Development of a Theory-Based Safety Climate Instrument

Michael E. Hall, Earl H. Blair, Susan M. Smith and June D. Gorski

Abstract

This study described the development of a safety climate instrument for employees at three mini-steel mill locations in the U.S. The instrument was validated by structural equation modeling using AMOS and measured safety climate at a specific "point in time" to assess the safety culture of the industry. The Hall Safety Climate Instrument was developed using a three-construct theoretical framework of the theory of planned behavior. Reliability of the instrument was established using Chronbach’s Alpha, exploratory factor analysis and confirmatory factor analysis. The instrument was designed, piloted and field tested at three mini-steel mills to assess employee perceptions of safety climate in a high-hazard industry. Managers and supervisors participating in the study self-reported a significantly higher safety climate than other participating employees. Individuals self-reporting no previous work-related injuries achieved a higher safety climate score than employees who self-reported previous work-related injuries.

Keywords
Safety climate instrument, theory of planned behavior, structural equation modeling, safety culture

Introduction

Work-related injuries can be costly to employers due to loss of life or permanent disabling injury, as well as impacting productivity. These monetary costs include insurance compensation for loss of life or injury. Injuries have been reported to reduce worker morale and to cause personal suffering (Barreto, et al., 2000; Brown, 1996; Brown, et al., 2000; Clarke, 1999; Courtney & Webster, 2001; Dedobbeleer & Beland, 1991; Mearns, et al., 2001). In the U.S. in 2010, 4,547 work-related injuries resulted in death (BLS, 2011). The cost associated with the year 2003 death statistic was $27.1 million per death (National Safety Council, 2003). Work-related injuries in the U.S. that result in death cost Americans $156.2 billion in 2003 (National Safety Council, 2003).

Historically, in the industrial sector, the accident reduction approach has focused on examining “lagging” data, such as lost-time accident rates/incident rates (Flin, 2007). The term “lagging” is typically used in economics and indicates past events. With lagging data, the injury or fatality needed to occur before the company took action to eliminate or reduce exposure to the hazard. With lagging data, the analysis occurred after the event and was documented by company records (Flin, et al., 2000). Therefore, reporting was after an incident rather than a proactive attempt to prevent injury.

Traditional methods of improving safety within industry focused primarily on accident investigations to determine specific causes and recommend changes in the future (Petersen, 1996). More recently, industries have changed the protocol and have adopted an approach to prevent injuries and fatalities by focusing on predictive measures to monitor safety culture (Flin, et al., 2000). Current safety management and injury prevention research suggests human behavior may have a greater role in preventing injuries or fatalities than was first suspected. The recognition of behavioral factors and the use of accident prevention programs to reduce injuries have been cited in research focused on organizational culture, human factors and safety culture (Brown, 1996; Brown, et al., 2000; Carder & Ragan, 2003; Cooper, 2002; DePasquale & Geller, 1999; Flin, et al., 2000; Griffin & Neal, 2000; Hayes, et al., 1998; O’Toole, 2002).

Need for Safety Climate Measurement

Safety climate incorporates the predominant attitudes and employee behaviors associated with the state of safety in an organization at a particular moment (Yule, et al., 2007). Safety climate is relatively unstable and subject to change depending on current conditions. Furthermore, safety climate is considered a temporal state or snapshot of safety culture (Dedobbeleer & Beland, 1991; Flin, et al., 2000; Mearns, et al., 2001). Safety culture can be indirectly evaluated from instruments that assess safety climate (Flin, et al., 2000). Published research supports the use of a reliable and valid safety climate instrument to measure safety climate (Bailey, 1989; Carder & Ragan, 2003; Clarke, 1999; Dedobbeleer & Beland, 1991;
Use of Safety Climate Assessments

Research has shown that a positive safety climate is associated with improved safety practices (Zohar, 1980), a decrease in accidents (Mearns, et al., 2001) and the practice of fewer unsafe behaviors at the workplace (Brown, et al., 2000). Professional organizations supporting best practices promote the use of measuring safety climate as one of the leading indicators of effective safety management (Flin, et al., 2000). Safety climate assessments have been used by organizations to benchmark the effectiveness of an overall safety process or to assess the progress of specific safety initiatives (Arboleda, et al., 2003; Blair, 2003; Brown, et al., 2000; Carder & Ragan, 2003; Clarke, 1999; Cooper, 2002; Diaz & Cabrera, 1997; Geller, 2000; Griffin & Neal, 2000; Mearns, et al., 2001; Petersen, 1996; Zohar, 1980).

One reported limitation associated with available safety climate instruments was that a majority of the instruments lacked a unifying theoretical model, and few attempted to address issues of validity and reliability during development (Flin, et al., 2000). Most instruments were found to be customized to fit the sponsoring organization’s requirements. Many instruments used focus groups and interviews to determine specific safety issues to incorporate in an instrument for a particular workforce and then developers tailored the instrument to focus on those issues (Cox & Cox, 1991; Niskanen, 1994; Diaz & Cabrera, 1997; Lee, 1998). A few instruments have attempted to determine an underlying factor structure (Brown, 1996; Brown, et al., 2000; Brown & Holmes, 1986; Mearns, et al., 2001; Niskanen, 1994; Seo, et al., 2004). However, Flin, et al. (2000) found these methodological inconsistencies in instrument development, and cultural differences among specific industries made it difficult to bridge the factor structures into a common group.

Targeting High-Hazard Industry

Of the 4.4 million work-related injuries reported in the U.S. during 2002, the manufacturing sector, including the steel industry, accounted for 23% of all injuries (BLS, 2004). This was the third-highest sector for occupational injury in the U.S. (BLS, 2004). The injury rate for the steel industry, including jobs with high-potential risk, increased from 15.2 in 2003 to 17.0 in 2004 (BLS, 2004). High-potential risk is “any situation, practice, procedure policy, process, error or occurrence of such a nature that, if it causes an accident, the accident will almost surely and predictably result in severe loss” (Lack, 2001). The high number of injuries as reported by the Bureau of Labor Statistics (BLS), the growing workforce and the increasing demand for steel products demonstrate the importance of addressing safety climate conditions in the steel industry in an attempt to reduce future injuries/fatalities.

The steel mill industry has been recognized as a high-hazard environment and the subject of previous research studies focused on the development of mitigation strategies to lessen the number of accidents (Ong, et al., 1987; Rosa, et al., 1996; Barreto, et al., 1997; Prussia, et al., 2003; Ologe, et al., 2005). Research studies on steel mills have suggested an association between accidents and specific variables related to causation.

Ong, et al. (1987) analyzed the role of shiftwork schedule and incidence of injury among steel mill workers. Differences in occurrence were found depending whether the employee was a dayshift or nightshift worker. However, since the employees had similar training and job function, along with associated risks, other contributing factors must be considered. Rosa, et al. (1996) went on to suggest possible modification to shift schedules that proved to enhance alertness and reduce fatigue, both of which were instrumental in reducing chance of accidents. The workers, due to social concerns, displayed resistance to these modifications. Motivation for behavior adoption needs to be considered when implementing safety protocols if the overall safety program is to be successful.

The hazardous work environment of steel mills was the subject of focus for Barreto, et al. (1997). These researchers found fatal injury was positively correlated with the number of environmental risk factors. Since many steel mills share the high-hazard environment, there is a need to determine the efficacy of safety measures and the likelihood of compliance by the workforce to prevent accidents.

Ologe, et al. (2005) chose to look at the specific relationship of PPE with awareness and attitude toward the behavior. These researchers found that even though workers were aware of the need for PPE, had access to PPE and had knowledge of the methods of prevention, only 8.8% actually used PPE.

Reviewing the existing body of research on safety in steel mills found that there are many contributing factors and unanswered questions (Brown, 2000; Prussia, 2003; Watson, 2005). Of particular interest is the relationship between identification of mediating procedures to address known factors associated with injury and the willingness of the employee to make the behavior changes necessitated by the procedures (Prussia, 2003). Previous research has not adequately addressed the underlying factors that groups of individuals contemplate when deciding to make a behavior change (Yule, et al., 2007).

Determining what changes employees need to make to prevent injury is not a solution if those changes are not adopted and implemented by the worker population (Yule, et al., 2007). This research focused on steel mini-mills because workers in this environment are considered a high-risk group for serious injuries and because the mill administrator afforded access.

Measuring Safety Climate

Safety climate is a collection of attitudes and behaviors as expressed at a point in time and can be measured using surveys...
Safety climate measurement has been shown to illuminate the industrial accident process through the linking of safety climate scores and risky behaviors. Also, safety climate has been linked to accident-related variables (Hayes, et al., 1998). These linkages indicate accidents can be prevented if countermeasures are taken to address areas of safety climate. This process allows safety managers to expand safety program focus and to address behavioral and safety climate concerns through uncovering accident-related variables.

Measurement of safety climate requires an instrument to record employees’ self-reported perceptions on safety issues. Safety climate instruments generate a score from a summation of safety attitude and behavior measurement items within the safety climate survey. Perception surveys, as designed by Rensis Likert, were used to measure organizational factors as they related to productivity (Petersen, 1996). Likert’s research examined the establishment of a relationship between “high achievement” and scoring high on the perception instrument domains. These domains or themes included support, supervision, attitude toward the company and motivation. The high correlation also supports the usefulness of the surveys to indicate weak areas that can be addressed by managers. In theory, improving the deficient areas of the survey results will improve workers’ productivity (Petersen, 1996).

This same approach used by Likert was adapted to safety management by Charles Bailey and Dan Petersen during the development of the “Minnesota Perception Survey.” This perception survey analyzed safety perceptions within the railroad industry (Bailey & Petersen, 1989). Bailey determined that the effectiveness of safety programs could not be measured by traditional procedural-engineering criteria. Rather, Bailey found safety program effectiveness was best measured by responses from the entire organization to assess the safety system. Bailey’s research found that the most successful safety programs effectively identify worker and supervisor behaviors and attitudes that affect safety performance (Bailey & Petersen, 1989). Bailey’s (1989) research concluded that safety climate surveys were a better measure of safety performance and predictor of safety results than traditional audit programs.

**Need for a Theory-Based Safety Climate Instrument**

Most safety climate instruments documented in the literature did not report procedures to test reliability or validity, and weighting factors were not included. Only a few of the instruments reviewed by the researchers were reported to have been adopted and reused by individuals other than those who created the instrument. Existing instruments reflected a lack of consistency in the items included in the survey, and a significant variety in the number of safety climate dimensions included in reviewed instruments did not agree. One possible explanation for the divergence of factor structures within existing instruments could be that each instrument was designed to only meet the needs of a specific population within an industry (Bailey & Petersen, 1989; Brown, et al., 2000; Carder & Ragan, 2003; Clarke, 1999; Dedobbeleer & Beland, 1991; Diaz & Cabrera, 1997; Flin, et al., 2000; Griffin & Neal, 2000; Niskanen, 1994; O’Toole, 2002; Petersen, 1996; Seo, et al., 2004; Williamson, et al., 1997).

Flin, et al. (2000) described a paradigm that existed at the time where safety climate instruments were developed or had been developed using similar techniques. These techniques can be identified as using literature review to select safety themes and to determine particular issues at a specific location. Additionally, Flin and associates (1997) were able to identify a core group of themes common to the published studies.

A recent review of the literature suggests that the paradigm described by Flin, et al. (2000) may still exist today. As a follow up, Flin (2007) reiterates the 2000 position while applying high-hazard industry safety climate questionnaires to the healthcare field. Recent studies have attempted to incorporate a theory-based approach to measurement of safety climate. The intention of other researchers was to measure intervention outcomes rather than explore the behavioral decision-making process (Christian, et al., 2009; Diaz-Cabrera, et al., 2007; Hartman, et al., 2009; Mark, et al., 2008; Tharaldsen, et al., 2008; Guldenmund, 2007; Vinodkumar & Bhasi, 2009).

Traditionally, there has been a lack of consistency in the approaches to measure safety climate in worksite settings (Flin & Mearns, 2000; Guldenmund, 2000, 2007). Guldenmund (2007) surmised that instruments intending to measure safety climate were typically developed following one of two pathways. The first approach is to use a theoretical perspective to establish a description of safety climate for the organization. The second is to build an instrument based on the findings of previous safety climate measures. This research study is an exercise in applying both techniques to develop a comprehensive instrument that possesses the attributes of a theoretical and a pragmatic design to measure safety climate. The use of behavior theory in the assessment of safety climate allows the discovery and understanding of the link between safety climate and the behavior outcomes (Fogarty & Shaw, 2010; Johnson & Hall, 2005).

Instruments that do not incorporate social cognitive theory (SCT) into their design are measures of factors that contribute to safety climate. Albert Bandura postulated that the SCT explained human behavior following a reciprocal model, which included the behavior, personal factors and environmental influences (Bandura, 1986). Psychosocial researchers have long applied the SCT to create procedures to influence the underlying variables in order to affect behavioral change. The recognition that the SCT can be used to change behaviors also supports that existing behaviors can be explained following the constructs of the SCT. The SCT explains how individuals learn and maintain acquired behaviors patterns; the understanding of the interaction of constructs is crucial when planning intervention strategies to change those behaviors.

To address the need for a theory-based instrument with both validity and reliability, the authors designed a theory-based safety climate instrument and tested it for validity and reliability. The instrument discussed in this article was based on behavioral theory. Behavioral theory is a conceptual tool that can be used by researchers as a guide for measurement and
assessment of the impact of interventions designed to influence behavioral choices (Glanz, et al., 1997). The use of theories during the stages of planning and evaluation of a new safety climate instrument allowed the researchers to seek answers to the critical questions of why, what and how (Glanz, et al., 1997). This new instrument was targeted for use as a tool to measure safety climate in high-risk industries. The industrial settings selected to pilot this instrument were high-hazard work environments with the potential for serious injury if appropriate safety practices were not followed.

Research Purpose

The purpose of this research was to 1) develop a theory-based, reliable safety climate instrument validated by structural equation modeling to assess the safety climate of steel mini-mill employees and on-site contractors at three mill company locations within the U.S. and 2) establish an initial profile of the safety climate at three steel mini-mill company locations within the U.S. (Hall, 2006). Further investigation of the initial profile included the research question, “Does safety climate differ depending on self-reported position, department or previous work-related injury experience?”

Methods

Theoretical Framework

The theoretical framework selected for use in the development of an instrument was the Theory of Planned Behavior (TPB). This theory was selected because it explores the relationship between attitudes, beliefs and self-efficacy. This relationship may affect decisions of the individual to follow or reject prescribed safety protocols. The theory of planned behavior is an extension of the theory of reasoned action. The central factor in the theory of planned behavior is the individual’s intention to perform a behavior. The constructs of the theory of planned behavior shown to affect health decisions are a) attitudes, b) subjective norms and c) perceived behavioral control. The development of a scale to measure safety climate based on human behavior theory allowed the measurement of the elements of that theory (Montano, et al., 1997) (Table 1).

The TPB has been examined as a suitable predictive model of behavioral intention in several safety and occupational settings (Arnold, et al., 2006; Elliot, et al., 2003; Evans & Norman, 2002; Petrea, 2001; Quine, et al., 2001; Sheeran & Silverman, 2002). The findings from these studies support a reasonable expectation that TPB can be used as the basis for development of a model representing safe behavior. Johnson and Hall (2005) found that many existing safe behavior studies evaluated specific intervention outcomes rather than explore the factors underpinning the decisions to follow those interventions. Johnson and Hall (2005) concluded that the TPB’s constructs can be appropriately used in a worksite setting to guide interventions to encourage adherence to safe behaviors. Fogarty and Shaw (2010) furthered the Johnson and Hall (2005) study by fortifying the structural model of the TPB with the addition of “management attitude to safety.” Fogarty and Shaw (2010) found that while holistically, the TPB was a suitable representation of factors that lead to behavior intention, there were disparities in influence exerted by the themes selected to represent the TPB constructs. A review of the literature led to

<table>
<thead>
<tr>
<th>Categories Assigned for Analysis</th>
<th>Theory of Planned Behavior</th>
<th>Fogarty &amp; Shaw Model</th>
<th>Hall Safety Theme Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor Linking Determinants a</td>
<td>“Management Attitude to Safety”</td>
<td>“Management/ Supervisor Attitude to Safety”</td>
<td></td>
</tr>
<tr>
<td>Determinant of Intention #1</td>
<td>“Attitude”</td>
<td>“Own Attitudes to Violations”</td>
<td>“Risk”</td>
</tr>
<tr>
<td>Determinant of Intention #2</td>
<td>“Subjective Norms”</td>
<td>“Group Norms”</td>
<td>“Group Norms” b</td>
</tr>
<tr>
<td>Determinant of Intention #3</td>
<td>“Perceived Behavioral Control”</td>
<td>“Workplace Pressures”</td>
<td>“Workplace Pressures”</td>
</tr>
<tr>
<td>Measurement Variable #1</td>
<td>“Intention”</td>
<td>“Intention to Violate”</td>
<td>“Intention to Follow Safety Procedures”</td>
</tr>
<tr>
<td>Outcome</td>
<td>“Behavior”</td>
<td>“Violation”</td>
<td>See Footnote d</td>
</tr>
</tbody>
</table>

Table 1 Theory Construct Assignment of Fogarty & Shaw Model and Hall Safety Theme Model*

Note: “The use of factor analysis to develop the new instrument was guided by findings of Fogarty and Shaw (2004) as an external link affecting “Determinants of Intention.” aGroup norms, competence and safety system were added to the model as recommended by Fogarty and Shaw (2004) as a measure of “Subjective Norm.” ‘The two additional determinants of intention “Competence” and “Safety System” were added by the researchers to increase strength of “Workplace Pressures,” which were reported by Fogarty and Shaw (2004) to be an inadequate substitute for “Perceived Behavioral Control.” The researchers also elected to measure “Intention to Follow Safety Procedures” as an indirect measure of behavior as recommended by Ajzen (1991) based on findings that intention is highly correlated with actual performance of behavior.
the development of the Hall Safety Climate instrument. The premise of this study was to build on the current understanding of application of TPB in the worker safety context by strengthening the measures of the TPB constructs by incorporating additional safety themes.

The selection of which safety themes were to be included was based on the meta-analysis by Flin, et al. (2000). Flin, et al. (2000) attempted to determine the fundamental base from which safety climate could be assessed. Flin, et al.'s (2000) findings were that a core taxonomy existed in the safety climate assessment field of research.

To create this new instrument, six safety themes and one intention measure were assigned. These included “Management/Supervisor Attitude to Safety,” “Risk,” “Group Norms,” “Workplace Pressure,” “Competence,” “Safety System” and “Intention to Follow Safety Procedures” to one of three constructs of the theory of planned behavior: “Attitude Toward Behavior,” “Subjective Norms” and “Perceived Behavioral Control.” The content validity of the initial six safety themes was supported because all eighteen safety climate instruments analyzed by Flin, et al. (2000) incorporated items that measured these six themes. A seventh measure of “Intention to Follow Safety Procedures” was added as an outcome variable. This intention measure was added for the “intention” variable derived from the theory of planned behavior. The intention variable is influenced by each of the six other theme variables (Figure 1). It should be noted in the unpublished manuscript that Fogarty and Shaw (2004) were referenced during the development and application of this study. The manuscript has since been published as Fogarty and Shaw (2010) found that an intention variable was needed to fulfill the requirements of the theory of planned behavior when used to model safety climate. A panel of three experts was selected to assist the researchers to establish face validity of the safety themes. Additionally, the panel approved the theoretical basis used to establish constructs for the instrument.

The approach that this research undertook, incorporation of the safety themes into the TPB model, allowed for the evaluation of predictive capabilities. Previous research that forgoes the incorporation of a social cognitive model into safety climate study lacks the ability to explain the interaction of the underlying factors that lead to safe work behavior (Fogarty & Shaw, 2004).

Development of Item Pool & Test for Reliability

The items, adapted for use in the Hall Safety Climate Instrument, were consistent in context to those used in previous published safety climate surveys. Additional items were incorporated to characterize demographic information to characterize if the individual respondent had experienced an injury event, acknowledged hazards in the work area and the specific job position and/or department of the respondent.

Sixty-five items were initially assigned to reflect concerns related to all of the six safety themes and the one intention variable. All 65 items were confirmed and randomly placed on the questionnaire regardless of the theme. The questionnaire used a 5-point Likert scale. The response options available to the respondent included 1-Strongly Disagree, 2-Disagree, 3-Neutral, 4-Agree, 5-Strongly Agree. The selection of the 5-point Likert response scale was based on use in previous organization and safety climate studies (Colla, et al., 2005; Zohar, 2000; Williamson, et al., 1997). Further consideration used to select 5-point over an even number of responses (4- or 6-point), the researchers chose to avoid overscaling the responses by forcing the respondents to select answering to one extreme or the other. Going above a 7-point scale may be too cognitively challenging (Colman, et al., 1997). The 5-point scale was ultimately selected to allow easier comparisons to existing safety climate studies. In addition, Colman, et al. (1997) found that 5-point response scales were equivalent to 7-point response scales when accounting for total variance.

The safety themes initially proposed in this research were used for instrument design purposes, and the issues by individual themes were further refined to incorporate factor analysis procedures. The instrument was tested for internal consistency reliability using Cronbach’s alpha (Schmitt, 1996). Published studies have used Cronbach’s alpha as a method of establish-
ing a reliability measure for instrument design (Carder & Ragan, 2003; Clarke, 1999; Hayes, et al., 1998; Williamson, et al., 1997).

**Pilot Data Collection Process**

A steel mini-mill located in the southeastern U.S. was selected for pilot testing of the Hall instrument and conducted during January 2006. Three hundred sixty eligible participants attended monthly safety meetings where the pilot Hall Safety Climate Instrument was introduced, and employees were given an opportunity to complete the survey. The on-site safety manager introduced, administered and provided direction for workers to submit responses for the voluntary completion of the survey during monthly safety meetings. The process used by employees for returning a completed or blank survey was anonymous. The purpose of the initial pilot study was to verify the data collection methodology and to collect data for instrument refinement. The findings of the pilot study were used to further refine the instrument and are presented below. The data collected were entered into a database using an earlier version of Statistical Package for the Social Sciences (SPSS); however, all final analyses were conducted using SPSS v19.0.

**Pilot Study 1**

Determining the factors (latent variables) of the instrument helped lead to improving the understanding of the main influences contributing to the overall safety climate as measured by the instrument. The 54 items were subjected to a factor analysis with principal component extraction and Varimax rotation. The scree plot generated from SPSS yielded an interpretable solution of five factors, which accounted for 77.1% of variance. The final solution determined 34 items that loaded .4 or greater on only one factor. The criteria for response item selection were adapted from a study conducted by Williamson, et al. (1997). Twenty items failed to load under these conditions on any factor.

The remaining 34 items had a five-factor structure. The first factor extracted was interpreted as “Understanding of Safety Program” because of the nature of the items that made up the factor. The second factor was interpreted as “Influence of Management and Supervisors” because it contained items that were related to the perceptions of management and supervisors. The third factor was interpreted as “Group Beliefs” because the nature of the items dealt with the individual’s perception of the belief of others around them. The fourth factor was interpreted as “Risk Acceptance” because the items focused on elements that may encourage risk-taking behavior. The final factor was interpreted as “Intention to Follow Safety Procedures,” and the items contained addressed variables that contribute to an individual adhering to safety procedures. Figure 2 represents the resultant model of factor interaction. All factors contained at least three items, and the internal consistency across items in each factor was acceptable for all. Additional measures to improve the Cronbach’s alpha for factors four and five were not conducted because further planned field testing of the instrument was designed to explore and confirm the factor structure. The factor Cronbach’s Alpha is presented in Table 2.

Response items from the Hall Safety Climate Instrument pilot were assigned to a factor if they loaded greater than .4 on only one factor. The final five-factor structure included 29 response items that met the criteria for factor assignment. Five items loaded above .4 but did on two or more factors and were discarded. To further investigate other possibilities for factor structure, the factor analysis was restricted to 4-, 3- and 2-factor solutions. Each of the four structures was tested during the structural equation modeling (SEM) portion of the results section.

Based on the findings from Pilot Study 1, the TPB constructs were represented by the resultant factors rather than the initial six safety themes proposed by Flin, et al. (2000). This technique of using EFA to determine the valid measure

<table>
<thead>
<tr>
<th>Safety Factors</th>
<th>Variance</th>
<th>Cronbach's* Alpha</th>
<th>N</th>
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</thead>
<tbody>
<tr>
<td>Understanding of Safety Program</td>
<td>45.664</td>
<td>.93</td>
<td>17</td>
</tr>
<tr>
<td>Influence of Management &amp; Supervisors</td>
<td>15.443</td>
<td>.87</td>
<td>8</td>
</tr>
<tr>
<td>Group Beliefs</td>
<td>5.505</td>
<td>.72</td>
<td>3</td>
</tr>
<tr>
<td>Risk Acceptance</td>
<td>4.690</td>
<td>.60</td>
<td>3</td>
</tr>
<tr>
<td>Intention</td>
<td>5.764</td>
<td>.62</td>
<td>3</td>
</tr>
</tbody>
</table>

*Round to two significant figures and none below .60 criteria

Table 2 Internal Consistency Reliability Analysis of Specific Safety Factors Within the Hall Safety Climate Instrument Pilot Study 1
of safety climate was essential to preserve the theoretical base of the TPB. Further refinement of the model was achieved through SEM testing to examine which factor structure best represented the constructs of the TPB.

**Field Test of Instrument Pilot Study 2**

Pilot Study 2 used the refined instrument based on the data collected during Pilot Study 1. In late 2006, an additional three steel mini-mill plants were selected to receive the 29-item Hall Safety Climate instrument.

Once the random order for the 29 items was determined, the final instrument was prepared for distribution. Each facility safety manager in the field study was contacted and provided a copy of the Hall Safety Climate Instrument, coversheet and instruction sheet. The industry facilities made copies and administered, collected and shipped the completed instruments to the researcher. The completed surveys were entered into an Excel database and screened for incomplete surveys.

**Survey Response Rate by Location**

Survey responses totaled 671 out of a possible 955, which yielded a response rate of 70.3%. The response rates for the three survey locations are as follows: location No. 1 (73.1%); location No. 2 (64.6%) and location No. 3 (72.6%).

After screening, the database was imported into SPSS for factorial analysis. Analyses included an exploratory factor analysis (EFA) to determine a 5-factor, 4-factor, 3-factor and 2-factor structure solution, and SEM procedures were used to confirm which factor structure best fit the data from response items on the instrument. Analysis of variance (ANOVA) and multivariate analysis of variance (MANOVA) procedures were used to explore group differences among the convenience sample respondents. When differences were detected, post hoc analysis was performed using Tukey’s Honestly Significant Difference (HSD).

**Structural Equation Modeling**

A panel of experts validated the initial mapping for the six safety themes. This content validity was further tested by maximum likelihood procedures in AMOS 6.0 by test-fitting the path model to the six safety theme variables. Additional measures were taken to revise the model based on modification indices along with theoretical considerations. This step was essential to the assurance that the resulting model was a valid measure and followed the constructs of the TPB.

**Survey Response at Three Field-Study Locations**

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<tr>
<td>Manager/Supervisor Support</td>
<td>Social Norms</td>
</tr>
<tr>
<td>Safety System Program</td>
<td>Perceived Behavioral Control</td>
</tr>
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</table>

**Results**

**Confirmation of 3-Factor Model to Represent the TPB**

SEM, using AMOS 6.0 was used to test the fit of the relationships among the instrument variables. The choice of fit indices in SEM was determined by literature review of similar studies (Fogarty & Shaw, 2004). The fit indices selected were (indicates acceptable value): the ratio of $\chi^2$ to degrees freedom ($<3$); Good Fit Index, GFI ($>.9$); Comparative Fit Index, CFI ($>.9$); Tucker-Lewis Index, TLI ($>.9$); and Root Mean Square Error of Approximation, RMSEA ($>.05, <.08$), (Byrne, 2001).

The three-factor model exhibited the best fit: $\chi^2$/df = 3.197; GFI = .894; CFI = .889; TLI = .878; RMSEA = .057, see Table 3, Revised Three Factor Model for the Theory of Planned Behavior. The modification index was selected as an output option in AMOS 6.0. The large values reported by the modification index may indicate the presence of factor cross-loading and error co-variances (Fogarty & Shaw, 2004).

At this point, further modification of the model becomes exploratory in nature even though Confirmatory Factor Analysis (CFA) procedures are continued in order to test the hypothetical factor structures. Items that have large modification index values were reviewed for wording and any similarity in meaning with other items. Based on the reported value and theoretical considerations, five items were discarded from the three-factor model to yield a modified structural equation model.

**Safety Climate & Safety Factor Mean Scores**

Independent variables were analyzed by comparing the safety climate mean scores and individual safety factor mean scores using ANOVA and MANOVA. If a significant difference was detected during the MANOVA, further analysis using post hoc tests, specifically Tukey’s HSD, were conducted to determine the specific differences.

**Safety Climate & Safety Factor Mean Scores by Job Position**

ANOVA analyses were conducted to determine if there was a significant difference in self-reported job position and safety climate. Self-reported job position was the independent variable and was compared to the average overall score of the instrument. Job position categories included 1) Manager; 2) Supervisor; 3) Employee; and 4) Non exempt. Note that the categories “Em-

**Table 3 Revised 3-Factor Model for the Theory of Planned Behavior Constructs**

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</tbody>
</table>

Note: The modified model fit was achieved in 10 iterations and exhibited excellent fit statistics: $\chi^2$/df = 2.876; GFI = .919; CFI = .913; TLI = .903; RMSEA = .053.
ployee” and “Nonexempt” were used because they were internal company designations to identify the type of work performed. “Employee” refers to hourly production work, and “Nonexempt” refers to hourly administrative and staff personnel.

ANOVA analysis detected significant differences at a \( p = .05 \) level in responses to job position and overall safety climate. The ANOVA F value was \( F(1,669) = 14.57, p = .001 \), indicating significant differences between job positions and overall safety climate. Post hoc analysis was performed based on the significant differences found using Tukey’s HSD. Job positions “Employee” and “Nonexempt” scored significantly lower than job positions “Manager” and “Supervisor.” Safety climate mean scores for job position are presented in Table 4.

ANOVA analyses were conducted to determine if significant differences existed between self-reported job positions and individual safety factor scores. Self-reported job position was the independent variable and was compared to individual safety factor scores.

MANOVA analysis detected significant differences at a \( p = .05 \) level in job position and individual safety factor scores. The MANOVA F value was \( F(9,1018.5) = 5.33, p = .001 \), indicating that significant differences exist between job position and individual safety scores. Post hoc analysis was performed based on significant differences found using Tukey’s HSD. Job positions “Employee,” “Nonexempt” and “Manager” scored significantly lower for safety factor “Risk-Taking Behaviors” than job position “Supervisor.” Job positions “Employee” and “Nonexempt” scored significantly lower for safety factor “Manager/Supervisor Support” than job positions “Manager” and “Supervisor.”

### Safety Climate & Safety Factor Mean Scores by Department

ANOVA analyses were conducted to determine if there was a significant difference in self-reported department and overall safety climate. Self-reported department was the independent variable and was compared to the average overall score of the instrument. Department categories included the Rolling Mill, Melt Shop, Maintenance, Administration and Contractor.

ANOVA analysis detected no significant differences at a \( p = .05 \) level in responses to job position and overall safety climate. The ANOVA F value was \( F(3,666) = 2.23, p = .064 \), indicating no significant differences between department and overall safety factor score.

Results indicate that safety climate was not different among employees based on department location. Safety climate score is presented in Table 5.

MANOVA analyses were conducted to determine if significant differences existed between self-reported department and individual safety factor scores. Self-reported department was the independent variable and was compared to individual safety factor scores.

MANOVA analysis detected significant differences at a \( p = .05 \) level in department and individual safety factor scores. The MANOVA F value was \( F(12,1757.07) = 2.26, p = .008 \), indicating that significant differences exist between department and individual safety factor scores. Post hoc analysis was performed based on significant differences found using Tukey’s HSD. Departments “Rolling Mill,” “Contractors,” “Melt Shop” and “Administration” scored significantly lower for safety factor “Manager/Supervisor Support” than “Maintenance.”

### Safety Climate & Safety Factor Mean Scores by Previous Work-Related Injury Experience

ANOVA analyses were also conducted to determine if there was a significant difference in self-reported prior work-related injury experience and overall safety climate. Self-reported prior work-related injury experience was the independent variable and was compared to the average overall score of the instrument. Responses to the item “At this or any previous place of employment have you ever been involved in a work-related accident that resulted in an injury?” were (1) yes and (0) no.

ANOVA analysis detected a significant difference at a \( p = .05 \) level in responses to self-reported prior work-related injury experience and overall safety climate. The ANOVA F value was \( F(1,669) = 4.85, p = .028 \), indicating a significant difference between self-reported prior work-related injury experience and overall safety climate. Respondents who reported a prior work-related injury experience scored significantly lower than those who reported no prior work-related injury.

MANOVA analyses were conducted to determine if significant differences existed between self-reported prior work-related injury experience and individual safety factor scores. Self-reported prior work-related injury experience was the independent variable and was compared to individual safety factor scores.

MANOVA analysis detected significant differences at a \( p = .05 \) level in self-reported prior work-related injury experience and individual safety factor scores. The MANOVA F value was \( F(3,666) = 5.20, p = .001 \), indicating that significant differences ex-

<table>
<thead>
<tr>
<th>Self-Reported Job Position</th>
<th>Number of Respondents</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manager</td>
<td>26</td>
<td>4.0</td>
<td>.3519</td>
<td>.0699</td>
<td>3.4</td>
<td>4.8</td>
</tr>
<tr>
<td>Supervisor</td>
<td>53</td>
<td>4.0</td>
<td>.4014</td>
<td>.0551</td>
<td>2.4</td>
<td>4.9</td>
</tr>
<tr>
<td>Employee</td>
<td>551</td>
<td>3.7</td>
<td>.4031</td>
<td>.0172</td>
<td>1.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Nonexempt</td>
<td>41</td>
<td>3.8</td>
<td>.4622</td>
<td>.0722</td>
<td>2.8</td>
<td>4.9</td>
</tr>
<tr>
<td>Total</td>
<td>671</td>
<td>3.8</td>
<td>.4171</td>
<td>.0161</td>
<td>1.5</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Table 4 Job Position Safety Climate Mean Scores from the Hall Safety Climate Instrument Field Study
Results of Pathway Model Testing

Pathway model testing resulted in an acceptable fit for the instrument. Factor analysis revealed an initial five-factor solution for the pilot data. Confirmatory factor analysis and follow-up exploratory factor analysis resulted in a three-factor solution for the field testing data. Significant differences were found during the ANOVA and MANOVA testing of the Likert-type item responses and specific differences identified with Tukey’s HSD.

Group differences in safety climate and safety factor scores were determined by ANOVA and MANOVA. Significant differences \((p < .05)\) among variables were identified when the \(F\) ratio indicated larger variance among variables than within variables. Post hoc comparisons were performed to determine the specific groups that yielded the significant differences. Pairwise correlations, specifically Tukey’s HSD, were computed to determine which groups differed the most in self-reported perceptions of safety climate.

It should be noted that a potential source of measurement error that threatens the validity of the conclusions is common method variance (CMV) (Podsakoff, et al., 2003). CMV is when measurement method is the actual source of variance rather than the variable of interest (Podsakoff, et al., 2003). In the case of this study, the procedure of measuring the independent variables and the dependent variables in the same instance could be a source of CMV. Lance, et al. (2010) argue that while CMV may artificially increase observed relationships between variables, there is a counteracting effect from measurement error. In light of these contrasting views, the reader must decide whether the effect of CMV is large enough to discount the findings.

Discussion

The Hall Safety Climate Instrument was created and validated to assess the safety climate of workers in high-hazard occupations in heavy industry, such as workers employed at three steel mini-mill locations in the U.S. Steps involved in the development of the instrument first required the creation of the Hall model based on the theory of planned behavior. This was accomplished by linking safety themes selected from current safety management research to the theory of planned behavior constructs. Then an expert panel was assembled and requested to validate that each safety management-related theme was correctly assigned to the appropriate theory construct. Specific survey items representing each theme were determined by the research through a rigorous search of the literature and review of other psychometric instruments. The expert panel was also requested to review the assignment of each survey item previously assigned to an appropriate theme by the researchers. The researchers then established internal consistency reliability and factor analysis reliability through the pilot testing of the survey instrument with employees at a steel mini-mill location in the U.S. and the analysis of the data the pilot study provided. Further reliability was measured by conducting a pathway analysis of the Hall model using AMOS 6.0 to refine the model and achieving excellent model fit statistics.

Survey responses further revealed that although the majority of employees and on-site contractors indicated agreement with the statement, “I know other workers at the company who do not follow safety procedures,” the majority also agreed that most participants have an intention to avoid taking risky behaviors that circumvent company procedures and that managers and supervisors supported safety at the organizational level. Differences were noted in perceptions from employees at various levels. Those in management and supervisory roles self-reported a higher company safety climate than hourly and nonexempt employees.

Three-Factor Model

SEM yielded a three-factor model, which best fit the path model representing the TPB constructs. Factor one was interpreted as “Risk-Taking Behaviors” because of the nature of the items that loaded on that factor were associated with individual

<table>
<thead>
<tr>
<th>Self-Reported Department</th>
<th>Number of Respondents</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Std. Error</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rolling Mill</td>
<td>227</td>
<td>3.7</td>
<td>.3854</td>
<td>.0256</td>
<td>2.6</td>
<td>4.9</td>
</tr>
<tr>
<td>Melt Shop</td>
<td>183</td>
<td>3.7</td>
<td>.4345</td>
<td>.0321</td>
<td>2.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Maintenance</td>
<td>116</td>
<td>3.8</td>
<td>.4640</td>
<td>.0431</td>
<td>1.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Administration</td>
<td>90</td>
<td>3.8</td>
<td>.3887</td>
<td>.0410</td>
<td>2.6</td>
<td>4.9</td>
</tr>
<tr>
<td>Contractor</td>
<td>55</td>
<td>3.8</td>
<td>.4054</td>
<td>.0547</td>
<td>2.8</td>
<td>4.9</td>
</tr>
<tr>
<td>Total</td>
<td>671</td>
<td>3.8</td>
<td>.4171</td>
<td>.0161</td>
<td>1.5</td>
<td>5.0</td>
</tr>
</tbody>
</table>

Table 5 Department Safety Climate Score Mean From the Hall Safety Climate Instrument Field Study
choices related to safety behavior. Factor two was interpreted as “Manager/Supervisor Support” because each item considered management or supervisory views on the behavior. Management has long been thought of as an influence on worker attitudes, but inclusion of supervisor consideration shows a disassociation of workers from floor-level supervisors.

The second factor was mapped to the “Social Norms” construct of the TPB since managers and supervisors set the climate for how safety behavior is to be regarded in the workplace. The final factor was interpreted as “Safety System Program” because the items reflected the self-efficacy, training and opportunity to follow safety procedures. This factor was thought to be representative of the individual’s ability to follow through with required safe behaviors and a good proxy for the TPB construct of “Perceived Behavioral Control.”

Job Position: Safety Climate/Safety Factor

Participants at steel mini-mills located in the U.S. in a supervisor job position reported under the safety climate factor for “Risk-Taking Behaviors” an intention to avoid risk-taking behaviors that circumvent company safety procedures higher than the safety climate factor reported by managers, employees and those respondents in nonexempt job positions. The disparity in perceived importance should be eliminated by addressing the need for all personnel to avoid poor safety decisions. This raises the question whether supervisors may perceive they are under greater pressure to produce than to work safely, even if the company jargon and management line espouse “safety first.”

Maintenance departments reported a significantly (.05 level) higher safety climate factor for manager and supervisor safety support at the organizational level than other departments. Efforts to replicate the delivery of safety programming in the maintenance department to the other areas of the company may be the best way to improve the perception of manager and supervisor support for safety.

Work-Related Injury Experience: Safety Climate/Safety Factor

Participants at steel mini-mills located in the U.S. who had no previous work-related injury experience reported significantly higher company safety climate scores than those who had a previous work-related injury experience. Participants also reported a significantly higher safety climate factor for “Risk-Taking Behaviors,” the intention to avoid risk-taking behaviors that circumvent company safety procedures than those who have had a previous work-related injury experience using a .05 level of significance. This implies there is individual variance in risk perception even when employees of an organization have experienced the same training and education and work in the same jobs. This self-reported factor also suggests that those individuals who have a lower perception of, and are less serious about avoiding risk-taking behaviors, are more likely to take risks and consequently may be more likely to be injured.

Conclusions

The Hall Safety Climate Instrument proved to be reliable, and an expert panel determined face validity of the selected factors to accurately reflect intended themes. This research revealed that a majority of employees and on-site contractors indicated that safety climate was perceived as “high” and that company safety programs were effective, confirming that high safety climate perceptions can exist in high-hazard occupational environments as found in previous studies (Brown, et al., 2000; Dedobbeleer & Beland, 1991; Fogarty & Shaw, 2010). This research further exemplified the fact that separate safety climates can exist among workers in different groups as reported in other studies (Fogarty & Shaw, 2010; Hayes, et al., 1998; Williamson, et al., 1997).

The identification of a three-factor model of safety climate can lead to a more focused approach to safety management. “Risk-Taking Behaviors” as a factor indicates a need to address consequences associated with poor safety decisions. The goal should be to convince employees that following safety protocol for each and every task performed is in their best interest. “Manager/Supervisor Support” reinforces the concept of a “top-down” approach to positively influencing safety climate. Employees need to know that upper management along with direct supervisors expect adherence to safety policies. One way to convey that message is to have involvement of key management and supervisory personnel during delivery of safety messages. “Safety System Program” addresses the need for safety to become a core value and to take priority over production if there is a conflict that could result in injury. Efforts to increase safety awareness, engage all levels in supporting, enforcing, and reinforcing safe behavior will affect the overall safety climate of the employees.

Additionally, employees who have had a previous work-related injury may need follow-up contact with safety personnel to identify possible reasons for the lower safety climate scores. There may be opportunities to affect these employees with positive reinforcement in a way that strengthens their attitudes concerning safety in the workplace. Perhaps employees with previous work-related injuries could share their experiences with others to increase awareness of the importance of adhering to safety policies. Some organizations have successfully taken a behavioral approach by pairing employees who have been injured with veteran employees who have not been injured and establishing a coaching or mentoring relationship.

Given the seriousness of work-related employee injuries and fatalities in high-hazard industry, more research that builds on the existing findings is needed. The utility of theory-based safety climate instruments resides in the potential to measure safety climates in other high-hazard industries. This research provides a foundation for the development and application of safety climate instruments based on the theory of planned behavior to specific high-hazard industries other than the steel mini-mill industry.

Further investigation is needed to explore the persistent gap in safety climate constructs between management and employees. Until the organization is able to view safety from a single
perspective, it will be difficult to create the culture necessary to effectively elevate safety as a core value. Additional attention should be given to streamlining the instrument to minimally impact the time away from production being used to complete the survey. One possible approach is to focus on the three-factor structure of “risk-taking behavior,” “manager/supervisor support” and “safety system program” as the basis for a leaner measure of safety climate.

References


