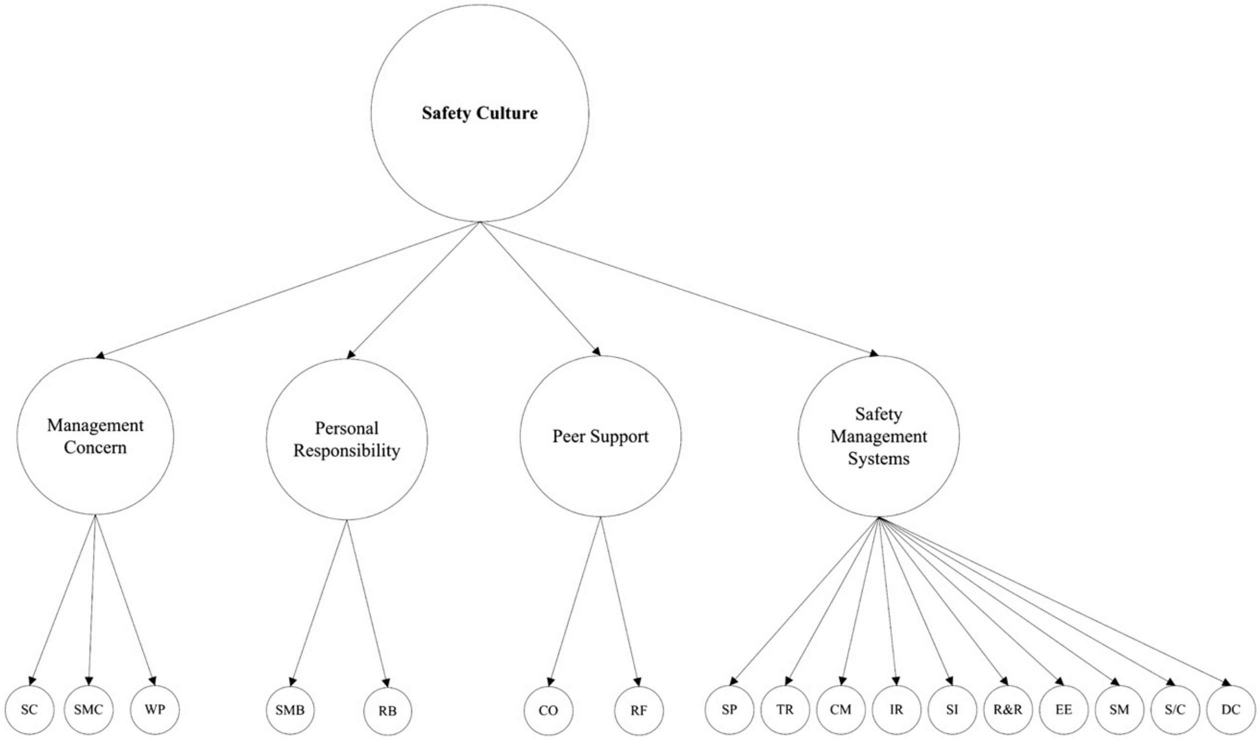

Fig. 1. Note: SC = Supervisor Concern, SMC = Senior Management Concern, WP = Work Pressure, SMB = Supervisor/Management Blame, RB = Risky Behavior, IR = Incident Reporting, CO = Caution Others, RF = Respectful Feedback, SP = Safety Policy, Procedures, and Rules, TR = Training, CM = Communication, IR = Incident Reporting & Analysis, SI = Safety Audits and Inspections, R&R = Rewards and Recognition, EE = Employee Engagement, SM = Safety Meetings/Committees, S/C = Suggestions/Concerns, DC = Discipline.

a more complete safety culture as compared to previous surveys in the literature. The second was that the survey items would be reduced to those that add meaningful statistical value to the safety culture survey.

5. Method

5.1. Participants

The 2010 revision of the Safety Culture Survey was administered by means of online and paper formats to 25,574 employees across five multi-national companies representing five different industries. The industries represented included: mining, chemical, healthcare, steel, agricultural. Countries representing all continents were included in this study. This study was approved by Appalachian State University's Institutional Review Board (#11-0189).

5.2. Survey development

Seven subject matter experts (SME) in safety culture with extensive professional experience as safety consultants were used for question development of the Safety Culture Survey. Each SME held a graduate (masters or doctoral level) degree in industrial/organizational psychology, industrial engineering, human factors engineering/ergonomics, organizational design and development, occupational safety and health, communications, or education & training.

The Q-Sort method (Van Exel & de Graaf, 2005) was used to construct questions for this safety culture survey. First, an analysis of the reviewed literature was evaluated by the SMEs. Then each SME prioritized the constructs, which revealed the importance of each construct. Next, each prioritized list was examined to show which constructs were most important in contributing to a safety culture survey. Once the factors were determined, a set of questions were created for each factor. These questions underwent various stages of sorting between the SMEs to determine which questions necessary to measure a safety culture construct and which were irrelevant or redundant. Once a consensus was attained, the questions were assembled randomly into a survey.

The SMEs developed 92 questions (see Table 1 for samples of the types of questions within original subscales; the actual survey was not included for proprietary reasons. To attain a copy of the survey refer to the Author Notes for contact information) which are tentatively organized into four broad scales: (a) management concern for safety (16 questions), (b) peer support for safety (10 questions), (c) personal responsibility for safety (7 questions), and (d) safety management systems (54 questions). All items were rated on the same 5-point Likert scale (e.g., "Strongly Disagree – Disagree – Neutral – Agree – Strongly Agree"). There were numerous questions that overlapped between scales, along with five questions that did not reliably fall into a potential scale but were considered important enough to keep in the survey. There were 12 items that were reverse-scored because the meaning of the questions were the opposite direction of the scale (i.e., high-rated items were considered negative responses, and low-rated items were considered positive responses).

6. Results

6.1. Descriptive statistics

The dataset consisted of 25,574 participants from five multi-national organizations within five different industries. Table 2 presents the means, medians, standard deviations, variances, skewness, standard error of the skewness, kurtosis and standard error of kurtosis for each item in the survey. Although most items were negatively skewed, normality is not an assumption of factor analysis (Tabachnik & Fidell, 2007). The overall reliability estimate (Cronbach's alpha) for the survey was $\alpha = .95$.

Correlations among the four sub-factors of safety culture including: management concern for safety, personal responsibility for safety, peer support for safety, and safety management systems were

Table 1
Sample questions from the 2010 revision of the safety culture survey.

Management Support for Safety: The Management Support for Safety Scale assesses whether employees feel the actions of management are supportive to building and maintaining a positive safety culture.
Sample Management Support for Safety Questions

- Safety is not compromised when determining production schedules, overtime, and staffing.
- Safety is considered when purchasing new tools/equipment.

Peer Support for Safety: The Peer Support for Safety Scale assesses employees' perceptions and opinions regarding how strongly they believe their coworkers support safety. This scale includes several items designed to gauge the level of 'Actively Caring' among coworkers.
Sample Peer Support for Safety Questions

- When I see a coworker working at-risk, I caution him/her.
- Employees often "short cut" safe work practices.

Personal Responsibility for Safety: The Personal Responsibility for Safety Scale assesses employees' perceptions and opinions regarding how strongly they believe *they* support safety.
Sample Personal Responsibility for Safety Questions

- I tend to work more risky when supervisors aren't present.
- I only get involved in safety activities because I'm required to do so.

Safety Management Systems: The Safety Management Systems Scale measures employee perceptions of many formal safety management systems. In addition, it also asks for opinions about the company's overall safety performance, and the effects of stress, drugs, and alcohol on safety.
Sample Safety Management Systems Questions: Discipline

- Managers, supervisors, and employees all know what behaviors will result in discipline.
- Discipline for safety violations is fair and consistent.

Sample Safety Management Systems Questions: Incident Reporting and Analysis

- All incidents, even minor ones, are thoroughly investigated if they have potential for serious injury.
- All factors (e.g., inadequate training, production pressure, excessive overtime) are adequately considered during incident analyses.

Sample Safety Management Systems Questions: Rules, Regulations, and Procedures

- Safety is considered when changes are made to rules and procedures
- Standard operating procedures have been developed for all critical tasks.

Sample Safety Management Systems Questions: Training

- Our training program ensures all employees who do the same job learn to do it the same way
- When asked to do a new job or task, I receive enough training to be able to do it safely.

Sample Safety Management Systems Questions: Safety Suggestions and Concerns

- I am comfortable raising safety concerns to my supervisor and manager.
- Employees receive quick responses to their safety suggestions, whether they are accepted or not.

Sample Safety Management Systems Questions: **Rewards and Recognition**

- Our safety reward/recognition program(s) encourage employees to work safely and participate in safety activities
- My supervisor often gives me positive feedback when s/he sees me working safely.

Sample Safety Management Systems Questions: **Safety Audits and Inspections**

- Safety audits/inspections are conducted regularly in my area
- Hazards are prioritized and corrected based on potential for injury.

Sample Safety Management Systems Questions: **Communication**

- Lessons learned from incidents and injuries are communicated to all relevant people.
- When rules or procedures are changed, the changes are promptly communicated to all affected employees.

Sample Safety Management Systems Questions: **Employee Engagement**

- Employees are involved in conducting safety audits and inspections.
- Employees frequently offer ideas and suggestions to improve safety.

Sample Safety Management Systems Questions: **Safety Meetings/Committees**

- Safety meetings help improve safety.
- Employees are kept informed of the safety committees' activities.

Table 1 (*continued*)

Sample Safety Management Systems Questions: **Miscellaneous**

- The people who lead safety efforts (e.g., safety reps, safety managers) have enough influence and staffing to adequately support safety.
- Alcohol or drug abuse is a problem at my site.

significant and strong (see Table 3). As expected, there were higher correlations between dimensions representing conceptually similar dimensions (i.e., management concern for safety, peer support for safety, and safety management systems). Also expected, was an artifactual reverse-scoring issue that arose with the personal responsibility for safety factor, which decreased both the correlations with the other factors as well as internal reliability of the personal responsibility factor consistent with Harvey, Billings, and Nilan (1985). Generally, though, reliability estimates were high for each of the four sub-factors of safety culture: $\alpha = 0.88$ for management concern for safety, $\alpha = 0.68$ for personal responsibility for safety, $\alpha = 0.84$ for peer support for safety, and $\alpha = 0.94$ for safety management systems. These descriptive results provide preliminary evidence that it is appropriate to continue with the factor analyses on the data set.

6.2. Exploratory Factor Analysis (EFA)

After initial descriptive analyses were conducted, the 92-item measure was subjected to an exploratory factor analysis (EFA) to assess the number of factors of safety culture using approximately half of the study's participants, 12,709 workers. This selection procedure was completed at random. The EFA was performed using SPSS for Windows, Release Version 18.0, (SPSS, Inc., 2009). The EFA was performed using principal axis factoring and a direct oblimin rotation on the randomly selected first half of the data set (Fabrigar, Wegener, MacCallum, & Strahan, 1999).

To determine the maximum number of factors that should be interpreted, we conducted a parallel analysis (PA) in order to establish the number of factors to retain for rotation and interpretation (Lautenschlager, 1989). This technique generates random data with the same properties as the original data (i.e., equal sample size and number of variables) and subsequently subjects the random data to a factor analysis. The results of the PA indicated that thirteen factors should be retained. However, given recent research that has indicated that PA tends to overfactor (Fabrigar et al., 1999; Hayton, Allen, & Scarpello, 2004), some have suggested using this technique in conjunction with minimum average partial (MAP) analysis) which focuses on the relative amounts of systematic and unsystematic variance remaining in a correlation matrix after extractions of increasing numbers of components (O'Connor, 2000). Examination of MAP results, confirmed the emergence of thirteen factors from the data.

While our results (shown in Table 4) indicated that 13 factors should be retained for interpretation, we omitted one factor. The original fifth factor held three items, two of which were Heywood cases and the other was a cross-loaded item. Consequently, this factor was removed from the analyses. Table 4 also indicates over 50% of the safety culture model can be explained by these 12 factors.

The resultant 12 factors and their factor names are presented below in Table 5 and the factor loadings are presented in Table 6. The *a priori* factors of management concern, personal responsibility for safety, peer support for safety, and safety management systems are reflected relatively evenly throughout the 12 factors. Factors 3 and 11 (Risky Behavior and Senior Management and/or Supervisor Blame, respectively) were indicated only by reverse-scored items, an occasional problem noted in past EFA research by Fabrigar et al. (1999) and Hinken (1995), but both rationally contributed to the model. Therefore, they were not discarded.

Table 2
Descriptive statistics.

Questions	N	Mean	Median	Std. Deviation	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis
Q1	25242	3.65	4.00	1.11	−0.81	2.00	−0.24	0.03
Q2	25220	3.77	4.00	0.97	−0.95	2.00	0.66	0.03
Q3	25150	3.86	4.00	0.96	−1.09	2.00	1.13	0.03
Q4	25109	4.29	4.00	0.82	−1.72	2.00	4.26	0.03
Q5	25161	2.46	2.00	1.14	0.51	2.00	−0.70	0.03
Q6	25156	3.55	4.00	1.05	−0.74	2.00	−0.10	0.03
Q7	25191	3.87	4.00	0.91	−0.96	2.00	0.91	0.03
Q8	25148	3.22	3.00	1.18	−0.32	2.00	−0.91	0.03
Q9	25161	3.99	4.00	0.97	−1.21	2.00	1.39	0.03
Q10	25189	3.83	4.00	1.03	−1.01	2.00	0.57	0.03
Q11	25158	2.54	2.00	1.17	0.46	2.00	−0.72	0.03
Q12	25095	3.72	4.00	0.95	−0.83	2.00	0.56	0.03
Q13	25211	3.54	4.00	1.08	−0.68	2.00	−0.35	0.03
Q14	25215	3.49	4.00	1.01	−0.63	2.00	−0.18	0.03
Q15	25222	3.75	4.00	0.93	−0.98	2.00	0.70	0.03
Q16	25209	3.42	4.00	1.10	−0.53	2.00	−0.38	0.03
Q17	25207	3.86	4.00	0.92	−1.06	2.00	1.11	0.03
Q18	25169	3.75	4.00	0.98	−0.87	2.00	0.49	0.03
Q19	25113	3.60	4.00	0.98	−0.69	2.00	0.15	0.03
Q20	25204	3.78	4.00	0.93	−0.97	2.00	0.86	0.03
Q21	25194	2.96	3.00	1.15	−0.03	2.00	−1.08	0.03
Q22	25198	3.53	4.00	1.04	−0.69	2.00	−0.21	0.03
Q23	25198	3.61	4.00	1.16	−0.73	2.00	−0.35	0.03
Q24	25222	3.06	3.00	1.12	−-0.21	2.00	−0.76	0.03
Q25	25209	3.53	4.00	1.05	−0.77	2.00	−0.07	0.03
Q26	25207	4.04	4.00	0.89	−1.34	2.00	2.24	0.03
Q27	25159	2.94	3.00	1.19	0.13	2.00	−0.96	0.03
Q28	25113	3.53	4.00	1.05	−0.70	2.00	−0.13	0.03
Q29	25204	4.09	4.00	0.82	−1.36	2.00	2.79	0.03
Q30	25194	4.00	4.00	0.94	−1.31	2.00	1.85	0.03
Q31	25198	3.53	4.00	1.06	−0.67	2.00	−0.26	0.03
Q32	25198	3.50	4.00	1.11	−0.62	2.00	−0.37	0.03
Q33	25185	2.84	3.00	1.18	0.19	2.00	−0.95	0.03
Q34	25216	3.53	4.00	1.02	−0.72	2.00	−0.05	0.03
Q35	25196	3.61	4.00	0.97	−0.80	2.00	0.10	0.03
Q36	25243	3.98	4.00	0.92	−1.15	2.00	1.37	0.03
Q37	25208	4.07	4.00	0.89	−1.32	2.00	2.07	0.03
Q38	25223	3.54	4.00	1.06	−0.63	2.00	−0.24	0.03
Q39	25267	3.77	4.00	0.95	−0.94	2.00	0.86	0.03
Q40	25085	3.88	4.00	0.93	−1.11	2.00	1.19	0.03
Q41	25137	3.62	4.00	1.01	−0.86	2.00	0.19	0.03
Q42	25154	3.82	4.00	0.89	−1.06	2.00	1.08	0.03
Q43	25162	3.81	4.00	0.85	−1.01	2.00	1.37	0.03
Q44	25144	3.80	4.00	0.92	−1.01	2.00	0.99	0.03
Q45	25122	3.73	4.00	0.97	−0.92	2.00	0.49	0.03
Q46	25173	3.90	4.00	0.82	−1.07	2.00	1.71	0.03
Q47	25243	3.61	4.00	1.09	−0.82	2.00	0.02	0.03
Q48	25208	3.74	4.00	1.01	−0.90	2.00	0.37	0.03
Q49	25223	4.03	4.00	0.82	−1.33	2.00	2.71	0.03
Q50	25198	3.44	4.00	1.04	−0.59	2.00	-0.38	0.03
Q51	25085	3.50	4.00	1.08	−0.61	2.00	−0.31	0.03
Q52	25137	3.65	4.00	0.99	−0.88	2.00	0.36	0.03
Q53	25154	3.30	3.00	1.04	−0.46	2.00	−0.30	0.03
Q54	25162	3.75	4.00	0.88	−1.01	2.00	1.07	0.03
Q55	25144	2.04	2.00	1.08	1.06	2.00	0.42	0.03
Q56	25122	3.43	4.00	0.90	−0.53	2.00	0.37	0.03
Q57	25173	3.80	4.00	0.92	−0.96	2.00	0.63	0.03
Q58	25144	3.80	4.00	0.84	−1.15	2.00	1.60	0.03
Q59	25135	3.80	4.00	0.84	−1.15	2.00	1.60	0.03
Q60	25180	2.11	2.00	1.13	0.91	2.00	−0.04	0.03
Q61	25176	3.86	4.00	0.92	−1.12	2.00	1.44	0.03
Q62	25155	3.54	4.00	0.98	−0.70	2.00	−0.15	0.03
Q63	25165	3.83	4.00	0.88	−1.09	2.00	1.41	0.03
Q64	25188	3.30	3.00	1.07	−0.41	2.00	−0.56	0.03
Q65	25152	3.26	3.00	1.00	−0.42	2.00	−0.47	0.03
Q66	25157	3.72	4.00	0.81	−0.91	2.00	1.00	0.03
Q67	25167	2.85	3.00	1.18	0.12	2.00	−1.04	0.03
Q68	25088	2.42	2.00	1.15	0.57	2.00	−0.61	0.03
Q69	25055	3.69	4.00	0.94	−0.96	2.00	0.67	0.03
Q70	25076	3.58	4.00	0.92	−0.74	2.00	0.09	0.03
Q71	25112	3.70	4.00	0.99	−0.86	2.00	0.30	0.03
Q72	25103	3.30	4.00	1.07	−0.50	2.00	−0.51	0.03
Q73	25066	4.03	4.00	0.72	−1.37	2.00	3.74	0.03
Q74	25080	3.78	4.00	0.99	−0.96	2.00	0.54	0.03

(continued on next page)

Table 2 (*continued*)

Questions	N	Mean	Median	Std. Deviation	Skewness	Std. Error of Skewness	Kurtosis	Std. Error of Kurtosis
Q75	25116	4.20	4.00	0.80	−1.52	2.00	3.67	0.03
Q76	25127	4.11	4.00	0.83	−1.33	2.00	2.63	0.03
Q77	25041	4.11	4.00	0.76	−1.33	2.00	3.15	0.03
Q78	25041	3.23	3.00	1.18	−0.36	2.00	−0.79	0.03
Q79	25036	2.33	2.00	1.09	0.74	2.00	−0.18	0.03
Q80	25108	1.92	2.00	1.00	1.31	2.00	1.39	0.03
Q81	25128	4.20	4.00	0.73	−1.48	2.00	4.37	0.03
Q82	25146	4.14	4.00	0.74	−1.36	2.00	3.80	0.03
Q83	25055	3.71	4.00	0.92	−0.91	2.00	0.72	0.03
Q84	25091	2.44	2.00	1.13	0.64	2.00	−0.50	0.03
Q85	25079	3.56	4.00	1.16	−0.71	2.00	−0.40	0.03
Q86	25074	3.45	4.00	1.01	−0.66	2.00	−0.17	0.03
Q87	25078	3.80	4.00	0.94	−0.98	2.00	0.84	0.03
Q88	25061	3.48	4.00	1.01	−0.64	2.00	−0.03	0.03
Q89	25133	2.23	2.00	1.26	0.85	2.00	−0.34	0.03
Q90	25126	3.84	4.00	0.82	−1.10	2.00	1.58	0.03
Q91	25088	3.49	4.00	1.00	−0.69	2.00	−0.16	0.03
Q92	25101	3.78	4.00	0.82	−1.00	2.00	1.27	0.03

Using Tabachnik and Fidell's (2007) recommendation of .33 as a minimum cutoff for a factor loading, 18 items were removed for insufficiently loading on any factor. Another two items were removed for cross-loading on multiple factors. Finally, two additional items were dropped because there was no rational basis to include them on the factors in which they loaded.

At the conclusion of this process, 70 items were retained representing the aforementioned 12 factors. This set of 70 items demonstrated good reliability ($\alpha = .93$). After trimming the factors, reliability estimates were very similar to the initial reliabilities for each of the four sub-factors of safety culture: $\alpha = 0.87$ for management concern for safety, $\alpha = 0.68$ for personal responsibility for safety, $\alpha = 0.85$ for peer support for safety, and $\alpha = 0.88$ for safety management systems. These factors were then tested using a hierarchical factor structure procedure to determine the accuracy of the presented model.

6.3. Hierarchical Confirmatory Factor analysis (HCFA)

After the exploratory analysis was completed, the other half of the randomly selected participants, 12,865 respondents, was examined using hierarchical confirmatory factor analysis (HCFA) using Mplus 4.21 (Muthén & Muthén, 2002). This was conducted to determine if the conclusions of the EFA were reliable.

A HCFA was conducted to cross-validate the four-factor structure that emerged from the literature review. MPLUS 4.21 (Muthén & Muthén, 2002) was employed to confirm the hypothesized model and the results of the EFA. The safety culture model was an *a priori*, hierarchical model, in which the superordinate safety culture construct affects the four second-order constructs.

Before conducting the analyses, it was necessary to parcel the items within the factors consistent with Hall, Snell, and Foust (1999). Parcels were formed on rational and grounds. The range of items within the parcels varied from two to nine items depending on the factor. Thus, three parcels were created for Management Concern (Supervisor Concern, Senior Management Concern, and Work Pressure), two were created for Personal Responsibility (Supervisor/Management Blame and Risky Behavior), two were created for Peer Support (Caution Others and Respectful Feedback) and four for Safety Management Systems (Communication, Training, Discipline, and Rewards and Recognition), This procedure allowed the HCFA to reveal the nature of the model better than the individual items could, because it reduces secondary factor contamination. Two factors, 3 and 12, were parceled together to account for the artifactual reverse-scored items, which fell on these factors.

After the parceling procedure was conducted, the hierarchical model was then specified to estimate each of the loadings on the four second-order factors and the 12 first-order parceled factors. There was a strong positive correlation ($r = .47$, $p < .001$) between factors 3 and 12, the two artifactual reverse-scored factors, so this was specified to further identify the model.

According to modification indices, model fit would be significantly improved if Incident Reporting (an indicator of Safety Management

Table 3
Four subfactor intercorrelation matrix.

		MC	PR	PS	SMS
MC	Pearson Correlation	1			
PR	Pearson Correlation	−.187**	1		
PS	Pearson Correlation	.573**	.023**	1	
SMS	Pearson Correlation	.770**	−.111**	.673**	1

**. Correlation is significant at the 0.01 level (2-tailed).
Note. MC = Management Concern for Safety; PR = Personal Responsibility for Safety; PS = Peer Support for Safety; SMS = Safety Management Systems

Table 4
Exploratory factor analysis eigenvalues and percent of variance.

Factor	Eigenvalue	Variance Percentage	Cumulative Percentage
1	26.06	28.32	28.32
2	4.13	4.49	32.81
3	2.94	3.20	36.01
4	2.56	2.79	38.80
5	1.66	1.80	40.60
6	1.54	1.68	42.28
7	1.46	1.58	43.86
8	1.30	1.41	45.27
9	1.23	1.34	46.61
10	1.16	1.26	47.87
11	1.07	1.16	49.03
12	1.03	1.12	50.15

Table 5
Exploratory factor analysis factor description.

Factor	Factor Description
1	Training and Rules
2	Peer Support Caution Others
3	Risk Taking
4	Peer Support Respectful Feedback
5	Reward/Recognition
6	Supervisor Concern
7	Senior Management Concern
8	Discipline and Investigation
9	Incident Reporting Behavior
10	Communication
11	Supervisor/Management Blame
12	Management Work Pressure

Table 6
Exploratory factor analysis pattern matrix factor loadings.

	1	2	3	4	5	6	7	8	9	10	11	12
Q48	.495											
Q50	.479											
Q57	.465											
Q20	.445											
Q29	.443											
Q44	.417											
Q36	.371											
Q19	.355											
Q77	.353											
Q82		.639										
Q81		.636										
Q75		.578										
Q76		.507										
Q73		.410										
Q4		.392										
Q80			.663									
Q55			.620									
Q84			.611									
Q79			.547									
Q67			.485									
Q68			.480									
Q60			.454									
Q90				.643								
Q92				.598								
Q70				.437								
Q43				.339								
Q66				−.355								
Q53					.759							
Q51					.681							
Q64					.670							
Q24					.623							
Q47					.604							
Q78					.567							
Q65					.394							
Q56					.374							
Q52					.337							
Q28						−.621						
Q10						−.605						
Q61						−.599						
Q49						−.575						
Q3						−.558						
Q63						−.534						
Q25						−.528						
Q30						−.421						
Q9							−.354					
Q8							−.347					
Q22								.617				
Q18								.615				
Q69								.595				
Q88								.388				
Q72								.376				
Q83								.356				
Q87								.354				
Q71									.581			
Q74									.567			
Q42										−.589		
Q40										−.541		
Q35										−.473		
Q13										−.451		
Q91										−.407		
Q25										−.392		
Q62										−.362		
Q86										−.358		
Q15										−.354		
Q11											.850	
Q27											.798	
Q33											.499	
Q32												.756
Q23												.697
Q38												.475
Q34												.416

Table 7
Hierarchical confirmatory factor analysis results: tests of model fit.

Comparable Fit Index	RMSEA (Root Mean Square Error Of Approximation)	SRMR (Standardized Root Mean Square Residual)
Value: .95	Estimate: 0.08 90 Percent C.I. 0.082 0.086	Value: 0.04

Systems) was allowed to load on the Personal Responsibility factor. This stands to reason as the volitional act of reporting an incident is a form of taking personal responsibility for safety at work. Once this modification was made to model specification, the *a priori*, hierarchical model from the literature view was confirmed through HCFA. Table 7 demonstrates a comparative fit index, which was expected to be close to 0.95 or greater (Hu & Bentler, 1999), was CFI = 0.95, a root mean square error of approximation, which was expected to be close to 0.06 or lower (Hu & Bentler), was RMSEA = 0.08, and a standardized-root-mean-square residual, which was expected to be close to 0.08 or lower (Hu & Bentler) was SRMR = 0.04. The chi-square difference test is hypersensitive to very large or small sample sizes, and can falsely indicate poor model fit (Tabachnik & Fidell, 2007). Consequently, because the sample size in this study was very large, it was not considered as a fit index in the analysis. Consistent with Kline (2005), the fit indices indicate a good fit to the data. There was a strong theoretical reason to expect a hierarchical structure. Therefore, these results were supportive of the *a priori* model. Fig. 2 shows the results of this model with all factor-loading coefficients.

7. Discussion

The purpose of this study was to determine a complete set of core factors that contribute meaningful variance to the measurement of safety culture. Fig. 2 shows the core factors extracted from this study and demonstrates the hierarchical structure determined by the HCFA. The a priori hypothesized model from the literature review was confirmed, with some exceptions. First, not all reviewed factors were extracted in the initial EFA. Second, two of the sub-factors, Personal Responsibility for Safety and Peer Support for Safety were determined to have a more complicated hierarchical factor structure according to the HCFA than was originally hypothesized. Conversely, the Safety Management System (SMS) factor was determined to be less complicated than hypothesized. However, because the factor loadings were so robust it is reasonable to assume that the overall model was supported and safety culture consists of the aforementioned factors.

The overall model indicated good fit (see Table 6). The CFI and the SRMR fell within range of good fit as indicated by Hu and Bentler (1999). The RMSEA fell within the close or acceptable range as indicated by Hu and Bentler (1998, 1999); Fan and Sivo (2007). Additionally, 50% of the variance of a safety culture is explained in this model (see Table 4).

The safety model presented in Fig. 2 illustrates safety culture as a first-order latent variable, Management Concern for Safety, Personal Responsibility for Safety, Peer Support for Safety, and Safety Management Systems as second-order sub-factors and the 12 parceled factors as first-order factors. The following is a summary of the factors extracted through the two analyses.

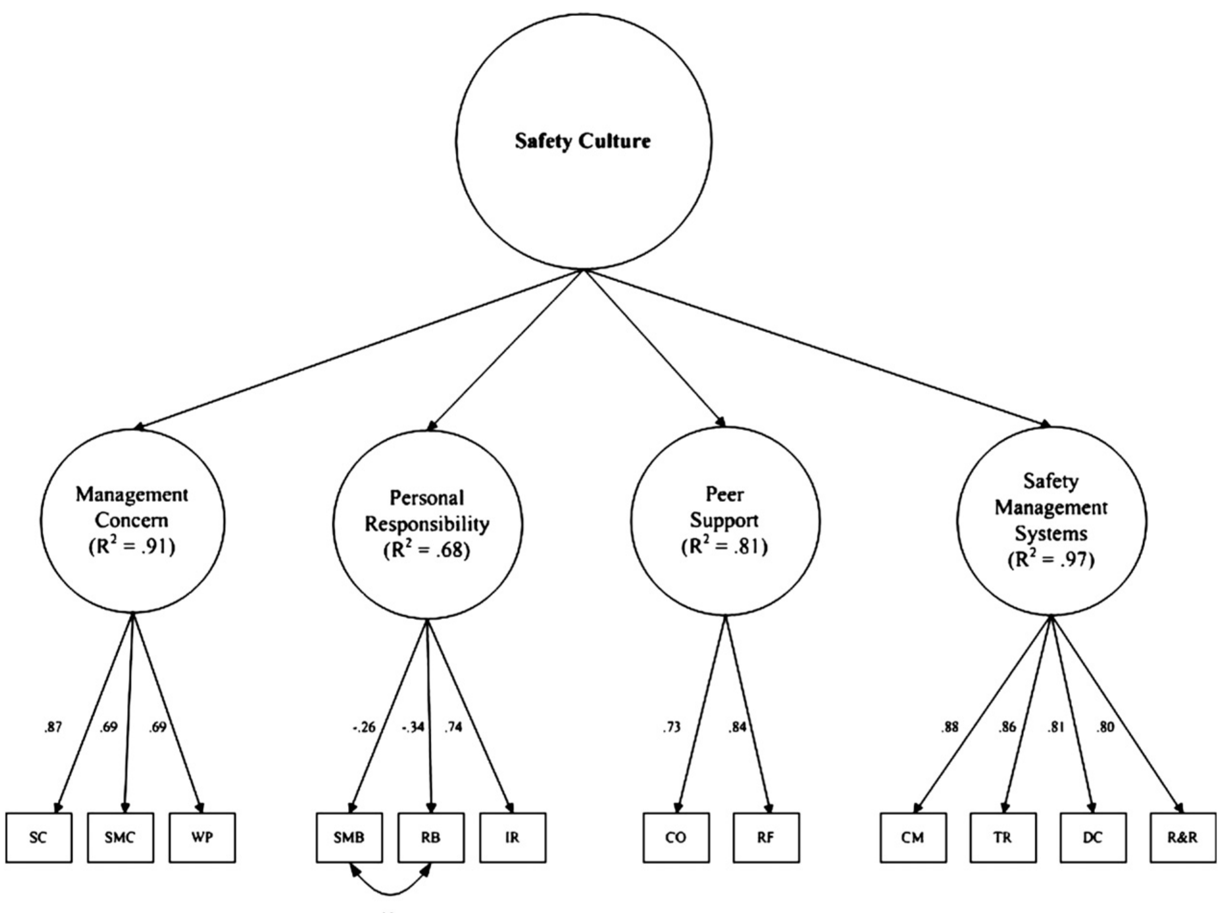

Fig. 2. Note: SC = Supervisor Concern, SMC = Senior Management Concern, WP = Work Pressure, SMB = Supervisor/Management Blame, RB = Risky Behavior, IR = Incident Reporting, CO = Caution Others, RF = Respectful Feedback, CM = Communication, TR = Training, DC = Discipline, R&R = Rewards and Recognition.

First, *Management Concern for Safety* was determined to be consistent with the literature review (Flin et al., 2000). The review suggested safety culture surveys should distinguish between different levels of management. The EFA extracted separate "supervisor concern" and "senior management concern" factors and the HCFA confirmed they should be sub-factors of management concern for safety. A third factor of "work pressure" was proposed to fall under management concern because supervisors and management control production and operation schedules. This factor was also extracted from the EFA and confirmed by the HCFA.

Second, *Personal Responsibility for Safety* was determined to have three sub-factors. This is not what the hypothesized model proposed, but the factors fell rationally under the personal responsibility factor, nonetheless. In the review, "risk taking" was the main factor of personal responsibility, and this was confirmed in the HCFA. "Risk taking" was one of the two reverse coded parcel factors. Therefore, there was a negative, although still strong, factor-loading. The other reverse coded factor was "supervisor and management blame." This was not reviewed as a separate factor under personal responsibility, but it is rational to put it under this responsibility factor. If supervisors and management blame the employee before an investigation or without looking at the overall situation, this is unconstructive and not a responsible way to supervise employees. This factor did not fall under the management concern, or *Safety Management Systems* factor because of the wording of the items. Once again, there was a strong negative factor-loading as shown in Fig. 2. The third factor was "incident reporting." This factor was reviewed under SMS, but the factor extracted in the EFA was most reasonably included under personal responsibility because it assesses the frequency of reporting incidents and near misses. It is the employees' responsibility to report incidents when they should.

Peer Support for Safety was not hypothesized to include sub-factors. However, two related but distinct, peer support factors were extracted from the EFA. The two factors are "cautioning others" and "respectful feedback." Each of these factors is rationally included under peer support for safety, and this was confirmed by the HCFA. Cautioning others assesses the occurrences, which workers will intentionally interrupt their production to caution a co-worker. Respectful feedback assesses whether they offer feedback to others and do so respectfully.

Lastly, *Safety Management Systems* was determined to be much less complex than the literature review suggested. Instead of the hypothesized 10 factors, four were extracted from the EFA and then confirmed by the HCFA. The four factors were "communication," "training and rules," "discipline," and "rewards." Training and rules were combined in a factor extracted from the EFA, and this is reasonable because workers can learn the safety rules through training. The EFA did not extract any factors of safety audits and inspections, employee engagement, safety meetings/committees, or suggestions/concerns. Additionally, the "incident report" factor fell under personal responsibility better than safety management systems because the individual is responsible for reporting their own incidents. Otherwise, "communication," "discipline," and "rewards" are rationally included under safety management systems as the literature review suggested.

Overall, this model is very consistent with the constructs and factors listed in the literature review (Flin et al., 2000; Geller, 2001a; Guldenmund, 2000). Some were expanded and others were removed, but the HCFA confirmed the rationality of the overall model. The survey, based on the model, accurately assessed safety culture according to these results. Thus, the proposed model addressed certain gaps in the literature, and statistical analyses confirmed the rationale behind the model.

7.1. Gaps Addressed in Current Model

Not all safety culture surveys have incorporated the necessary core safety culture factors as proposed by the current research. For example, no surveys previously reviewed incorporated any *Peer Support for Safety*. Thus, this study expanded on a key gap in the literature by including this factor. Second, a full *Personal Responsibility for Safety* factor was sparsely reviewed in the literature (Cox & Cox, 1991; Coyle et al., 1995; Harvey et al., 2002), although risk taking is prominent in many safety culture surveys (Flin et al., 2000).

Some have suggested a systems or SMS factor is not necessary in assessment of safety culture (Flin et al., 2000). However, others confirmed that this factor was not only necessary, but an essential part of evaluating safety culture (Fernández-Muñiz et al., 2007; Hale, 2003). Fernández-Muñiz et al. had come closest to fully reviewing the proposed model of SMS, but still omitted important components of the construct. In the current study, the proposed model was not entirely confirmed, as "training and rules," "communication," "discipline," and "rewards" were the only extracted factors found on *Safety Management Systems*. As previously suggested, the other factors either did not reliably fall on a factor, or they rationally fell on a separate factor (i.e., personal responsibility for safety). Whether the factor fell on a *Safety Management System* or *Personal Responsibility for Safety* factor, depended on the wording on the items.

7.2. Limitations

The findings suggest that the safety culture survey is a useful tool for future research. However, this study does have several limitations to acknowledge. As with all measurements of safety culture, this survey can only measure the attitudes and perceptions of workers about the priority of safety in their organization. What the survey cannot do is measure the actual behaviors eluded to in the workplace. Future research could seek to correlate the results of behavioral observations or archival measures of behaviors (e.g., near miss reports) with survey results.

Another limitation was the 12 artifactual reverse-scored items. Although it was rational to include the factors in the model, the reliability and inter-item correlations decreased with the frequency of reverse-scored items as was consistent with Harvey et al. (1985). Nevertheless, the model still exhibited robust results in both factor-loadings and overall reliability.

Lastly, Hu and Bentler (1999) suggested the RMSEA, should be .06 or less to be indicative of good model fit. The RMSEA was determined to be 0.08 in this study. This is still within acceptable range as poor fit is indicated by an RMSEA of 0.10 or higher. Nonetheless, the other fit statistics robustly reproduced the data, so this was not determined to be of great importance.

7.3. Future directions

The current research confirmed the a priori theoretical model of safety culture, but more research should be conducted for further validation of the survey. Criterion and construct validation should be conducted in future studies. Measurement of safety culture perceptions is important, but prediction of safety performance would create a solid basis for applied efficacy. Therefore, criterion validation is one avenue for future research.

Criterion validity. There is not a consensus on whether measuring safety culture can improve or predict actual safety performance (Cooper & Phillips, 2004; Glendon & Litherland, 2001). Criterion validity assesses if the measure of safety culture is indeed related to safety performance. Concurrent and predictive validity research could offer validation of this survey. Concurrent validity could be assessed by comparing the overall scores from the measure with current safety performance statistics (e.g., minor injuries, near misses, lost workdays). Predictive validity could be assessed by examining the scores from the survey at one point and comparing those scores with the safety performance from a future date. If a predictive link is empirically supported from this safety culture survey to safety performance, the value of the measurement will surely increase.

Construct validity. Construct validity could also be examined in future research. Construct validity determines if a measure truly measures the theoretical construct it claims to assess. This would involve determining convergent and discriminant validity. For convergent validity, the safety culture survey should theoretically correlate with other measures of safety culture. While divergent validity would determine if the safety culture survey did not correlate with other measures, which it theoretically should not.

7.4. Implications

When an organization has a systematic measurement of their safety culture, they can better correlate the financial benefits and other business outcomes from safety interventions. For example, management concern is necessary when creating a safety culture, but a lack of management involvement can have some negative financial implications. Smallman and John (2001) conducted a thorough analysis of senior management in FTSE companies in Britain and found they all viewed safety as a priority. They collectively agreed a poor safety record could negatively impact stakeholders' views of the organization and damage the company financially. Conversely, it was also noted, that an excellent safety record did not always translate to financial success.

Peer support for safety has the most empirical support for financial returns. When Turner, Hershcovis, Chmiel, and Walls (2010) evaluated three levels of organizational support (i.e., senior management, supervisors, and co-workers), co-worker support was the most important variable for increasing worker safety in hazardous situations. The study showed that with increased co-worker support there were decreased injuries translating into lower financial expenditures for the organization.

Financial benefits can be sustained when the Safety Management Systems are consistent with safety and organizational goals. Organizations who implement a good SMS lower their injury rates and enjoy superior business results compared to companies who do not have a well-organized SMS (Bottani et al., 2009). sInvestment in a quality SMS should provide the organization with financial success. While a poor system that is not consistent with organizational goals may enhance safety performance but may not necessarily increase financial results (Podgórski, 2006).

One of the more interesting implications is the cumulative interaction of the proposed model. Cox, Jones, and Collinson (2006) have demonstrated that trust (i.e., Management Support for Safety), accountability (i.e., Personal Responsibility for Safety), and caring (i.e., Peer Support for Safety) can have an economic benefit to organizations and their stakeholders. Their study found that organizations who exhibit high trust could have a substantial increase to the bottom line. Those with a lower level of trust show a negative economic impact on their respective businesses. Thus, when the entire proposed model is implemented efficiently and effectively, considerable business outcomes can be achieved.

7.5. Summary and conclusion

To conclude, this study attempted to evaluate the core factors of a safety culture, including two factors that needed expansion and one factor that seemed to be missing from the measurement literature. Safety culture was determined to be a higher-order latent variable, which consisted of four sub-factors (management concern for safety, personal responsibility for safety, peer support for safety and safety management systems) and 12 total factors loading on the sub-factors. The safety culture survey was reduced from 92 to 70 items, which measure the 12 factors of the higher-order safety culture construct. Further research should examine the predictive ability of the measure for practical use within different organizations.

However, the use of a survey is not enough to change an unsafe safety culture. Procedural intervention is necessary (Redmon & Mason, 2001). Fortunately, the current measure attempts to assess mechanisms an organization utilizes to implement safety interventions (e.g., employee involvement). DePasquale and Geller (1999) found that organizations who implemented voluntary programs attained more positive organizational results than other organizations who implemented mandatory programs.

The construction of a positive safety culture is not easy, and it is not universal. Something that works well in one organization may not work in another. Adjustments will need to be made depending on the resources available and the goals of the different organizations. No matter what an organization does to increase safety, the current study suggests the workforce needs to be included in the process beyond simply measuring their attitudes.

It is important to emphasize that measuring employee perceptions of safety culture does show some commitment to safety, but that cannot be the end of the process. The results of the measurement must be communicated and a plan should be implemented to ensure workers that senior management considers safety performance a priority, not just safety culture measurement, (Cooper & Phillips, 2004).

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